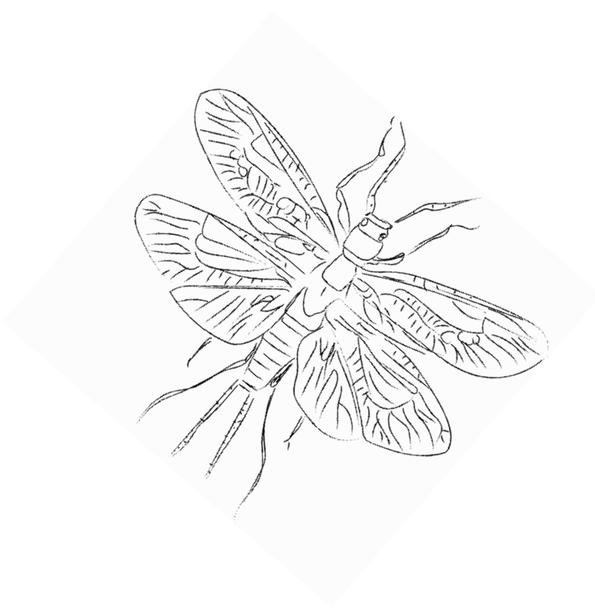
ABSTRACT BOOK



SEFS11 Abstract book

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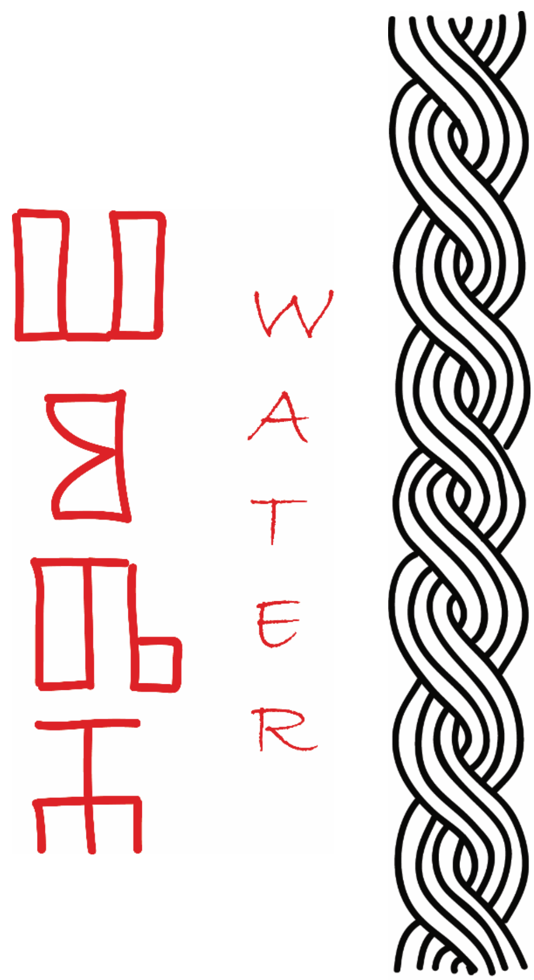

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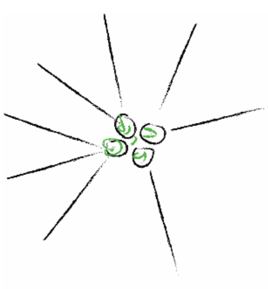

Plenary lecture 1

EU environment policy-related research needs for nature and water protection in Europe

Keynote speaker: **Frank VASSEN***
Affiliation: European Commission, DG Environment, Unit ENV.D3 – Nature protection, Brussels, Belgium

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Despite significant amounts of EU funding being invested into biodiversity-related research programmes across the EU, the direct relevance of the results of many of these programmes for the practical implementation and monitoring of EU nature and water policies remains limited. In my presentation, I will argue that, from an EU perspective and with regard to freshwater ecosystems, research needs for biodiversity are mostly related to the implementation of the relevant key pieces of EU environmental legislation, namely the EU Birds and Habitats Directive on one hand, and the Water Framework Directive on the other: (i) improving the quality, relevance and cost-effectiveness of monitoring the status and trends of freshwater habitat and species; developing, testing and implementation support to new (long-term) monitoring approaches that make use of recent technological advances; (ii) improving the identification of key/priority areas and key measures in order to most efficiently implement conservation or restoration strategies; (iii) improving our understanding on when nature is in a healthy / good state; support the development of definitions of favourable reference values/ favourable conservation status/ good ecological status of freshwater ecosystems, habitats and species. The lack of attractiveness of the above key research issues may be due to their "excessive" down-to-earth nature, being on the side of "applied" research rather than on broader conceptual questions on which research funding is currently focussing. An additional constraint is related to the long time-perspective needed for proper monitoring, typical research projects running for a few years only. I will end my presentation with suggesting possible solutions to bridge the gap between science and policy implementation.

Plenary lecture 2

Dispersal and oviposition of aquatic insects: critical events that link terrestrial and aquatic phases of populations and influence population dynamics

Keynote speaker: **Jill LANCASTER***
Affiliation: School of Geography, University of Melbourne, Australia

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Ecologically, dispersal can link local populations and influence population size, but only if dispersal is successful. For adult aquatic insects, successful dispersal must be followed by oviposition, which results in recruitment. Stream insect populations may also be linked along channels by larval drift, provided drifters can establish in new locations. Empirical data on dispersal, however, is scarce and virtually no attention is given to the question of whether dispersal is successful. This talk will highlight new and published evidence of how these vital processes of dispersal and oviposition can influence population size. A large-scale field experiment demonstrated successful dispersal by some species, but failed to find an association between dispersed success and traits that are commonly assumed to reflect dispersal capability. Several studies demonstrate that the number of oviposition sites in a riffle or river is strongly associated with the number of egg masses. This effect of oviposition site availability can carry through to subsequent larval stages, demonstrating potentially long-lasting effects on population size. Oviposition site selection is species-specific and egg-hatching success can vary with ambient environmental conditions and egg predation. Eggs of aquatic insects are typically spatially aggregated in rivers, but the degree of aggregation depends on the spatial arrangement of preferred oviposition sites and behavioral interactions among females (congregation vs avoidance). Such aggregation has implications for populations, especially as it influences density-dependent processes during larval life. A more comprehensive understanding dispersal and oviposition will facilitate effective integration of population and community ecology for aquatic insects.

Plenary lecture 3

Relationships of multiple stressors and biological responses in freshwaters: Impact, scales and mechanisms

Keynote speaker: **Daniel HERING***
Affiliation: Department of Aquatic Ecology, University of Duisburg-Essen, Germany

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European freshwater ecosystems are commonly exposed to multiple stressors, with diffuse pollution and hydromorphological degradation being most frequent. The interaction of stressors in affecting lake and river biota is poorly understood, and it is currently not possible to predict under which circumstances stressors will interact. First, I will present a concept on the mechanisms of how multiple stressors affect freshwater biota. Second, we analysed original data from European lakes and rivers, resulting from the MARS and GLOBAQUA projects, covering 180 recent mesocosm experiments, basin- and cross-basin studies in which two stressors and a biological response variable were investigated. The biological response to paired stressors was analysed by generalised linear regression to partial out the effects of the individual stressors and their interaction term. In 40 % of cases only one of the two stressors significantly affected the biota, while 27 % revealed additive effects and 33 % interactive (antagonistic or synergistic) effects, supporting conjecture that stressor interactions are rarer in real-world situations than might be inferred from small-scale experimental studies. For lakes, the share of cases with single stressor effects, additive stressor effects and stressor interactions followed the same order of magnitude for mesocosms, basin- and cross-basin scales, while for rivers the share of cases with additive and interactive effects increased strongly with scale. This is likely due to the increase of stressor intensity gradients with scale, which is more pronounced for rivers than for lakes. The total explanatory power (R2) of our models decreased with scale for both lakes and rivers, but the partial R2 of interaction (relative to the total R2, for cases with significant interaction term) did not differ between scales. This observation underlines that the interaction strength between stressors stays similar, irrespective of confounding factors related to scale. In lakes, the effects of eutrophication usually exceeded those of the second stressor (e.g. warming or hydrological changes), while a heterogeneous pattern was observed for rivers with the effects of eutrophication depending on the specific stressor combination and biological response. This result vindicates the prioritisation of eutrophication in lake restoration, while highlighting that for rivers more individual management choices are required. The suitability of management measures applicable to multiply stressed waterbodies is discussed.

Plenary lecture 4

Migratory waterbirds as key vectors of dispersal for plants and invertebrates – case studies from Europe

PhD awardee

Keynote speaker: **Ádám LOVAS-KISS***
Affiliation: MTA Centre for Ecological Research-DRI, Department of Tisza Research, Debrecen, Hungary

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Research to date on avian dispersal of plants has focused mainly on frugivory or on scatter-hoarding. However, both classic and more recent research has shown that migratory waterfowl can disperse a broad range of other plants by endozoochory). During endozoochory, the propagules are ingested by the vector and later egested, while retaining their viability. Endozoochory can be considered to have two forms, both primary endozoochory when only one vector is transporting the propagules, and secondary endozoochory when there are two vectors. We studied these two types of dispersal on three different birds. We examined the primary dispersal of plants by mallards in Hungary. This is a unique study of the spatial variation in plants dispersed by endozoochory by a migratory waterbird. Secondary dispersal of propagules can be even more important for the dispersed organisms than primary dispersal. Recent studies showed the importance of mammals as secondary vectors, but we lack knowledge about the role of waterbirds. We focused on a piscivore (great cormorant, *Phalacrocorax carbo*) and an omnivore (lesser-black backed gull, *Larus fuscus*). Our results confirm that secondary dispersal by waterbirds of both plants and aquatic invertebrates can be of great importance, both when feeding on different fish species or an alien crayfish. This dispersal mode can promote the expansion of both native and alien species. Secondary dispersal pathways associated with complex food webs must be studied in detail if we are to understand changes in species distributions in a rapidly changing world.

RS1 Algae

RS1_O1_Effects of artificial light at night on benthic primary producers in freshwaters

PhD awardee

Author(s): Maja GRUBIŠIĆ[1]*; M. Cristina BRUNO[2]; Guido ZOLEZZI[3]; Michael T. MONAGHAN[4]; Franz HÖLKER[5]

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Presenting author*: grubisic@igb-berlin.de

In recent decades, the use of artificial nocturnal illumination has rapidly increased worldwide, leading to light pollution in many areas – an increase of nocturnal light above natural levels, and a disruption of natural light/dark cycles. This widespread alteration of the natural light regime by artificial light at night (ALAN) contributes to global environmental change and raises concerns about potentially adverse effects in illuminated ecosystems. Ecological studies on ALAN report effects on a range of organisms along the food chain, however they have largely focused on nocturnal animals and terrestrial ecosystems. Effects on aquatic ecosystems, and in particular on primary producers, remain relatively understudied. We conducted manipulative field experiments in two different freshwater systems: a flume system on a sub-alpine stream and a lowland agricultural drainage ditch. We mimicked light conditions of urban and suburban areas (approx. 20 lux at the water surface) using white LED or high-pressure sodium (HPS) lamps and compared biomass and community composition of periphyton exposed to ALAN to those of periphyton grown under natural night lights. Nocturnal LED illumination over three to six weeks decreased the biomass of phytobenthos in both aquatic systems. In stream phytobenthos, LED illumination also changed proportions of diatoms and cyanobacteria in contrasting patterns that depended on periphyton growth stage and season. We found no impact of the nocturnal HPS illumination on the periphyton. We also show that ALAN can significantly impact primary producers in reality, with yet unknown consequences for higher trophic levels and/or ecosystem functions.

RS1_O2_Taxonomic shift over a phosphorus gradient affects the stoichiometry and fatty acid composition of stream periphyton

Author(s): Alessandra IANNINO[1]*; Alexander T.L. VOSSHAGE[2]; Markus WEITERE[2]; Patrick FINK[2]

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Phosphorus enrichment of stream ecosystems increases primary production in the benthos, but less is known about eutrophication effects on the nutritional quality of benthic algae for grazers. On short time scales, high phosphorus inputs may lead to a low C:P ratio and a high essential fatty acid content of periphyton, which are important determinants of food quality for grazers. However, in the long run, nutrient enrichment may alter the taxonomic composition of periphyton and favour the growth of less palatable algal species. In this study, we grew stream periphyton under a gradient of five increasing phosphorus concentrations, to investigate eutrophication effects on periphyton taxonomy, C:P stoichiometry, and fatty acid composition. After six weeks, periphyton grown at the lowest phosphorus concentration was mainly composed of diatoms. Filamentous chlorophytes and cyanobacteria gradually replaced diatoms along the phosphorus gradient and dominated the community at the highest phosphorus concentration. Periphyton content of essential polyunsaturated fatty acids showed a unimodal relationship with phosphorus availability and peaked at the intermediate phosphorus level, likely as a result of both taxonomic and physiological nutrient effects. Interestingly, periphyton C:P was the lowest in the highly oligotrophic treatment and increased with phosphorus availability in a logarithmic fashion, suggesting a tendency of chlorophytes and cyanobacteria to produce more biomass per unit of assimilated phosphorus compared to diatoms. Our results demonstrate that increasing phosphorus concentrations in freshwater ecosystems may worsen periphyton nutritional quality for herbivores, not only in terms of biochemical composition but also in terms of nutrient stoichiometry.

RS1_O3_Functional response of the phytoplankton community towards changes in stratification in a large oligotrophic lake

Author(s): Benedikt EHRENFELS[1]*; Athanasio Stephano MBONDE[1]; Kathrin BAUMANN[1]; Christian DINKEL[1]; Andreas BRAND[1]; Bernhard WEHRLI[1]

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Abstract

Lake Tanganyika is the world's second largest freshwater lake by volume and characterized by a nutrient rich hypolimnion and an oligotrophic epilimnion. Increasing stratification due to global warming is diminishing the overall primary productivity of the lake, but little is known about the functional response of the phytoplankton community towards enhanced stratification. We collected vertical profiles of density, photosynthetically active radiation, dissolved nutrients, photopigments, and the phytoplankton community in a highly resolved latitudinal gradient during two seasons at Lake Tanganyika. We observed two different situations. (1) Weak and/or shallow thermocline within the euphotic zone: primary producers profit from a high vertical flux of nitrate and light availability near the thermocline. Hence, the chlorophyll peak is centred around the thermocline. The phytoplankton community structure is diverse, while the abundances of diazotrophic cyanobacteria are generally low. (2) Strong and deep thermocline below the euphotic zone: the vertical transport of nitrate into euphotic zone is heavily reduced, but phosphate is available in excess. This provides a competitive environment for diazotrophs with high abundances of *Anabaena* sp. as well as high phycoerythrin and phycocyanin concentrations, especially near the surface. Diazotrophs and diatoms of the genus *Nitzschia* sp. are the key players and therefore the chlorophyll peak is located near the surface, as well. During heavily stratified conditions, *Anabaena* sp. can form blooms despite the highly oligotrophic state of the water. Enhanced stratification will probably lead to increasing numbers of diazotrophic cyanobacteria in Lake Tanganyika, with unknown repercussions on nutrient cycling and food web dynamics.

RS1_O4_Bioindication of the aquatic ecosystems status in Ukraine within the framework of European Water Policy

Author(s): Olena BILOUS[1]*

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Abstract

Ukraine, having recognized European integration as a priority and fulfilling its commitments under the EU-Ukraine Association Agreement, have implemented common water management policy and model defined in the six water directives, mostly EU Water Framework Directive (Directive 2000/60/EC, WFD). For the aquatic ecosystems' achievement of a good status one of the tools is ecological status assessment according to WFD, characteristics of modern conditions via comparison with natural (reference) conditions, and some managemental actions for improvement of the aquatic ecosystems' status. Recognizing the importance of aquatic ecosystems assessment using the biological quality elements as phytoplankton, phytobenthos, macrophytes, macroinvertebrates and fish fauna, the reported work was intended only in bioindicational aspects of algae. It is known that benthic algae and phytoplankton can be used to detect eutrophication, organic pollution, acidification, salinity etc. Some of these aspects may be characterized using special indices as well as using bioindication information (included in indices or not). Our work consisted on gathering all ecological characteristics (habitat preference, stream flow and oxygenation, temperature, acidification, salinity, organic pollution by Watanabe and Sladeček, nitrogen uptake metabolism by Van Dam et al., trophic state by Van Dam et al., etc.) of indicator algae that might be used for Ukrainian aquatic ecosystems, grouping them according to modern taxonomy and giving them appropriate names. Untill now, three thousand indicator algae can be exploited for water quality assessment in Ukraine. Considering similarity European and Ukrainian floras, the created database is appropriate for water quality assessment in the EU countries.

RS2 Climate change and freshwater ecosystems

RS2_O1_Influence of the paraglacial landscape along the river continuum in a deglaciating Alpine catchment

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Abstract

Several deglaciating catchments in the Alps have already surpassed the peak water of maximum discharge associated to glacier shrinkage, and are increasingly dependent on stochastic precipitation, groundwater sources and permafrost influence. We investigated the seasonal (June, August, September) and daily (every 3 hours) variability of water temperature, discharge, turbidity, electrical conductivity, and channel stability in a glacier-fed stream in a deglaciating area of the European Alps (Zay Valley), from the glacier snout to the closing section (13 stations). These parameters, measured also in the main tributaries (i.e. a rock glacier outflow and a groundwater-fed stream), were used to investigate the role of the glacier, a proglacial lake, a moraine, a rock glacier, and a talus slope in shaping the stream conditions along the river continuum. Mixing diagrams were used to identify different runoff components during baseflow conditions. Spatial trends were attributed to the decreasing influence of the glacier, paralleled by the increasing role of the rock glacial and groundwater tributaries. Seasonal and daily trends were attributed to the different phases of the alpine summer. The glacial influence dropped directly below the proglacial lake/moraine body in all periods. Noteworthy, the rock glacial stream influenced the parameters of downstream waters in the gradient, especially in September when glacial ablation was lowest. Our work suggests that the paraglacial landscape is becoming a key hydrological driver in the late stages of deglaciation, and that rock glaciers have an increasing role in shaping water conditions at the overall catchment scale.

RS2_O2_Climate-induced drivers shaping biodiversity of subarctic freshwater ecosystems

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Located at the edge of the Arctic and temperate zones, Iceland offers a great opportunity to study and forecast changes of warming climate in freshwater ecosystems the Arctic. Numerous recent scientific publications have emphasized that freshwater ecosystems are particularly vulnerable to climate change e.g. due to limited abilities of the dispersal of freshwater organisms, changes in the freshwater ecosystem function and that many freshwaters are already exposed to many climatic stressors. Our presentation will focus on the status and temporal changes of the sub-Arctic flora and fauna of Icelandic freshwater ecosystems across long-term and paleolimnological time scales, as well as discussing the possible effect of warming on stream ecosystem function. Observed changes will be related to changes in environmental variables such as discharge, rapid recession of glaciers, temperature, precipitation and water chemistry, as well as to human impact on these ecosystems. In addition, changes in phenology and distributional patterns of aquatic insects will be discussed. Icelandic glaciers are rapidly retreating, which opens up new freshwater habitats and with enhanced glacier melting the discharge and turbidity of streams increases. Species shifts and distribution have been documented for salmonids, where Arctic char has declined, especially in the southern parts of Iceland, and has been replaced by brown trout and in some cases Atlantic salmon.

RS2_O3_Structural and functional responses of macroinvertebrate communities to climate change in five Alpine streams fed by shrinking glaciers

Author(s): Valeria LENCIONI[1]*; Federica CAMIN[2]; Gianluca BIANCHINI[3]; Alessandra FRANCESCHINI[1]; Francesca PAOLI[1]; Marzia RIZZO[3]; Agostino TONON[2]; Daniele DEBIASI[1]

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The general aim of this work was to highlight as glacial influence affects structure and functional features of macroinvertebrate communities in six streams fed by glaciers with different size and shrinking rates, in three mountain groups (Italian Alps). The nine selected sites were suitable to this aim, as they were characterized by different glacial influence (measured also using as hydrochemical tracers the stable isotopes of water ^{2}H and ^{18}O in combination with conductivity), within 2 km downstream of the snouts, spanning six kryal, two glacio-rhithral, one glacial pond. In all, more than 15,000 macroinvertebrates were collected in summer 2018, of which 82% chironomids. The predictable longitudinal pattern of taxa richness and functional diversity (evaluated also as rate of organic matter breakdown) was observed in streams where, in the kryal, temperature was <5-6°C. Here a simplified food web persisted, with the grazer *Diamesa* spp. as dominant taxon. Food webs with more trophic levels and higher functional redundancy occurred in kryal sites that had lost their harsh environmental features and in glacio-rhithral sites. Species distribution was analysed in relation to food availability, estimated as epilithic Chlorophyll *a* and BPOM separated from over 60 benthic samples. The relative importance of allochthonous and autochthonous food resources was quantified using stable carbon (^{13}C) and nitrogen (^{15}N) isotopes, highlighting the importance of drifting organic matter for kryal species. Shrinking glaciers are resulting in upstream migration of a) specialist species tracking retreating glaciers until they disappear and b) generalist species to sites once exclusive for kryal species.

RS2_O4_Peculiarities of energy metabolism of northern populations of freshwater amphipoda as adaptation to climate variability

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In the light of current climate changes, to which the animals of the Polar regions are most vulnerable, the study of their adaptive capabilities becomes an urgent task. In the light of current climate changes, to which the animals of the Polar regions are most vulnerable, the study of their adaptive capabilities becomes an urgent task. In this regard, there is a relevant question whether animals of high latitudes, living at low temperatures, will be able to maintain an optimal level of energy exchange during warming or extreme fluctuation of factors. It is important to include in consideration what the interspecific and ontogenetic differences in energy metabolism; and how food habits (especially, for predaceous animals) and other functions that can affect metabolic level and the adaptive capabilities. The work revealed patterns of energy metabolism in amphipods of the Gammaridae, belonging to different ecological and biographical groups, from northern latitudes (lakes of North Karelia on the White Sea coast). The differences in the level of oxygen consumption were significant among representatives of different biogeographic (Arctic *Gammaracanthus loricatus*, Palearctic *Gammarus oceanicus*, Holarctic *G. lacustris*) and ecological (littoral, deepwater) groups. Interspecific differences in the level of standard metabolism in different species were determined by adaptation to life under certain conditions. For the Arctic *G. loricatus* and the Palaearctic *G. oceanicus*, the maximum rates of oxygen consumption were at 15 °C, and for the Holarctic *G. lacustris* at 20 ºC. For Arctic species, metabolic independence was revealed within the low temperature range of 0–5 °C, i.e. respiration intensity remained approximately at the same level. Ontogenetic changes in energy metabolism were pronounced when the young individuals reacted sharply to temperature changes, changing the rate of oxygen consumption. The effect of the specific dynamic action of food (in the case of amphipod predatory feeding) was expressed in a 1.5–3-fold increase in the amount of oxygen consumed by them from the standard level. Eurytherms that are evolutionary adapted to temperature variations may acclimate faster to climate changes than stenotherms and juveniles.

RS2_O5_Long-term water temperature trends in Europe's fourth largest lake show recent and rapid warming in winter

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In this study we aimed to analyse multiannual variability, determine long-term trends and detect changes in the frequency of extreme events in the lake surface water temperature (WT) of Lake Peipsi (Estonia/Russia), the fourth largest lake in Europe. We used daily surface WT measurements at the Mustvee hydrometric station (58º50´ N, 26º57´ E) of Lake Peipsi for the years 1950 to 2018. Dynamic water temperature parameters were calculated using the smoothed water temperature curve fitted to daily water temperatures. Results showed that, although the average WT did not increase significantly on an annual basis since 1950, it rose steadily in the winter season during the last decade (~+0.5 °C). However, WT in summer did not rise significantly. Continuous increase in trend since 2006 exhibited a marked delay in the ice formation (~15 days) resulting in a longer open water period. Although very (97.5th percentile) and extreme (99.5th percentile) high WT did not occur more frequently, we noticed a recent increase in stochasticity in WT during the winter season. The consequences of the on-going winter warming are expected to be crucial for Lake Peipsi ecosystem functioning and ecosystem services provisioning.

RS2_O6_Winter sheltering from a predator – importance of shelter quality

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For ectotherms, low winter temperatures constrain predator-detection and the ability of prey to escape predators, making them vulnerable to predation. Investigations of temperature effects on predator-prey interactions can therefore be of special importance in light of ongoing climate change, where winter temperatures are predicted to increase substantially at northern latitudes. Many studies exist on how stream fishes respond to endothermic terrestrial predators, whereas fewer are directed towards ectothermic aquatic predators. In two experiments, we tested the effect of burbot (*Lota lota*) on winter sheltering behaviour of brown trout (*Salmo trutta*). In one experiment, we studied trout sheltering in the streambed in the presence and absence of fine stream wood under daylight and night conditions. In the second experiment, we measured trout's use of overhead cover and the distance it positioned itself relative to the predator during day, twilight and night conditions. Our results showed that trout sheltered less at night. Availability of fine wood decreased sheltering in the streambed, and this was more pronounced in daylight than in darkness. Presence of burbot decreased sheltering in the streambed, had no effect on use of fine wood and resulted in more non-sheltering trout. Presence of burbot and light increased trout's use of overhear cover. At night and dawn, trout positioned themselves further downstream when burbot was present, whereas in the absence of burbot, trout were located further upstream. These results show that shelters differ in quality and may not offer the same protection from predators.

RS2_O7_Drivers of change and predictability of lake biological diversity in an age of climate change

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Global climate change is anticipated to affect plankton biodiversity in freshwater lakes. Statistical and climate models are frequently used for biodiversity projections under future climatic changes, but their predictive capacity for freshwater plankton biodiversity is highly uncertain. This uncertainty stems from our limited knowledge of the non-linear and complex relationships between freshwater plankton species and their environmental requirements under conditions of competition and environmental variability. Given the growing intensity of global change and the increasing use of statistical models for biodiversity projections, it is crucial to provide models with high predictive abilities which capture the complex nature of interactions and feedbacks of ecosystems. Long-term, high-resolution data allow capturing this complexity that together with advanced machine learning approaches enable the assessment of predictability of plankton biodiversity in freshwater lakes. Here, we applied unsupervised clustering and machine learning techniques on long-term (1979-2018) high-resolution (weekly) biomonitoring data (biological, climatic, chemical and physical) from a central European lake (Lake Müggelsee), and assessed (1) which are the most important drivers of plankton biodiversity and (2) how predictable is plankton biodiversity. To achieve this, we used a variety of plankton biodiversity metrics such as cell abundance/biomass, species richness, Shannon diversity, taxonomic distinctness, size diversity, and functional trait diversity for both zoo- and phytoplankton species of Lake Müggelsee. This research identifies the metrics that best describe variability in plankton diversity. Such quantitative analyses directly contribute to our understanding of the links between global climate-change and biodiversity, which is valuable for predicting potential global-change effects on taxa distributions.

RS2_O8_The global sensitivity of lake phytoplankton communities to climate change

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Future climate impacts on lake temperature and stratification are a cause of global concern owing, in part, to the potential influence these impacts will have on lake phytoplankton communities. Of particular interest is whether these changes will promote an increase in blooms of toxic cyanobacteria. The concern over changes induced by climate raises another interesting question: given that lakes in different parts of the world experience very different climates, how much does location of a lake alone influence the phytoplankton community in a lake? That is, if the exact same lake, with the exact same nutrient loading existed in different parts of the world, how much would the phytoplankton community of the lake differ? To answer this question, we have carried out a global lake modelling experiment using an idealised lake, the phytoplankton community model, PROTECH, and the lake physics model, FLake, calibrated using remotely sensed surface temperature. We have used gridded, modelled meteorological data, both from recent history and for a future climate scenario to drive the lake models. As expected, lake temperature and stratification patterns of this idealised lake vary enormously across the globe, but these physical differences induce a huge variation in algal biomass and percentage of cyanobacteria, demonstrating lakes have a significant geographic sensitivity to nutrient loading. The future climate model runs show that different parts of the globe will be differently vulnerable to a changing climate, with temperate regions being particularly susceptible to increasing cyanobacteria in a globally warmed world.

RS2_O9_Eutrophication or climate change? Long-term decrease in the efficiency of trophic coupling between phytoplankton and zooplankton — A causality analysis

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Here, we analyzed long-term trends (1994-2014) of phytoplankton and zooplankton in the deep, dimictic, oligo-mesotrophic Lake Stechlin (Germany) with the aim: (1) to investigate whether long-term trends do occur in community structure and function of phytoplankton and if so, how they affect zooplankton in the lake; (2) to assess how resource use of these two trophic compartments of the planktonic food-web have altered over time; and (3) to find out if the observed changes could be attributable to long-term changes in climate. Our results indicated increasing dominance of filamentous cyanobacteria (*Aphanizomenon flosaquae*, *Dolichospermum* spp.) in Lake Stechlin was paralleled by the decrease in large-sized zooplankton species (e.g. *Eurytemora lacustris*, *Eudiaptomus gracilis*). Resource use efficiency of phytoplankton (phytoplankton biomass/TP ratio) increased over time, while that of zooplankton (zooplankton carbon/phytoplankton carbon) decreased. Reverse trends in the ecosystem functioning of phytoplankton and zooplankton may suggest a long-term trophic decoupling with potentially decreased energy transport towards higher trophic levels. According to causality analysis, the observed eutrophication signals were induced by climate change via altered stability of the water column. This latter appeared to be a good descriptor of a changing climate, and was crucial for the overall functioning of the pelagic ecosystem of Lake Stechlin.

RS2_O10_Disentangling the impacts of changing mixed depth and water temperature on a modelled lake phytoplankton community

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With climate change, the surface waters of many lakes are predicted to become warmer resulting in a shallowing of the surface mixed layer. Previous work suggests that warmer water and shallower mixed depths will increase phytoplankton biomass and the dominance of toxic cyanobacteria in lake phytoplankton communities. Water temperature and the mixed depth impact phytoplankton growth in different ways: temperature directly influences the rate of cellular processes and therefore the growth rate, whereas the mixed depth determines the light and nutrient environment that phytoplankton are exposed to. Water temperature and the depth of the mixed layer are intrinsically linked, making it difficult to disentangle their independent effects on phytoplankton growth. We isolate the effects of these physical processes on the phytoplankton community of a small meso-eutrophic lake using the phytoplankton community model, PROTECH. The results presented demonstrate that isolated changes in temperature and mixed depth have different impacts on phytoplankton communities, and combined temperature and mixed depth changes have a synergistic impact on phytoplankton biomass. Increases in water temperature increased biomass and cyanobacterial dominance. Mixed depth shallowing from intermediate depths (4–6 m) also increased cyanobacterial biomass at the highest temperature increases. However, mixed layer shallowing at deeper mixed depths (9–13 m) and high temperature increases resulted in a reduction in phytoplankton biomass and a reduction in low-light adapted cyanobacteria. These results indicate that lakes with deeper mixed depths may see a reduction in the dominance of low-light adapted cyanobacteria with mixed depth shallowing and increases in water temperature.

RS2_O11_The nutritional quality of phytoplankton influences the tolerance to extreme water temperatures in the waterflea *Daphnia magna*

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The increasing frequency and the intensity of summer heat waves is challenging the thermal limits of many aquatic ectotherms such as zooplankton. In parallel, higher average temperatures also promote cyanobacterial blooms. Cyanobacteria represent an important challenge for zooplankton because they lack essential biochemicals such as sterols and polyunsaturated fatty acids (PUFA). During cyanobacterial or algal bloom situations the stoichiometric carbon to phosphorus (C:P) ratio of phytoplankton can also dramatically increase leading to a nutritional P limitation of zooplankton. In a series of thermal tolerance tests at temperatures ranging from 34.5° to 38.5°, we determined the survival time of juvenile *Daphnia magna* fed highly controlled diets with contrasting cholesterol, eicopentaenoic acid (EPA, an important PUFA) and C:P ratios. We find evidence that dietary cholesterol and C:P ratio, but not EPA can modulate thermal tolerance. Low cholesterol levels significantly decreased the projected critical thermal maximum (CTmax) by up to 0.7°C. For P, the decrease of the CTmax was also significant but less important (0.3°C) and quite surprisingly occurred only at moderately low P levels. Although moderate, these CTmax differences imply that at ecologically relevant temperatures for temperate water bodies (<34°C), sterol and P nutrition can lead to survival time differences of more than 12h, and hence determine whether *Daphnia* can survive an extremely hot day or not. Our results indicate that phytoplankton food quality, which, is also affected by climate change, can play an important role in mitigating or amplifying the negative effects of extreme climatic events on zooplankton.

RS2_O12_Multidecadal trends in hydrology, hydrochemical variables and phytoplankton in large shallow eutrophic Lake Võrtsjärv (Estonia)

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Lake Võrtsjärv (area 270 km^2, mean depth 2.8 m) is one of the best-studied lakes in Europe. In this presentation we analyse long-term trends in water levels, wind, and ice phenology since the 1920s, phytoplankton community changes since the 1960s and changes in hydrochemistry since the 1980s. Water level (WL, annual mean amplitude 1.4 m, maximum range 3.3 m) is the most influential factor controlling water quality and phytoplankton development in this shallow lake but does not show any long-term trend. Ice phenology shows accelerating trends: since 1994, ice-cover is shortening at a rate more than 20 days per decade, more due to later freezing than earlier ice break-up. Eutrophication phenomena increased from 1950s-80s followed by decreasing trends in both nitrogen and phosphorus. Since the end of the 1970s when light limitation exceeded nutrient limitation, phytoplankton biomass is strongly inversely related to WL. Despite decreasing trends in nutrients, chlorophyll concentrations and phytoplankton biomass are increasing. This increase can be explained by a stepwise wind stilling since 1996 resulting in less sediment resuspension in the lake that created a "light niche" stimulating the growth of the light-limited phytoplankton species. Besides declining nutrient levels, alkalinity shows persistent increasing trends over the last 25 years ranging from 5.5 mg L^{-1} $decade^{-1}$ in winter to 18 mg L^{-1} $decade^{-1}$ in spring. A slight brownification trend observed in the lake since the 1980s reversed since 2010.

RS2_O13_The climate crisis increases not only vertical and seasonal water temperature differences, but also irregular variabilities in a mountain lake

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Lakes around the world are warming, but not all water layers are warming at the same rate, some are even cooling. Most studies on lake water temperatures have focused on surface temperatures during summer or analyzed short-time series. In this study we analyzed, a 44-year time-series of water temperature from nine depths in a small mountain lake using dynamic linear models and temporal trend decomposition. We observed a significant long-term warming trend that only happened from August to December in all water layers. Overall, the lake warmed ca. twice as fast (0.23°C per decade) as the air, but warming of the epilimnion slowed down remarkably (from 0.65°C to 0.10°C per decade) after 1993, a consequence of changing stratification timing during the study period. Deeper water layers even cooled thereafter, pointing to a stronger isolation and thermal separation from surface layers, which were still warming over the whole study period. This differential warming of the lake was accompanied by significant shifts of lake freezing and thawing dates leading to shorter ice cover periods (~5 days per decade). Besides changes of mean temperatures, also temperature variance in the epilimnion increased significantly, together with increasing variance and extremes of local air temperature. Our work thus demonstrates that air temperature extremes are generally conveyed to lake water. In addition, our long-term analysis of Piburger See indicates how water temperatures and nutrient dynamics are related in this mountain lake.

RS2_O14_Initial steps in understanding the in-lake effects of floating solar (floatovoltaics) deployments; changes to the stratification and thermal dynamics

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Floating solar photovoltaics, or floatovoltaics, are a relatively new form of renewable energy, with their deployment and scale rapidly expanding globally. The potential benefits to both energy production and the water bodies used for deployment are numerous. Benefits include reduced land-use pressure, higher energy-generating efficiencies, in comparison to ground-based systems, and reduced evaporative losses. However, at present, the effects of floatovoltaic deployment on water body function and implications for water quality are unknown. Floatovoltaics reduce two key drivers of water body function: wind speed and solar radiation. Here, for the first time, we modelled the potential effect of floatovoltaic-induced changes in wind speed and solar radiation on stratification dynamics, mixed layer depth and water column irradiance. Utilising the one-dimensional process-based MyLake model, we simulated the daily vertical distribution of lake water temperature using a lake in the English Lake District as a test case. To resolve the effect of floatovoltaic arrays of differing sizes, we scaled observed wind speed and solar radiation from 0% to 100% in 1% intervals. The simulations varied considerably from the unmodified system, with substantial changes to stratification dynamics and mixed layer depth, demonstrating floatovoltaics significantly alter water body function. Modifications to the stratification and thermal dynamics of the water body will subsequently alter chemical and biological processes, with implications for ecosystem service provision and water treatment costs. Fully resolving the impacts of floatovoltaics will guide decision-makers within both the energy and water sectors when attempting to balance low-carbon energy generation and water quality management.

RS2_O15_Impact of rising CO_2 concentrations on harmful cyanobacterial blooms – from cell to bloom dynamics

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Bloom-forming, toxic cyanobacteria can form dense surface blooms which can have a severe environmental and economic impact on eutrophic waters across the globe. Global warming is expected to increase the frequency, intensity and duration of cyanobacterial blooms, but how blooms respond to rising atmospheric pCO_2 concentrations is less clear. In controlled lab experiments, we measured how carbon fixation rates, growth, and competitive interactions changed in the notorious cosmopolitan freshwater cyanobacterium *Microcystis aeruginosa* in response to acclimation to elevated pCO_2 concentrations. Our results show an exceptionally strong increase in net carbon fixation rate in *Microcystis* at elevated pCO_2 in comparison to other phytoplankton species. This strong increase in the ability to fix carbon promotes growth rates and biomass production, and increases the competitive strength of *Microcystis* at elevated pCO_2. We also developed a mathematical model that predicts dynamic changes in dissolved inorganic carbon concentrations during the development of cyanobacterial blooms. We tested the model in chemostat experiments with *Microcystis* at a range of different CO_2 levels. We then used the model to explore how cyanobacterial blooms will respond to rising atmospheric CO_2 concentrations in a range of eutrophic waters. The model predicts that rising atmospheric CO_2 concentrations will boost cyanobacterial blooms in a broad range of lakes. Together, both our laboratory experiments and model predictions warn that rising atmospheric CO_2 concentrations are very likely to increase the intensity of cyanobacterial blooms.

RS2_O16_CO_2 emission from lowland streams of the Pampean region (Argentina)

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Quantifying CO_2 fluxes between fluvial systems and the atmosphere is necessary to understand the carbon budget at global scale. However, the geographical coverage of CO_2 flux data is strongly biased towards North America and Europe. We measured for the first time CO_2 concentration and fluxes from 10 streams of the Pampean region (Argentina) characterized by low current velocities and rich macrophyte and biofilm communities. We also analyzed possible drivers of CO_2 fluxes, including hydraulics (current velocity and flow), water properties (conductivity, dissolved oxygen, nutrients, alkalinity), and land use (cropland, cattle breeding, natural vegetation, other uses). Mean CO_2 concentration in stream water varied between 1255 and 9999 ppm, and all streams were emitters of CO_2 to the atmosphere (range: 35-493 mmol/m^{-2} d^{-1}). However, we observed a high spatial heterogeneity in CO_2 fluxes within each stream reach that is possibly associated to differences in current velocity and the presence of macrophytes and algae mats. Our preliminary results show a positive relationship between CO_2 flux and cropland cover. Pending further analyses, these results suggest that the CO_2 flux may increase with stream metabolic activity, which is enhanced by the higher nutrient load associated to agricultural activities.

RS2_O17_Do conventional and conservation agricultural management practices play an important role for CO_2 flux in summer paddy production of Myanmar?

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Rice (*Oryza sativa*. L.) is a major food crop widely grown in Myanmar and hence it might play an important role in a global budget of the emission of greenhouse gases (GHGs) such as methane (CH_4) and carbon dioxide (CO_2). Although there exist several numbers of investigations on methane (CH4) and nitrous oxide (N_2O) emission from rice field, emission of CO_2 from the rice paddy soil was only rarely investigated. This study, conducted in experimental field condition at Yezin Agricultural University, Myanmar, investigated the effects of conservation and conventional soil management practices on CO_2 fluxes. Day and night CO_2 flux measurements were performed during the whole cropping season for summer paddy season (January-May) using airtight chambers. Generally, CO_2 fluxes during the night were significantly higher compared to those during the day, and net CO_2 emissions from conventional practices were significantly higher than conservation one during night. The total CO_2 fluxes from conventional practices during the night ranged from 156 to 1254 mg CO_2 $m^{-2}h^{-1}$ and from 153 to 1040 mg CO_2 $m^{-2}h^{-1}$ in conservation practice. The significant increase of aboveground biomass and yield components were observed in the conventional practices (5.52 Mt ha^{-1}), causing significant increase in both the uptake and emissions of the CO_2 during day and night, respectively. Our data suggest that in spite conventional practice maximizes grain yield, management of a soil exposed to considerable mechanical agitation and manuring leads to higher CO_2 emissions compared to conservation practice.

RS2_O18_Changes on river ecosystem functioning caused by dam operations

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Flow regulation by dams produces a strong deviation from natural flow regimes, which significantly influence the functionality of river ecosystems. Ecosystem metabolism as gross primary production (GPP) and ecosystem respiration (ER), is an integrative measure of the processes controlling organic matter dynamics and nutrient cycling in the ecosystem, and is also a good indicator of the ecosystem life-supporting capacity. The analysis of metabolism, therefore, has been applied to assess the response of rivers to natural and human-induced stressors affecting the river health. As in-stream organisms adapt to the hydrological cycle of the rivers, it is necessary to assess fluvial metabolism along the hydrological year to better understand how hydrological alteration by dams modifies fluvial metabolism. This study presents the analysis of river metabolism estimated in four seasons of the hydrological year (2017-2018). The metabolism was estimated applying the single station open channel diel oxygen method at 6 control and 14 flow-regulated rivers in the North of Spain, based on a Control-Impact surveying design using a natural hydrological classification. Preliminary analysis detected that the ecosystem metabolism changed across seasons with more GPP and ER in spring and summer. The flow regulation by dams generally contributed to a higher GPP and ER; however there were important differences in both GPP and ER related to the type of dam operation. These differences might be explained because the effects of dam operation on important drivers of river metabolism such as water temperature and biomass of primary producers.

RS2_O19_Warming bends the threshold elemental ratio in a homeostatic consumer

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Temperature and nutrition drive consumer’s performance, yet their interactive effects remain poorly understood. Until now, studies investigating whether daphnia will be C- or P-limited when facing temperature elevation remain conflicting. Here we investigate how the dietary C:P ratio, that optimizes consumer’s growth (TERC:P: Threshold Elemental Ratio), changes along temperature gradients by combining theory and growth experiments with the model organism *Daphnia magna*. Both lines of evidence show that TERC:P in *D. magna* presents a U-shaped thermal response. The TER initially decreases with increasing temperature until a minimal value where the dietary C requirements relative to those of P are minimized. Above this value, the TER increases again with temperature indicating a rise in the relative C demand. Our model suggests that the shape of the TERC:P response should be primarily driven by the thermal sensitivities of C ingestion and C assimilation efficiency. We discuss how our results can contribute to the unification between thermal biology and ecological stoichiometry and the forecasting of global change effects.

RS2_O20_Multiple stressors and river biofilms: a mesocosms approach to elucidate the impacts of global change on biodiversity – ecosystem function

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Freshwater ecosystems are currently threatened by climate and land-use changes. Understanding these so-called multiple stressor effects is still seen today as one of the most pressing challenges in ecology, especially when non-additive interactions such as synergism and antagonism occur. We conducted a manipulative experiment using 24 artificial streams to examine individual and combined effects of warming (2°C increase in water temperature), hydrological stress (simulated low-flow situation) and chemical stress caused by pesticide exposure (370 ng L^{-1}) on river biofilms. Response of epilithic and epipsammic river biofilms was evaluated by means of structural and functional variables. Structural response included bacterial community composition assessed by high-throughput sequencing of the 16S rDNA gene marker, while functional response included photosynthetic and metabolic rates, as well as organic matter use. Hydrological stress showed the strongest negative impacts on river biofilms. Accordingly, between 60% and 70% of bacterial taxa in epilithic biofilm significantly changed their abundance in response to hydrological stress. This change in community structure translated into altered photosynthetic capacity and organic matter use. Conversely, warming and pesticide exposure showed less intense effects. Non-additive antagonistic interactions appeared related to warming and pesticides, and affected mainly the community composition of epipsammic biofilms, which translated into altered gross primary production and community respiration. Our study reveals that freshwater biofilms exposed to global change may adapt to multiple stressors by selecting tolerant taxa, therefore promoting antagonistic interactions that deviate from a priori predictions and result into altered biodiversity-ecosystem function responses.

RS2_O21_Integrating water quantity and quality in eco-hydrological relationships

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Primary productivity and respiration rates in rivers are fundamental indicators of river ecosystem health. Yet, there is still a lack of understanding about the metabolic regime and its driving mechanisms for lotic ecosystems. This study aims to investigate ecosystem metabolism dynamics in the River Thames and predict ecosystem response to multiple environmental and anthropogenic stressors under present and future scenarios. To achieve this, a dynamic, mechanistic water quality model is used to simulate hourly variations in river flows, temperature, nutrients, dissolved oxygen (DO), and phytoplankton behaviour along a 60 km long stretch in the Thames catchment for 2013-2014. Hourly monitoring data were used at the upstream boundary of the river reach to simulate water quality and algal concentrations at two sites along the downstream section. The model successfully simulates the temporal variations in chemical and biological parameters and water temperature (Nash Sutcliffe Efficiency values often above 0.9). Water temperature is primarily influenced by flows and riparian shading. Diurnal DO variation in summer is mainly regulated by photosynthetic production, respiration, and aeration at weirs. Algal blooms develop within an optimum range of flows, temperature and sunlight, and are largely influenced by phytoplankton growth and death rate parameters. The model will be used to analyse the impact of multiple stressors on river ecosystem and its response under future climate and management scenarios. The model can further be used to extract river metabolism rates to study ecosystem phenology and its controls.

RS2_O22_Hydrology: key to restore lowland streams and mitigate climate change

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Climate change in the NW European plains implies warming and altered precipitation patterns: longer dry periods and more intense rain showers in summer and more wet winters. The lowland stream catchments in these areas are not prepared for these changes upon the current multistress they already experience. Our aim is to tackle both future climate change and current multistress in an integrated restoration approach. Therefore, our hypothesis is that hydrological measures to store and retain water and to retard discharge are the key for change. Testing these hydrological measures in practice, catchments had to be redesigned based on building with nature principles; using intrinsic geohydrological, morphological, chemical and ecological processes. We studied three cases where large scale hydrological measures were implemented by means of the development of inundation zones, marshes and swamps along lowland streams and in stream valleys. We looked into the role inundation zones, marshes and swamps can play for both the hydrological processes as well as the stream and riparian zone ecosystems. We evaluate the appropriate techniques to create such landscape types, e.g. by reshaping the wide streambed into a shallow, narrow bed with inundation zones, and we studied the biodiversity effects in-stream (macroinvertebrates) and in the riparian zone (vegetation types, carabid beetles, wolf spiders). We predicted the potential marsh forest types for such area. We showed a return of 36% of stenotopic bank and marsh species of carabid beetles and wolf spiders. The results contribute to the development of sustainable lowland stream and stream valley ecosystems.

RS2_O23_Ecological consequences of current and future conductivity in German surface water under climate change

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Global environmental change including climate and land use changes can increase the transport of salts into surface waters. Elevated ion concentrations can pose risks to freshwater organisms. Models predicting baseline salinity help to establish benchmark conditions and can be used to assess whether stream water quality has degraded through secondary salinisation. Moreover, if coupled with climatic or land use forecasts, such models can inform on the changes and the range of variation that are likely to occur. Finally, they represent a first step towards investigating ecological consequences. In this study, we used Random forest (RF) to predict background electrical conductivity (EC) in German running water bodies. Prediction was driven by the major factors controlling salinity including geologic and soil properties, climate, vegetation, and topography. Next, the model was used to forecast the changes in background EC for the period of 2070 to 2100 in response to climate change. The future forecasting shows approximately 10 and 15% increases in mean EC. Finally, Jaccard's index (JI) was applied to determine the changes in species composition and diversity along categories of EC gradients (in terms of difference between observed and predicted EC by the background model). We found significant differences along the EC categories using analysis of similarity (ANOSIM). In our presentation we discuss the results with respect to their relevance for current and future freshwater management.

v

RS2_O24_Catastrophic forest fires, global change, and water quality

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Greater catastrophic forest fire activity worldwide is linked to increased aridity, higher temperatures, and higher wind speeds. Forest fires now cover broader areas and occur over longer periods. Rising temperatures, earlier snowmelt, more rain and less snow, greater vapor pressure deficits in spring and autumn, forest dieback and increasing forest fire frequency and severity strongly affect these catastrophic fires. A catastrophic forest fire occurred in central New Mexico, USA, in June and July of 2011 burning 634 km^2 with an estimated 46% of the fire being of severe or moderate intensity. Extreme water quality excursions were observed in the Rio Grande downstream of the burned catchments. Charcoal, ash, and sediment were routed through intermittent streams and rivers into the Rio Grande after thunderstorms producing intense black water events. At four sites along the river, in situ sensors captured the responses of dissolved oxygen, turbidity, and pH to these flood events. Runoff from burn scars caused turbidity peaks (to >2500 NTU), dissolved oxygen sags (to 0.0 mg L^{-1}), and pH sags (up to 0.75 units). These water quality excursions extended 50 km downstream and caused the closure of a major water supply intake. Sensors continuously measuring dissolved nitrate and phosphate in streams and rivers impacted by the forest fire also showed consistent enrichment in nutrients. Sudden, dramatic changes to forested catchments from severe forest fires are very likely to be among the strongest impacts of global change on stream and river ecosystems worldwide.

RS2_O25_Changes in the vegetation structure in a lake dominated by a rare charophyte, *Lychnothamnus barbatus*, in the light of climate change and human impact

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Lychnothamnus barbatus is used as a bioindicator of oligo-mesotrophic waters. While the number of *L. barbatus* occupied sites decreased in the last century, new sites have been described and the recolonization of the former sites has been observed in recent decades, for instance in Lake Kuźnickie (Poland), a meso-eutrophic water body, where we analyze the impact of climatic changes and human pressure on *L. barbatus* population. Gathered data on the lake's vegetation and water chemistry was compared with meteorological records. We also collected three 30-cm long sediment cores from minimum, average and maximum depths of *L. barbatus* occurrence in order to study the vegetation structure in the past. Sediment cores were dated using the radioisotopes of 210Pb, 137Cs and 14C. The study was supplemented by spatial analysis of the lake's catchment during the last 120 years. Results indicate the recovery of *L. barbatus* over the studied period. However, as no significant changes were documented in the catchment, the lake's vegetation changes likely corresponded to warming and reoligotrophication and were manifested by simplification of its structure. In 1980s, a decrease in the number of aquatic plant macroremains in the sediments likely resulted from the trophic breakdown due to grass carp introduction. The study of macroremains evidenced also that the amount of *L. barbatus* increased in first half of 19th century, after the termination of the Little Ice Age.

RS2_O26_Moderate warming over the past 25 years has already reorganized stream invertebrate communities

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Climate warming often results in species range shifts, biodiversity loss and accumulated climatic debts of the biota (i.e. slower changes in the biota than in temperature). Here, we analyzed the changes in community composition and temperature signature of stream invertebrate communities over 25 years (1990–2014), based on a large set of samples (n=3782) over large elevation, latitudinal and longitudinal gradients in central Europe. Although warming was moderate (average 0.5 °C), we found a strong reorganization of stream invertebrate communities. Total abundance (+35.9%) and richness (+39.2%) significantly increased. The share of abundance (TA) and taxonomic richness (TR) of warm-dwelling taxa (TA: +73.2%; TR: +60.2%) and medium-temperature-dwelling taxa (TA: +0.4%; TR: +5.8%) also increased, while cold-dwelling taxa declined (TA: −61.5%; TR: −47.3%). The community temperature index, representing the temperature signature of stream invertebrate communities, increased at a similar pace to physical temperature, indicating a thermophilization of the communities and, for the first time, no climatic debt was indicated. The strongest changes occurred along the altitudinal gradient, suggesting that stream invertebrates use the spatial configuration of river networks to track their temperature niche uphill. However, this may soon come to an end due to the summit trap effect. Our results indicate an ongoing process of replacement of cold-adapted species by thermophilic species at only 0.5 °C warming, which is particularly alarming in the light of the more drastic climate warming projected for coming decades.

RS2_O27_30 years of climate drying: impacts on Australian mediterranean-climate stream invertebrate communities and what European med-streams might expect in the future

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Southwestern Australia has experienced climate-change driven climate drying for at least 50 years and is decades ahead of other mediterranean-climate regions experiencing such impacts. In southwestern Australia, many formerly perennial streams have transitioned to intermittent flow regimes because groundwater decline has caused streams to change from gaining to losing. Detailed studies of stream invertebrate communities by Bunn (1986) occurred at a time when most streams were perennial. We returned to these same streams in 2016-17 to sample macroinvertebrate communities, and compared the historical (early 1980s) macroinvertebrate communities to present day assemblages. One stream and another stream reach remained perennial. We found that assemblage composition has changed markedly between the two time periods. Several species that were formerly common are now rare or absent from most streams, although some of these are still present in the perennial reaches. Other taxa not recorded by Bunn are now present in the streams, and some formerly rare taxa are now more abundant. General trends include lower diversity and abundance of shredders and lower abundances of EPT taxa, most of which are endemic. Long-term climatic drying and flow regime change have significantly altered invertebrate assemblage composition. As drying continues, the fauna may continue to lose species, inevitably altering in-stream processes.

RS2_O28_The impact of drought on non-perennial river inundation patterns: a case study from the Nuwejaars River, Cape Agulhas, South Africa

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Cape Agulhas is a semi-arid region on the southern-most part of South Africa. The area supports diverse fynbos vegetation, a mosaic of fresh and saltwater wetlands, and an Important Bird Area and Ramsar wetland site. Changes in agricultural practices, invasive alien species, and changes in rainfall patterns, threaten the water resources in this region. This study investigates the effects of a recent drought on water quantity and quality in the Nuwejaars Catchment. This catchment has been instrumented since 2015. Below-average rainfall, between 300-400 mm per year, over the last two years, resulted in a drastic drop in water levels and, subsequently, the river has not flowed. Without flows, most of the largest, permanent wetlands dried up in 2018. Water levels only slightly recovered during austral winter 2018 but were still more than 90% lower than in 2016. Similarly, groundwater levels dropped 11% during the same period. In addition, many parts of the system became hyper-saline (where does the salt come from?). This is likely due to shifts in groundwater and surface water interactions, where wetlands and parts of the river have become disconnected from the discharge/recharge zones. The implications of losing permanently wet refugias in an otherwise dry landscape are not well understood and further research is needed to understand how rainfall amount and timing may cause hydrological processes to alter and drive state changes in the landscape. This research also illustrates the need to improve our understanding of semi-arid catchments and the need for dynamic catchment management strategies, especially in the light of global change.

RS2_O29_The effects of temperature during embryogenesis on juvenile fish: Atlantic salmon and brown trout in an altered climate

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Global warming scenarios for Sweden predict temperature increases of 3-5°C by 2080, with larger increases in winter than in summer. While many of the direct effects of temperature on ectotherms are well studied, little is known about how temperature during embryogenesis influences the behavior and physiology of subsequent life stages. Using Atlantic salmon and brown trout, two species that incubate their eggs in winter, I tested the effects of water temperature during embryogenesis on the behavior, body shape and physiology of these species as juveniles. Eggs were incubated at two temperatures, ambient and elevated (3-5°C), but once the fish hatched they were raised under the same conditions. I found that juvenile salmon, whose eggs were subjected to elevated temperatures, were less aggressive than juveniles, whose eggs were subjected to ambient temperatures. Even body shape differed, with "warm" salmon having slenderer bodies and smaller pectoral fins than "cold" fish. Ventilation rates, a proxy for metabolic rates, were measured for brown trout. I found that "warm" trout had lower ventilation rates than "cold" trout. Additional tests of embryonic temperature on juvenile growth and the decision to migrate are ongoing, but the results to date are already providing insight as to how ectotherms respond and adapt to the warmer temperatures predicted by climate models.

RS2_O30_Structural and functional long-term changes in large-river fish communities detected with a novel meta-analysis framework

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Ongoing global changes are causing major ecological shifts worldwide. Biological trends need to be assessed over long periods of time to better understand past and current community responses. We developed a methodological framework for meta-analyses to be conducted that account for the temporal and spatial autocorrelation of observational data. This meta-analysis framework was applied to investigate trends in environmental and fish-community time series in multiple stations in large French rivers over the past four decades. Changes over time were assessed at species and community level using metrics related to assemblage structure and species' functional characteristics. General significant upward and downward trends were highlighted in water temperature and flow discharge, respectively. Concomitantly, the density of numerous species increased, resulting in large increases in both species richness (about +50%) and total fish abundance (approximately four fold). The strongest signal underlying community changes was replacement of northern by southern species. Long-term changes were also investigated considering species' ecological traits. Over the past four decades, we observed a general decrease in the densities of species showing common reproduction, habitat and feeding strategies whereas the densities of species having uncommon reproduction strategies strongly increased. These results highlighted a great structural and functional turnover in large-river fish communities over the past four decades. This turnover was notably characterized by the replacement of 'K' strategists by 'r' strategists combined with a poleward shift of freshwater fish communities in response to ongoing global changes.

RS2_O31_Colonization of benthic invertebrates in karstic spring area: a case study

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Impact of climate change on freshwater ecosystems is one of the main scopes in current limnology. Such studies are focused on the recovery of affected areas where the dynamic of recolonization by benthic community has a key role. Nevertheless, knowledge about this process is still scarce. With the aim to get a basic insight into the recolonization process, a comprehensive study in freshwater habitat with stable environmental conditions without anthropogenic disturbance was conducted in Jankovac spring area in Papuk Nature Park. Preliminary study was done in June 2013, and later repeated in June 2018, when the methodology was greatly improved, as: i) it was conducted for longer period (every 12 hours for six days); ii) diverse artificial substrates were used (differing in colour, structure and stability) by replicate procedure; iii) physical and chemical parameters of water were studied in detail, and iv) the canopy coverage of the habitat was analysed. Composition of benthic invertebrate community was similar in both studies with the most numerous organisms of 1 – 2 mm body size, such as insect larvae of Ephemeroptera and Diptera (Chironomidae and Simuliidae). The higher abundance of benthic invertebrates occurred in uncovered, light area of the habitat, regardless to the substrate type. Unfixed substrates were more actively colonized than the fixed ones. Current velocity was proven to be the key parameter influencing colonization dynamics. Many results of this study help in better understanding of the benthic invertebrate colonization, which will serve as a basis for future more specific studies.

RS3 Conservation

RS3_O1_Feeding and habitat preferences in streams of the endemic New Zealand freshwater mussel (kākahi – *Echyrydella* sp.) and insights into translocation

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Freshwater mussels or kākahi (*Echyrydella* sp.) are highly-valued species by Māori indigenous peoples of Aotearoa New Zealand. Kākahi are ecologically important as filter feeders, ecosystem engineers and are recognised by Maōri as an important food resource. Functionally, this species removes algae and particulate matter including potentially harmful bacteria while also creating habitats for other species. For example, they assist with sediment transport through bioturbation and their living and spent shells serve as habitat for other invertebrates. The three New Zealand species are now classified as “in decline” and there are concerns for their persistence. Significant gaps exist in our understanding of their feeding behaviours and preferences which could be essential to informing translocation of individuals and restoration of their habitats. We present preliminary research that examines *E. menziesi* in streams and river ecosystems in the Canterbury and West coast regions of the New Zealand South Island. First, field surveys were conducted in streams ranging from highly-modified agricultural drains to forested systems based on historic knowledge of their distributions. Laboratory feeding trials were also conducted to assess feeding rates across differing size classes and turbidity. Findings show strong relationships between size classes and filtering effeciency. Finally, we conclude with suggestions to inform future translocations and restoration of their stream habitats.

RS3_O2_Combining species distribution model and conservation planning software to assess the suitability of an existing protected river network

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Freshwater ecosystems are amongst the most vulnerable to global change. Protection measures are thus needed to limit their degradation and biodiversity erosion. Surprisingly, while designing protected areas is a key strategy for terrestrial and marine biodiversity conservation, it has received much less attention for running waters. This gap is likely due to the difficulty in accounting for the connectivity and the directionality of such dendritic networks when implementing protection measures. Here, we present a case-study in southeastern France where a protected river network was established by regional fish-experts in 2010. Brown trout (*Salmo trutta*) is the main targeted species with about one-third of the hydrographic network defined as potential spawning or/and living habitats for this cold-water species. First, based on observations at 680 sites, we used a species distribution model (SDM) to estimate its current range in the study area and to forecast potential shifts under future climate change. Second, we used conservation prioritization methods (ZONATION software) to assess the overlap between the identified priority areas and the existing protected network. We highlighted a major risk of contraction in brown trout range in response to climate change. We also pointed out priority areas for the species conservation under present and future climate conditions. While a significant proportion of these areas encompassed the existing protected network, some gaps remained to protect effectively the species. This study illustrates the relevance of combining expert-based and computational approaches in conservation planning to achieve a consensus between fine-grain knowledge and regional-scale management.

RS3_O3_A flexible spatial approach to integrate floodplain and upstream catchment connectivity in spatial planning

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Systematic conservation planning has contributed to the spatial design of reserve networks in river ecosystems by recognizing the importance of maintaining longitudinal connectivity. In the dynamic landscapes of river-floodplain systems, however, it is still challenging to account for the spatio-temporal connectivity among all waterbodies that compose the riverine landscape. In this study we present a new framework to account for both within-floodplain (lateral) and longitudinal river connectivity in freshwater systematic conservation planning. We run four prioritization scenarios comparing different rules of connectivity for the rivers and floodplains of the entire Amazon River basin. The scenarios involved the comparison of local protection only versus integrated upstream protection for floodplains. The spatial framework combined two types of planning units, with connectivity between them assessed using two distance-based measures for within-floodplain and upstream-downstream connectivity. The scenario including only within-floodplain connectivity failed to detect the propagation of impacts from the surroundings and upstream catchment. In contrast, the scenario that integrated within-floodplain and longitudinal river connectivity agglomerated subcatchments around the priority wetlands, generating catchment-integrated units that efficiently reduced impacts. We also demonstrate that the integrated connectivity can be manipulated to meet different conservation objectives. This new approach offers more ecologically meaningful protection to floodplains because it considers local wetland boundaries and connectivity within wetland complexes together with connectivity with the upstream landscape. This framework can be applied to integrated wetland conservation and management throughout the world and provide a valuable tool to safeguard the ecosystem functioning of complex river- floodplain mosaics.

RS3_O4_Conservation status of *Chirocephalus marchesonii* Ruffo & Vesentini, 1957 in the Pilato Lake (Sibillini Mountains National Park, Central Italy)

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Chirocephalus marchesonii is a fairy shrimp endemic to the Pilato Lake, a small temporary high elevation lake (1948 m a.s.l.) located in the Central Apennine (Italy). The species has a particular conservational interest, since it has limited thermal tolerance, reduced dispersal capacity and is represented by a single population with very restricted range. The anthropic pressure linked to summer tourism and the habitat's vulnerability to global climate change represents the main threats to the species. Particular concern has been aroused by episode of total drying up of the lake occurred in the summer season of 2017, after the earthquakes of 2016. Therefore, the main aims of the present study were: i) to evaluate the conservation status of *C. marchesonii* and its habitat; ii) to provide useful information to underpin proper conservation strategies. The *C. marchesonii* population was monitored monthly from July to November 2018, using 80 μm mesh net within transects of known length. In each sampling occasion, 13 physico-chemical parameters were measured, and fluctuations of water level and surface area of the Pilato Lake were recorded. Compared to the past, our analysis revealed no substantial differences in the physical-chemical characteristics of the water. The mean population density estimated for *C. marchesonii* (0.06 ind L-1) showed that, despite the climatic anomalies, the species has completed its biological cycle. Our results suggest that the occurrence of drought periods seems to be mainly attributable to decreasing precipitation rather than changes in soil permeability resulting from the earthquakes.

RS3_O5_Successful reintroduction of macroinvertebrates in a restored lowland stream

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Positive effects of stream restoration on macroinvertebrate communities can be limited as a result of isolation from source populations of the targeted organisms. This was demonstrated by carrying out an experimental reintroduction of the functionally important caddisfly *Lepidostoma basale* in a restored lowland stream in the Netherlands. In spring 2014 2400 last instar larvae were released at a single site within a stream with suitable habitat requirements, but which had become increasingly isolated from potential source populations. Population development was monitored for four years by surveying dead woody debris, the substrate preferred by the species, along the entire length of the stream. The species established in the stream and reproduced successfully the following years. In 2018, 879 larvae and pupae were found up to 2.51 km downstream and 0.34 km upstream of the initial release site, with most observations concentrated in the downstream stream section. Our study showed that reintroduction of stream macroinvertebrates with a complex life cycle is possible, and that in this case isolation from source populations and not the post-restoration environmental conditions were limiting the establishment of the species. These findings imply that reintroduction can be considered as a management option when there are indications of a depleted regional species pool.

RS4 Ecological modelling

RS4_O1_Use the past to predict the future – on the use of historical data to validate species distribution models

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Species distribution models (SDMs) are valuable tools to identify species potential ranges and shifts in the extent of suitable habitats for species. SDM outputs, especially future predictions and their interpretation can greatly influence the success of conservation efforts, making reliable and correct outputs of SDMs of major importance. Typically, model validation is done by cross-validation, where species data are split into a model calibration and validation subset. However, this type of model validation is prone for uncertainties, as it only uses one snapshot of the species-habitat relationship and ignores i.e. temporal variability or human impacts. In this study we used independent historical species data to estimate uncertainties in SDM predictions. First, we created SDMs for native fish species in the Upper Danube catchment with current occurrence and environmental data as input data. We then used these models to predict historical habitat suitability patterns in the beginning of the 20th century. Assuming niche conservatism and that habitat species requirements do not change over relatively short time periods, we compare the mismatch between predicted habitat suitability and observed historical occurrence points. This discrepancy transformed into an uncertainty index that was combined with future prediction of the species in 2080. Although often hard to obtain, historical data can provide a promising way to complement SDM validation and increase reliability of future predictions. This information is needed for SDM predictions to make them a valuable tool for conservation planning and management.

RS4_O2_Water quality and macrophytes in the Danube River: ANN modeling

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The aim of this study was to develop predictive models for the water quality in the Danube river and its tributaries using macrophytes. Macrophyte binary matrix (123 samples, 64 species) and environmental data (nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, dissolved oxygen and orthophosphates), were extracted from the Joint Danube Survey 3 database. Due to lack of the unique water quality classification system in the Danube Basin, water quality classes were compiled considering the national water quality standards and boundaries of all Danube countries. Modelling was carried out using Python programming language and Keras library. Five different feed-forward ANN models (one for each water quality variable) with backpropagation algorithms were constructed. ANN models consisted of four layers: an input layer including of 64 neurons (macrophyte species), two hidden layers (12-8 neurons) and one output layer consisting of seven neurons (water quality classes). ANN models were performed on standardized data using Adam Optimizer, ReLu activation function and the Binary Cross-Entropy Function. The Leave-one – out cross validation approach was used to estimate model performances, where the most excited neuron in the output layer, corresponding to the particular water quality class, was considered as the output result. The results demonstrated usability of the raw macrophyte data in predicting river nutrient status. The high prediction rate was obtained for all environmental variables (dissolved oxygen -84%, nitrate nitrogen -76%, nitrite nitrogen -97%, orthophosphates -67%, ammonia nitrogen -85%). ANN models, compared to the measured environmental values, predicted lower quality classes for tributaries vegetation samples.

RS4_O3_Three-dimensional modelling and satellite remote sensing for assessing the water quality of a Mediterranean Reservoir

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Mediterranean reservoirs are strategic water resources, particularly for drinking water supply. Hydrodynamics is one of the main drivers of their water quality. For management and planning purposes, an accurate understanding of their hydrological and thermal regime is required in particular for waters affected by harmful algal blooms. When in situ data are scarce and missing data interrupts the time-series, this limitation can be overcome by three-dimensional modelling coupled to satellite remote sensing images covering the whole surface domain. The objective of this work is to reproduce and understand the impact of hydrodynamics on cyanobacteria dynamics at Karaoun Reservoir, Lebanon through a 3D hydrodynamic model, Delft3D, in combination with satellite remote sensing images. Simulations of the water level and of water temperature during 2017 spring to autumn period were performed. The model results were compared with thermistor measurements recorded in 2017, and showed minor discrepancies. Water surface temperature was retrieved from Landsat 8 and corrected for atmospheric interferences. Remote sensing estimations of surface water temperature were compared to in situ observations and model simulations with overall good agreement. The model reproduced well water temperature, stratification, mixing processes and water level fluctuations. Simulations of cyanobacteria biomass in 2017 were also compared to field measurements and were found to be well represented. This study demonstrated the importance of satellite remote sensing as an additional source of data for integration into 3D modelling. Results will further help understand the driving factors of ecosystem dynamics at Karaoun Reservoir.

RS4_O4_Quantifying projected effects of global change on riverine phytoplankton species richness

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Global change accelerates biodiversity loss, especially in the vulnerable freshwater ecosystems due to multiple stressors. The trade-offs between the biodiversity conservation and the ecosystem services demands are a key challenge. It is valuable to understand how multiple stressors translate into losses of diversity and to evaluate the potential risks of future land-use change. In this study, a mixed-model approach was applied. First, random forest model was developed for ranking the stressors' importance, and then general linear mixed model for quantifying and projecting the potential response of phytoplankton biodiversity under the main stressors' interactive impacts. We focused on the responses of the species richness. Multi-metrics environmental filters included water flow regime, watershed land-cover pattern, spatial factors and local physicochemical conditions. The results illustrated that land-use factors, precisely the share of forest and pasture area, have outstanding explanation to the variation of riverine phytoplankton species richness. Besides, the short-term alteration of hydrological indices are also good indicators of the phytoplankton patterns. Water temperature showed a negative correlation with species richness, indicating that the phytoplankton diversity may decrease with increasing temperature. Our findings highlight that forest land cover area in the catchment has a significant positive relationship to phytoplankton diversity, whereas the share of pasture land-use area is negatively correlated to the diversity. This emphasizes the significance of protection and preservation of forest areas in maintaining both the aquatic algal biodiversity and global ecosystem functioning in the future.

RS4_O5_The conceptual and empirical nature of freshwater macrosystem research

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Definitions of an aquatic macrosystem vary substantially among ecosystem types and the research foci of investigators studying them. As such, the physical boundaries are as arbitrary as those for populations, communities, and ecosystems. We suggest that a single lake or river constitutes an "ecosystem", whereas a "macrosystem" consist of multiple ecosystems interacting via natural and anthropogenic, teleconnections of either a biotic or abiotic nature. Macrosystem ecology overlaps with the term macroecology, with both covering relatively large geographic areas. In our presentation, up to eight lotic ecosystem concepts are analyzed for potential contributions to riverine macrosystem ecology, although none are intrinsically macrosystem theories. Four of these (in order of publication) are especially amenable to this analytical approach: the River Continuum Concept, the Process Domain Concept, the Network Dynamics Hypothesis, and the Riverine Ecosystem Synthesis. General strengths and weaknesses of many of these eight concepts are briefly discussed. Analyses of aquatic systems which include both lotic and lentic features are discussed. We recommend that future macrosystem projects: (a) better integrate aquatic, terrestrial, geological, and atmospheric studies; (b) expand temporal components from modern conditions to include decanal, centurial, and even millennial changes where possible; (c) contrast alternative sampling reference frames where possible; (d) include the human dimension as appropriate; and (e) emphasize more multi-disciplinary research approaches. Recommendations for ideal lotic macrosystem projects are presented.

RS4_O6_Effects of landscape permeability on dispersal and colonization of a aquatic insect – a modeling approach

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Recent developments such as meta-population theory have highlighted the relevance of dispersal as an ecological process determining population persistence. Meta-population models can be used to study the influence of varying environmental conditions on dispersal. Recent studies mainly focused on terrestrial or aquatic species, whereas models for hemimetabolous aquatic species that rely on aquatic stream sites for larval development and primarily disperse in the terrestrial system are lacking. We developed a process based, spatially explicit meta-population model for a (generic) hemimetabolous aquatic insect. The model was used to analyze the influence of landscape permeability, resulting from varying shares and configurations of four landscape types incurring increasing dispersal costs, on patch colonization for differently structured habitat networks. We simulated population dynamics and dispersal processes within a broad range of 675,000 networks. The networks were set up by varying (1) landscapes scenarios, representing different levels of permeability, (2) stream network segments and (3) relative amounts and arrangements of habitat patches using least-cost path analysis. We found that habitat networks structured by a comparatively high amount of habitat patches evenly distributed along the stream segments were last sensitive to decreasing landscape permeability. The simulations further indicated that the geometry of stream segments influenced dispersal and, in turn, colonization. We discuss the relevance of our findings for future freshwater management options.

RS4_O7_Disentangling the influence of climate and hydrological predictor variables on benthic macroinvertebrate distribution

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Predictive models such as species distribution models (SDMs) are increasingly used to complement empirical analysis. It is well established that aspects of flow regime i.e. the duration, timing, frequency, magnitude and rate of change of flow events are highly important in the distribution of river communities. However, many predictions to date still lack the stream-specific environmental variables vital for accurate predictions, despite the increasing availability of open access datasets describing river hydrology. These datasets are a vital step in improving predictive modelling approaches for river ecosystems, especially in regard to their ability in informing catchment management decisions. We applied and tested three openly sourced climate and hydrological datasets in SDMs on benthic macroinvertebrates. The datasets describe either climate and hydrology separately, or include properties of both, which when applied in SDMs can result in 1) the common problem of highly co-correlating variables, and 2) multi-modal information (i.e. climate & hydrology) encoded within the same data. Both instances make the predicted distributions and most influencing factors on individual species difficult to interpret. We assess different combinations across and among datasets to estimate macroinvertebrate distribution in Germany. We show the importance of including hydrological variables in terms of predictive power and resulting changes in predicted distribution. Here we are able to disentangle the influencing variables' importance and can make accurate interpretations on which influence macroinvertebrate distributions.

RS4_O8_Mechanistic versus empirical models: experience with macroinvertebrates in streams

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The most fundamental decision for the development of ecological models concerns the modelling approach. Mechanistic models (e.g. differential equation models) are driven by the knowledge about the mechanisms and describe important processes explicitly. In contrary, empirical models (such as statistical, regression type models) are data driven and can be used to infer potential causal relationships from calibration. While these approaches might appear as opposing paradigms, reality is not black and white. Mechanistic models include empirical aspects, e.g. functional relationships between process rates and external influence factors, and model parameters can be inferred from empirical data. On the other hand, empirical models can largely profit from mechanistic understanding about the system to choose an appropriate model structure and a reasonable set of input variables. Both modelling approaches can use Bayesian inference to integrate prior knowledge as well as information in observational data of the model output variables. Important criteria that affect the decision for one or the other approach are related to the aim of the study, availability of important resources, such as data, knowledge about the system, availability of efficient algorithms and software implementations, computational resources, and familiarity of the researcher with the different approaches. Bridging the gap between empirical and mechanistic modelers will contribute to improving our mechanistic understanding and the predictive capacity of our models. In this presentation, I will share my experience with both types of models to predict the probability of occurrence of macroinvertebrates in streams and discuss challenges and limitations that come with them.

RS4_O9_Effects of site selection and taxonomic resolution on the inference of stream invertebrate responses to environmental conditions

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Biomonitoring of stream invertebrates is often used to infer anthropogenic impacts. However, our ability to quantify responses of invertebrates to anthropogenic stressors depends on key aspects in the design of a biomonitoring program, namely the taxonomic resolution, sampling locations, and time and frequency of sampling. Using data from Swiss federal and cantonal biomonitoring programs, we prepared four datasets that differ in taxonomic resolution, geographic distribution of sites, and sample size. We applied a multi-species distribution model to analyse how differences among the datasets affect our ability to quantify the effect and relative importance of selected natural and anthropogenic environmental conditions, and to predict the distributions of taxa. Stream temperature was the most important explanatory variable in each dataset, followed by catchment-wide agricultural insecticides and urban land use over riparian agriculture and forest cover. The relative importance of the explanatory variables was lowest for the dataset with a grid-based site selection approach and family-level resolution. An increase in explanatory power could be achieved by either increasing the taxonomic resolution or by combining different biomonitoring programs at the family level to increase the environmental coverage. Identifying EPT taxa at genus and species level increased the explanatory power of the selected variables, with widespread families revealing more diverse and significant responses at genus or species level. We show that multi-species distribution modelling of stream invertebrates can contribute to the selection of specific taxa for identification at higher taxonomic resolutions, potentially facilitating the standardization and combination of multiple biomonitoring datasets at mixed taxonomic resolutions.

RS4_O10_190_Modelling robustness of habitat networks against stress

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Habitat loss and fragmentation due to climate and land use change are main drivers of global biodiversity loss as the survival of meta populations relies on suitable habitats and the ability of individuals to disperse between habitat patches. To effectively prioritize habitat management efforts, simple methods for evaluating the robustness of habitat networks against fragmentation are important. Graph theory provides powerful tools to represent the interaction between landscape characteristics and species traits that can be represented as graph-based habitat networks. We modelled different stress events resulting in varying degrees of loss of habitat patches taking into account a variety of habitat network types. Characteristics of different species were included by simulating random extinction of populations in habitat patches with varying extinction probabilities and subsequent recolonization of those patches due to dispersal with varying dispersal abilities from neighbouring patches. The fraction of colonized habitat patches over different degrees of stress was used to evaluate the network's and species' robustness against stress. Furthermore, the initial habitat networks were analysed using conventional graph theoretic metrics. These results were then compared to the fraction of colonized habitat patches. Finally, we identified metrics that can be used to estimate the robustness of a network without having specific knowledge of the exact stress event.

RS4_O11_Modelling the synergy of multiple stress effects

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Various environmental stressors contribute to the global biodiversity crisis. Examples include the loss of bees and the reduction of aquatic biodiversity. The talk addresses the question to which extend synergistic interactions of various stressors aggravate the ecological effects. For example, the current approach of pesticide risk assessment fails to protect biodiversity when multiple stressors concurrently affect organisms. To quantify such multiple stress effects, we developed the "Stress Addition Model" (SAM). With this I identified that the joint effect of environmental stressors exceeds the effects predicted by effect addition as null-model by several orders of magnitude. Accordingly, with the SAM approach, we provide a tool that quantitatively predicts the highly synergistic direct effects of independent stressor combinations. The talk explores possibilities and also limits of this approach, providing ideas for future developments.

RS4_O12_Do urban multi-stressors and their effects on stream biota shift during droughts?

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In 2015 during a 30-year drought, U.S. Geological Survey sampled 87 streams across an urban disturbance gradient in the Pacific Northwest region (PNR) of the U.S. Objectives were to assess how aquatic assemblages respond to multiple stressors and how drought conditions modulate them. Ecological condition was assessed in relation to streamflow, habitat, nutrients, and contaminants. Streams were sampled for algae, macroinvertebrates, and fish in the summer under base-flow conditions. Response models developed using Boosted Regression Trees indicate that flow alteration accounted for less of the variability in ecological condition than might be expected in urban systems, likely due to drought conditions. Contaminants were among the most important explanatory variables in the invertebrate and algal models; this was surprising considering there were few if any storm generated run-off events during our sampling. Temperature and water depth were common variables in the fish models. Explanatory variables in the three biotic assemblage models under drought conditions in the PNR appeared to have shifted from what might be expected and also differ from many other urban studies.

RS4_O13_Modelling the food web structure of a large shallow lake

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In this study, we constructed food-web models of a large shallow lake from Estonia (Northeastern Europe). We employed Ecopath with Ecosim modelling suite (EwE), which was calibrated using a 34-year long database. Food web structure consisted of 23 functional groups: three macrophyte types (emergent, floating, submerged), two phytoplankton groups (large, small), two zooplankton groups (protozooplankton & metazooplankton), benthic macroinvertebrates, eight planktivorous and benthivorous fish, two piscivorous fish (pike & pikeperch), and detritus. Piscivorous fish were further divided into three stanzas (young-of-the-year, juvenile, adult). We also included biomass, production, metabolic rates, diet composition, and fishing fleets of the food web components. Results show that large phytoplankton (cyanobacteria) is not efficiently grazed by zooplankton, their biomass being mostly transferred to detritus. Consequently, most of the food web carbon is processed through the detrital loop, which sustains the upper trophic levels of the lake.

RS4_O14_Automated calibration strategies in ecological modeling using high-frequency in situ data

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Lake ecosystems are subject to various stressors (e.g. climate change, pollution, eutrophication) that threaten their ecological functioning, often leading to harmful algal blooms. Coupled hydrodynamic-ecological models are valuable tools to reach a deeper understanding of the key factors triggering events such as cyanobacterial blooms. However, their calibration and validation is often a challenging task. In situ data available for calibration are usually sparse in space and time and the high number of variables and interactions in the biogeochemical cycle is often reflected in models with a high number of parameters to be estimated. High-frequency in situ data can help overcome these issues as they make it possible to perform the calibration on a shorter period for which the simulation time is not too long. Thus, we can use calibration methods that require performing an important number of model simulations for different parameter sets. Among these techniques, likelihood-free methods based on Bayesian inference are increasingly used in the fields of ecology and biology. Approximate Bayesian Computation (ABC) is a class of computational methods that can be applied to estimate most probable parameters without the need to evaluate the likelihood function . In our study, we apply and compare different calibration strategies based on ABC methods to calibrate and validate a 3D ecological model (Delft3D/BLOOM, Deltares). The case-study is a small urban lake (Greater Paris, France) which is affected by repeated cyanobacterial blooms and for which high-frequency in situ data are available.

RS4_O15_What catchment-lake relationships reveal about organic carbon budget: insights from Estonian lakes

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We calculated the allochthonous organic carbon (OC) mass balance for thirteen natural lakes using lake water budget, catchment features and water column chemistry variables as input in a process-based model. Parameter distribution and uncertainty of model outputs were assessed within a Bayesian framework. Results revealed that “active” lake-catchment systems received and emitted the largest amounts of allochthonous OC, whereas lakes depending mostly on atmospheric inputs exhibited much more modest OC fluxes. Simulated organic carbon retention varied accordingly from 12% in some drainage lakes to 99% in seepage lakes. Lake allochthonous OC loads and exports were strongly correlated with drainage ratio (catchment area/lake area, R^2: 0.89 and 0.92, respectively) and to forest ratio (catchment forested area/lake area, R^2: 0.86 and 0.89), but not to wetland ratio. The simplicity of the model makes it easily transposable to a large variety of lakes. For a better insight into carbon processing we suggest a more integrative approach accounting for interactions between lake hydrology and catchment land cover.

RS4_O16_Modelling accretion dynamics and C sequestration in coastal agrosystems under sediment deficit

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Pristine deltas are millenial-scale blue carbon sinks but in the last centuries their wetlands have been severely degraded by anthropogenic activities. In the Ebro delta (as in many others) the construction of dams during the last century severely reduced the sediment load carried by the river (circa 99%). This may have greatly reduced the rate of accretion of the deltaic plain both in wetlands and rice fields, and has negatively impacted carbon sequestration, among other services. Rice production in the Ebro Delta started in 1860's and presently extends over 70% of the total area, replacing wetlands and other pristine habitats. Data obtained from soil cores shows that rice field soils have not experienced accretion in the last 50 years, while accretion rates before dams could reach 5mm/yr. In order to model soil dynamics in rice fields we have adapted the Marsh Equilibrium Model (MEM) to this type of artificial wetland, looking at the effects of changes in sediment inputs, organic matter inputs and rate of decomposition dynamically over time. The model is a useful tool to predict the changes in accretion process and carbon sequestration in coastal agrosystems due to human activities interfering sediment and organic matter dynamics.

RS4_O17_Quantifying the contribution of cattle access to stream nutrient loading using real-time data and a modelling approach

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Restricting cattle access to streams in agricultural catchments is often included as a mitigation measure in agri-environmental schemes with the aim of reducing loading to downstream aquatic systems. Despite this, there are few studies to date that quantify nutrient loads from in-stream cattle access and place them in the context of loading from all sources within a catchment. In the Irish COSAINT Project (Cattle exclusion from watercourses: environmental and socio-economic implications), data from real-time monitoring was used to estimate changes in phosphorus (P) loading to the stream from cattle access. The study included deployment of auto-samplers upstream and downstream of an active cattle access site, together with motion-activated cameras (Bushnell Trophy HD 119676) to record cattle activity. A modelling scenario was then constructed using the Generalized Watershed Loadings Function (GWLF) model for a study catchment (2751 ha) which had access for 1350 cattle at 45 discrete access points. The scenario assumed that each field with access points had an average herd of 30 cattle, and that each animal urinated once and defecated once in-stream per day. The estimated average daily total P (TP) load from all cattle to the stream was estimated at 2.25 kg TP day-1, representing 16% of the catchment TP load. These data were in line with the measured changes in concentration from the real-time monitoring and indicated that cattle access can make a substantial contribution to downstream TP availability during the grazing season.

RS4_O18_Extreme events and community resilience in lakes: testing the concept with a phytoplankton model

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Emerging from concerns about climate change, there has been growing interest in the impacts of extreme events on ecosystems. In this study, we use a model (PROTECH) to examine the impact of a storm induced mixing event on a phytoplankton community in both a shallow and deep lake, and with low, medium and high nutrient loads. We recorded the impact caused by the mixing event and the subsequent recovery of the community, looking at overall biomass and alpha and beta diversity at both the species and functional levels. The results showed that, in general, mixing initially caused losses in biomass but sometimes in the lower/medium nutrient shallow lake biomass increased. Post-disturbance, the return time of biomass was most rapid, followed by functional alpha diversity, species alpha diversity, functional beta diversity and species beta diversity. Our results therefore demonstrate that different structural attributes of communities are not expect to respond in the same way to extreme events.

RS5 Ecotoxicology and stress responses

RS5_O1_Multiple stressors interacting on ecological processes in Dutch drainage ditches

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Drainage ditches are man-made water bodies, originally dug to reclaim wetland areas. They can be regarded as one of the most extensive aquatic habitats in the urban environment. For example, in the Netherlands alone their combined length is estimated at 300 000 km. As the land surrounding drainage ditches is used for various anthropogenic activities, they are impacted by multiple interacting stressors. Although legal instruments, like the European Water Framework Directive, encourage to protect both ecosystem structure and functioning in these waters, the emphasis of most water authorities is only on community metrics. The aim of the present study was therefore to assess the impact of three pollution sources, including waste water treatment plants (WWTPs), bulb fields, and metal industries, on the ecological processes in drainage ditches, compared to ditches with low pollution pressure. We measured nutrient concentrations and toxic pressure in the water column and sediment, alongside ecological processes, such as microbial and invertebrate decomposition rates, sediment oxygen demand, and oxygen dynamics in twenty Dutch drainage ditches. Our results showed that high nutrient input from bulb fields and even higher inputs from the WWTPs related to enhanced microbial and invertebrate decomposition rates compared to unimpacted ditches, despite the observed toxic pressure. We stress the importance of assessing all the joint effects of interacting stressors to identify how ecological processes are impacted in the urban environment.

RS5_O2_Multi-stressor's effects on contamination and toxicity in french streams using ecotoxicological indicators based on caged gammarids

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Many freshwater ecological studies focused on the effects of environmental stressors induced by anthropogenic activities such as land use or alteration of hydromorphology and physico-chemistry conditions. While it is recognized as a potential major driver of ecological alteration, ecotoxicological stress is yet rarely explicitly considered. By combining ecological monitoring and field ecotoxicological approaches, the purpose of this research is to focus on the origin and levels of bioavailable contamination as well as toxicity in freshwater ecosystems taking into account various stream typologies and unraveling the relative impacts of other stressors on these two variables. Datasets of active biomonitoring at the French national scale were established, with 333 sites being investigated from 2009 to 2018. Bioavailable contamination (metallic and persistent organic substances) in freshwater ecosystems was assessed by bioaccumulation measurement in caged gammarids. Stream toxicity was based on mortality and feeding activity of exposed organisms. For each site, integrated indicators of contamination and toxicity were computed with weighting chemical and biological measurements by national reference values. The link between environmental stressors and ecotoxicological indicators was modeled via Structural Equation Modeling. The model was adjusted according to the source of pollution and is reliable with the consideration of multi-scale and multi-stressor concepts. It enables to understand the role of driving forces (land use, hydromorphology, etc.) and their impact on the two outputs (contamination and toxicity). Its application improves the understanding of contamination and toxicity levels. It can also provide a prediction of risks of contamination and/or toxicity in aquatic environments.

RS5_O3_Can microbial functions mediate the impact of multiple stressors on regime shift in lake ecosystems?

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Aquatic ecosystems are submitted to multiple stressors such as chemical pollution and climate change. In lake ecosystems these stressors may induce abrupt regime shifts between macrophyte and phytoplankton dominance. The aim of our study is to investigate how a cocktail of pesticides, copper and nitrate mimicking agricultural runoff (ARO) and rising temperature, separately or together, influence the functioning of lentic ecosystems. More particularly, we test the possibility of a shift from a macrophyte-dominated clear water towards a phytoplankton-dominated state. We conducted two microcosm experiments using two temperatures and three concentrations of ARO. The aim was to test the effect of ARO either added once or as pulses in two different contexts: primary producers only (three macrophytes, six benthic and four planktonic microalgal species), and primary producers and consumers (invertebrate grazers and filter feeders). We measured enzymatic activity, potential functional diversity and respiration of water, sediment and biofilm microbial communities, phototroph community composition and litter decomposition. Our results show that in the absence of primary consumers, ARO enhanced a shift towards a phytoplankton-dominated state while temperature also affected phytoplankton dynamics. With primary consumers, no effect of ARO or temperature on phytoplankton was observed. This may be due to an indirect effect of ARO that reduced invertebrates grazing and therefore enhanced the competition between benthic and planktonic primary producers. Microbial functions were affected principally by temperature but also by ARO with sometime opposite results (for example for litter decomposition) with and without primary consumers.

RS5_O4_Biological responses of Prussian carp (*Carassius gibelio*, Bloch 1782) to the impact of industrial wastewaters in the Ilova River

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Ilova River is a part of "Lonjsko polje" Nature Park, but it is threatened by industrial wastewaters polluted by metals. The existing anthropogenic impact was estimated upstream (reference site) and downstream (polluted site) of the pollution source in autumn (2017) and spring (2018) using a dominant fish species, the Prussian carp, as a bioindicator. Metal exposure assessment involved metals measurement in fish intestinal homogenates (total metal levels) and cytosolic fractions (metabolically available metal levels), in order to estimate the proportion of potentially toxic metal fractions from the dietary uptake route. Additionally, biomarkers of metal exposure (metallothioneins, MT), oxidative stress (malondialdehyde, MDA) and antioxidant capacity (total glutathione, GSH; catalase activity, CAT) were used to assess pollution impact. Disturbed environmental conditions at polluted sites were confirmed in both seasons by significantly higher levels of most measured metals in water, of Cd and Cu in homogenates of fish, and of Ca, Cd, Cu and Fe in cell cytosols. Less than 50% of the total Cu and Fe concentrations were present in cytosols, while those of Cd, Co, Mo, and Zn were over 55% in cytosols, where metals can bind to sensitive biomolecules, therefore causing toxic effects. Significantly higher MDA concentrations in both seasons and CAT activity in spring in fish from the polluted site pointed to oxidative stress. Higher MT concentrations were evident at the same site, while GSH did not show clear trend. These results indicated potential risks for the protected area of nature park and emphasized the need of continuous monitoring.

RS5_O5_Investigating the behavioural and physiological response of endangered freshwater pearl mussels to stress exposure

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Our understanding of the environmental characteristics associated with successful *M. margaritifera* proliferation in the wild is poor. Additionally, evidence to suggest how *M. margaritifera* respond to variation in the associated parameters, is limited. The purpose of this study was to address this knowledge gap via the establishment of a non-invasive method for quantifying acute mussel stress. Experimental analysis compared the behavioural and physiological responses of *M. margaritifera* to a similar freshwater mussel, *Anadonta anatina*, across two different environmental stressors – aerial exposure and high concentrations of suspended fine particulate inorganic matter. Direct observation of behaviour using high resolution camera technology assisted researchers in establishing the presence and frequency of three sublethal endpoints: Transition Frequency, Avoidance Behaviour and Foot Extension. Variation in physiological response was recorded via analysis of oxygen consumption rates using intermittent respirometry. Exploration of the results at the individual level revealed variation in the reaction norms across individuals and species, with mussels appearing to display different sensitivities to the stress exposures; accentuated by the perceived alterations in behavioural and physiological traits. Attempts to discern the commonality between behavioural and physiological response highlighted the relationship between valve movement and metabolic rate. Conclusions drawn from this study, suggest further exploration of remote sensing technologies to monitor valve movement in *M. margaritifera* in their natural habitat, which – when coupled with continuous monitoring of environmental parameters – would enable researchers to explore factors influencing the condition of *M. margaritifera* populations across freshwater systems; providing, urgently required empirical data to drive future conservation strategies.

RS5_O6_Locomotor and cardiac responses of crayfish exposed to simulated predation risk at environmental concentration of methamphetaminental concentration of methamphetamine

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Evidence of the ecological and biological impacts of psycho-active compounds (PhAC) in surface waters on aquatic organisms is increasing. Methamphetamine (MEA) is an illicit drug with stimulating effects on central nervous system. MEA from human excretion is analytically detectable in surface waters. To investigate long-term effects of MEA at environmentally relevant levels we evaluated heart rate (HR) and locomotion of signal crayfish *Pacifastacus leniusculus* during a 21-day exposure to 1 µg MEA L-1, followed by 14 days long depuration phase. Locomotion and HR were recorded in crayfish exposed to the natural stressor (physiological fluids of an injured conspecific). Data were collected during the period of 30 min before and 30 min after the stress stimulus application and analyzed. This treatment was repeated four times during MEA exposure and four times during depuration phase. A significant increase of HR following stress was found in both MEA-exposed and control crayfish. Significant group-specific HR changes were also detected between drug-treated and control crayfish. Locomotor activity during MEA treatment and depuration phase showed significant differences between MEA exposed group and control, in general reflected by weaker locomotion of MEA exposed group. According to obtained results, it could be assumed that crayfish population can suffer from higher predation risk if continuously exposed to environmental levels of MEA. However, the question of real predation pressure on exposed animals by exposed predators is worth solving in the future.

RS5_O7_Linking exposure of pesticides to ecological effects in small streams

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Amongst several environmental stressors, pesticides are omnipresent in the environment and contribute to the global ecological crisis. In the aquatic environment, agricultural pesticides are frequently detected at concentrations exceeding regulatory thresholds for surface waters. However, even at concentrations below the regulatory acceptable concentration, contamination results in community alterations, impaired ecosystem functions and reduced biodiversity. In 2018 we monitored 70 sites all over Germany monitoring various environmental parameters including 98 pesticides that were sampled with rain-event triggered approaches, morphological structure and continuous oxygen concentration. Community structure could be related especially to pesticide toxicity. We revealed that in 82% of the investigated sites regulatory acceptable concentrations were exceeded. Only 18% of streams with agricultural catchment showed good or better WFD related quality class. The quality goals for streams, identified by the EU were by far not met. We also identified that that ecological relevant concentrations of pesticides were a factor of 10 lower than expected by the first tier governmental risk assessment; that sensitive species could be identified with the indicator system SPEAR; and that biodiversity and biomass of invertebrates was impacted most strongly by pesticides.

RS5_O8_Pesticide pollution increases the risk of infection with schistosomiasis

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Agricultural pesticides regularly enter surface waters and considerably shape the macroinvertebrate community composition. We identified that this pesticide-induced community alteration favors freshwater snails that transmit schistosomiasis, thus increasing the risk of infection. Schistosomiasis, also known as bilharzia, is a severe public health issue in Africa and particularly in the study region of western Kenya, but has recently also returned to Southern Europe. We showed that the host snails of schistosomes are particularly tolerant to insecticides and can be found mainly in habitats with pesticide pollution where less tolerant potential competitors have decreased. Among 29 environmental variables investigated, pesticide pollution best explained the abundance of host snails, followed by the dominance of competitor species. Other important environmental variables were associated with the available amount of food. Remarkably, the effects of pesticides were observed at concentrations several orders of magnitude below the acute LC50 of most macroinvertebrates such as the sensitive reference test organism *Daphnia magna*. Though several studies have shown that such concentrations affect the macroinvertebrate community composition, they are considered safe according to the European regulatory framework. We conclude that even low concentrations of agricultural pesticides in surface waters can cause environmental effects that result in an acute threat to human health. The results suggest that the environmental risk assessment of pesticides needs to be reconsidered.

RS5_O9_Impact of two herbicides on "classical descriptors" and fatty acid profiles of the freshwater diatom *Nitzschia palea*

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Fatty acids are essential elements for the structure of biological membranes and for the storage of metabolic energy. The impact of pesticides on fatty acid profiles of marine diatoms were already proved but scarce studies revealed their effects on freshwater diatoms. The aims of this study were to: 1) evaluate the fatty acid profiles of a freshwater diatom with and without pesticide treatment; 2) investigate the impact of herbicides on photosynthesis, growth rate, pigment concentrations and expression levels of target genes. The freshwater diatom *Nitzschia palea* (NPAL) was exposed during seven days to diuron and S-metolachlor at 10µg.L-1. Without contamination NPAL had a growth rate of 0.16div.day-1, an effective quantum yield of 0.52 and chlorophyll a and carotenoid concentrations of 5.6 and 2.4mg.L-1 respectively. In a global way highly unsaturated fatty acids (HUFA) were the most represented fatty acids class without pesticide treatments. Under diuron contamination, the photosynthesis and pigments concentrations were reduced while an induction of the gene expression was noted for cat, d1 and nd5. Regarding the fatty acid profiles, diuron increased the percentage of saturated fatty acid (SFA) and decreased the percentage of HUFA. Conversely, under S-metolachlor treatment no effect was observed for photosynthesis, growth rate, pigment concentrations nor fatty acid profiles while a repression of the gene expression of cox1 and nd5 and an induction of cat and psaA were found. Finally, these results demonstrated that NPAL's response to pesticide exposure was dependent of the contaminant used and of the endpoint considered.

RS5_O10_Linking benthic diatom community metrics to stream pesticide contamination

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Benthic diatoms are known to be suitable indicators of ecological quality and are one of the key biological quality elements investigated in the Water Framework Directive. Many studies have reported that benthic diatom community functions and structure can be impaired by pesticides. However, field pesticides monitoring often does not correspond to the ecological monitoring, making linkages between diatom communities and realistic exposure difficult in a spatio-temporal gradient. Moreover, the presence of pesticide mixtures in the environment is problematic. The aim of this study was to establish links between environmental benthic diatoms community structure and life-history traits to realistic environmental mixtures of pesticides based on parallel biological and chemical sampling at 56 agricultural streams across Germany. First, the co-structure of diatom communities based on microscopy and metabarcoding was assessed in the light of the analytical results of in situ pesticide contamination. To assess the toxic potential of in situ mixtures, single-species microalgal cultures were exposed in laboratory to water extract from sampling sites. Finally, these multiple-lines of evidence results were associated to hazard quotients of environmental mixtures to highlight trends between diatoms biological metrics and pesticides in general and per mode of action.

RS5_O11_Standartox – a tool for assessing the risk of chemicals

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A large number of chemicals such as pharmaceuticals, pesticides and synthetic hormones are in daily use all over the world and enter the environment deliberately or as byproducts of their use. Assessing the risks from chemicals is pivotal to fully capture the pressures on freshwater ecosystems. This is typically done by relating field concentrations to concentrations from standard laboratory tests that cause high mortality or similar effects. However, such data is scattered over multiple databases and requires pre-processing to harmonize units, test results from multiple labs and test conditions. Current (Meta-) Databases such as the Pesticide Property Data Base (PPDB) that standardize toxicity data remain confined to certain classes of chemicals or lack a reproducible process workflow. We developed Standartox – a web application for assessing chemical risks in a standardized way for all chemicals for which results have been published. Standartox works as a Meta-Database that compiles toxicity data from the US EPA ECOTOX data base, physico-chemical and ecological databases, providing standardized toxicity data complemented by physico-chemical characteristics of the chemicals and ecological information of the test species. Hence, Standartox is the first Meta-database that simplifies a reproducible consideration of chemical risks when assessing freshwater ecosystem pressures. We present the application of Standartox for a case study in Romania where derived most-sensitive effect concentrations were used for assessing in-stream chemical risks.

RS5_O12_Into the freshwaters and back: transfer of emerging contaminants through the aquatic-terrestrial habitat linkage

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Understanding of bioaccumulation and biomagnification of emerging contaminants (ECs) such as pharmaceuticals (PhACs), endocrine disrupting compounds (EDCs) and antibiotics in aquatic food webs are incomplete. Furthermore, up to date there are only few studies on transfer of ECs to terrestrial ecosystems through the vital aquatic-terrestrial habitat linkage. Accordingly, the aim of the current study was to provide novel insights into bioaccumulation of ECs in freshwaters, as well as aquatic-terrestrial food web coupling. These were approached by combining field based research (in situ) and the laboratory (mesocosm) experiment using aquatic macrophytes, different life stages of aquatic insects and riparian spiders. The mesocosm experiment conducted with the mixture of 4 PhACs and 2 EDCs provided a direct evidence of bioaccumulated ECs transfer from aquatic to terrestrial ecosystems through emerging adult insects. This was further supported by the results of *in situ* collections, where emerging insects (adult Trichoptera and Odonata) and riparian spiders had 5 different PhACs, 2 antibiotics and 11 EDCs bioaccumulated in their tissues. The results of both, in situ collections and mesocosm experiments, provided first insight into variability of patterns of ECs bioaccumulation in respect to compounds, taxa and life stages, highlighting the need of more taxon- and trait-specific evaluation of bioaccumulation and biomagnification scenarios.

RS5_O13_Tackling chemical and n-chemical stress in running water ecosystems: Lessons learned from a longitudinal approach

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Multiple stressors are the common reason for failing ecological water quality standards of aquatic ecosystems. Nevertheless, the detection of stressor effects on ecosystems and the identification of relevant stressors in complex environmental settings remains a major challenge for efficient water management. Present indicator systems often fail in this respect. In order to identify relevant stressors and their effects on both ecosystem structures and function, we performed a longitudinal study along a central European stream, which faces multiple pressures along the downstream passage. The parameters to assess the status were established methods of the EU – Water Framework Directive as well of state-of-the-art methods for eco-toxicological and ecosystem assessment based on bacteria, algae, macroinvertebrates and fishes as well as on functional parameters. As an example, effluents of a local waste water treatment plant resulted in immediate responses of production-related metrics (macroinvertebrate quantity, bacteria production and enzyme activity) in close proximity to the efflux, which were probably related to increased local resource availability. In contrast, the composition of macroinvertebrate communities showed a longer-lasting response to sewer efflux with decreasing proportions of species being sensitive towards pesticides (SPEAR pesticides), which strongly correlates with toxic units of micropollutans. Overall, our longitudinal approach showed that state-of-the-art tools from ecotoxicology and ecosystem analyses reveal a differential picture of stressor effects, which have not been detected by established indicators.

RS5_O14_Contaminated leaf litter reduces shredder growth but increases decomposition

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Plant litter decomposition is a fundamental ecosystem process in streams providing nutrients and energy to aquatic food webs. A higher diversity of litter, particularly of leaves, can increase the decomposition rate. Conversely, ecosystem processes can be decreased by anthropogenic stressors, such as pesticides. Systemic pesticides such as neonicotinoids are easily taken up and distributed within the whole plant and may ultimately affect decomposition of dead plant parts. Neonicotinoid contaminated leaves can decrease decomposition through inhibition of shredders' feeding. Nevertheless, it is unknown whether the addition of different and uncontaminated leaf species can potentially mitigate those negative effects on decomposition. We examined the response of decomposition, shredder feeding activity and growth to treatments of litter diversity and contamination to identify their potential interaction. We deployed cages containing shredder assemblages together with individual leaf species or their mixtures (alder, hazel and beech) in the Landau Stream Mesocosm Facility. Leaf decomposition was highest for alder and lowest for beech. The decomposition rate of mixtures was largely non-additive. By contrast, growth and feeding rate exhibited an additive effect in leaf mixtures suggesting a homogenizing effect of leaf mixtures. Contamination, in contrast, increased leaf decomposition but decreased shredders' growth. We discuss possible explanations for our results and provide an overall evaluation of associated risks and potential amelioration through resource diversity.

RS5_O15_Agricultural run-off-induced regime shift in aquatic phototrophic communities changes with elevated temperature

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Agricultural land-use increases worldwide with negative impacts for aquatic ecosystems. Agricultural run-off (ARO) transports nutrients, trace metals and pesticides from the field into adjacent aquatic ecosystems, especially during rainfalls. Shallow ponds or slow flowing streams are especially vulnerable to these processes. Such systems are known for potential shifts between their dominant primary producers; they can be dominated either by submerged macrophytes, which stabilize clear-water conditions, or be in a turbid, phytoplankton-dominated state. The role of periphyton is less well understood in those systems. We are interested in how ARO in interaction with heat-waves affects the competition between dominant primary producers (macrophytes, periphyton, phytoplankton). We hypothesize that 1) ARO induces a regime shift from a clear-water state to a phytoplankton- or periphyton-dominated state in shallow aquatic ecosystems and 2) that elevated temperatures make aquatic ecosystems more vulnerable towards ARO-induced shifts. To test our hypothesis, ARO composed of a herbicide, insecticide, fungicide, copper and nitrate was applied to microcosms containing macrophytes, phytoplankton and periphyton in a dose-response design at 22°C and 26°C. The effects of the ARO and the elevated temperature differed between the different groups of primary producers. Only microphytes reacted to both stressors; macrophytes only responded to the elevated temperature. At elevated temperatures, the observed shift towards phytoplankton dominance occurred at higher ARO concentrations. This likely happened due to the higher turnover rate of the microphytic community in comparison to macrophytes. In conclusion, a regime shift in aquatic ecosystems can be caused by agricultural run-off and the shift is temperature dependent.

RS5_O16_Effects of complex micropollutant mixtures on benthic invertebrates

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Micropollutants (MPs), i.e. organic and inorganic substances causing effects at very low doses, are not effectively removed by wastewater treatment plants yet. To reduce their concentration, advanced treatments such as adsorption on activated carbon or oxidation with ozone are necessary but have not been implemented in many wastewater treatment plants so far. As consequence, MPs are released into aquatic environments, where they affect aquatic organisms at various levels of biological organization. To investigate the effects of MPs under natural conditions, we evaluated the structural community characteristics upstream and downstream of ten wastewater treatment plants representing a gradient of additional MP pollution. We observed increasing effects of the wastewater treatment plants on benthic community composition along the gradient. Nevertheless, it was not possible to clearly identify the main stressor, because the investigated gradient was simultaneously influenced by other environmental factors (e.g. concentration of nutrients and ammonia). To gain deeper insight into the potential effects of MP mixtures, we performed a laboratory experiment and exposed common benthic invertebrates (*Gammarus fossarum, Ancylus fluviatilis*, larvae of *Chaetopteryx* spp. and *Baetis rhodani*) to different pollution scenarios. The laboratory study showed sub-lethal effects of MP mixtures, indicated by negative effects of MPs on physiological indicators of energetic condition (concentration of glycogen and triglyceride, stored amount of energy) in most tested species. The results of the laboratory study emphasize that MP at least contribute to the observed effects in the field study. However, they also point towards species-specific differences in the response of physiological indicators to MPs.

RS5_O17_Sublethal effects of micropollutants from wastewater treatment plants in benthic invertebrates – a field study

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Micropollutants are a vast and expanding group of organic and inorganic substances defined by very low effective doses. They have a wide range of toxic effects at cellular, individual and population level of aquatic organisms. To date, the effects of micropollutants are mainly investigated in the laboratory under standardised conditions using specific model organisms exposed to single substances. However, such laboratory studies can hardly simulate the complex conditions of natural environments, where different organisms are usually affected by complex mixtures of micropollutants. To investigate the effects of micropollutants on natural benthic communities, we used an alternative approach. We investigated sublethal effects by analysing physiological indicators in benthic invertebrates which were sampled upstream and downstream of ten wasterwater treatment plants, representing a gradient of additional pollution by micropollutants. The biomarkers energetic condition and RNA/DNA ratio were analysed to assess sublethal effects in the field-collected organisms. Sublethal effects on benthic invertebrates downstream of wastewater treatment plants could be detected as changes in the RNA/DNA ratio within the gradient of additional pollution. However, as the investigated gradient not only represented the micropollutant concentration but also other environmental factors (e.g. nutrient concentration), it was not possible to identify the main stressor. Changes in the energy storage of the organisms were positively correlated with the nutrient concentrations. This leads to the assumption that increased nutrient availability masked a potentially negative impact of micropollutant exposure on the energy storage of benthic invertebrates in the field.

RS5_O18_Microplastics in caddisfly larval cases: first evidence of freshwater microplastics incorporated into larval constructions

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Plastic pollution is present in aquatic systems worldwide. While numerous studies investigate microplastic effects on marine organisms, microplastic effects on freshwater organisms are rarely studied. Insects, which are of high ecological importance, are particularly rarely considered. Moreover, studies of microplastic mainly focus on their dietary uptake. The incorporation of microplastics into biological constructions in fresh water, as commonly known from macroplastics in birds' nests, is largely unknown. So far, microplastics have only been observed in the tubes of marine polychaetes. In freshwater systems, common caddisfly (Trichoptera) larvae build cases by using silk and mineral grains from benthic sediments that are known microplastic sinks. Therefore, we examined caddisfly cases for microplastic presence. To do that, we collected caddisfly cases in the field and deconstructed them using hydrogen peroxide. Afterwards, we verified the presence of microplastic through micro-Fourier-transform infrared spectroscopy (µFTIR). We found microplastics of different shapes, colors, sizes and chemical compositions. The cases not only contained high-density microplastics (e.g. polyvinyl chloride), which are more likely to accumulate in sediments, but also low-density microplastics (e.g. polyethylene), which tend to float in the water column. Furthermore, the microplastic concentration in the surrounding sediment was higher than in the water column, suggesting that the microplastics in the cases were of sediment origin. Therefore, this is the first study to show that microplastics are incorporated into the constructions of a freshwater organism. The ecotoxicological impact of microplastics in a case surrounding larvae is still unclear, but may be harmful as microplastics often emit toxic leachates.

RS5_O19_Influence of mıxture of mıcroplastıc partıcles (MP) on n-bıtıng mıdges of *Chironomus riparius* ın laboratory setup

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Effects of microplastics on chironomid species *Chironomus riparius* Meigen, 1804 were investigated using the OECD spiked water and sediment toxicity test. Chironomid larvae were exposed to low microplastics concentration (LC, environmentaly relevant), high microplastics concentration (HC, 10x higher than LC) and control (C). The LC was 0.007 g/m^2 on the water surface + 2 g/m^2 in the water column + 8 g/m^2 in the sediment. The size of microplastics varied between 10 – 200 micrometers. The microplastic mixture consisted of polyethylene-terephtalate (PET), polystyrene (PS), polyvinyl-chloride (PVC) and polyamide (PA) in the ratio 45% : 15% : 20% : 20%, respectively, for the sediment exposure; 100 % polyethylene for the water column exposure; and 50 % polyethylene – 50 % polypropylene for the water surface exposure. Monitored endpoints were: morphological changes in the wings of adults and in the mandibles and mentums of the 4th instar larvae, mortality, emergence ratio and developmental time. The geometric morphometric analysis showed the tendency toward widening of wings, elongating of mentums and changing the shape of mandibles for specimens exposed to microplastics. The control differs from low microplastic concentration treatment, and both are distinguished from the HC treatment. The Development time of *C. riparius* was significantly ($p<0.05$) prolonged with the MP treatment and it was 13.8 ± 0.5; 14.4 ± 0.6; and 15.3 ± 0.4 days (mean ± SD) in the C, LC, and HC, respectively. The study indicate that mixture of different types of microplastis have influence on *C. riparius* especially at larval stage.

RS5_O20_Evaluation of Cerium-oxide (CeO_2) nanoparticle toxicity to freshwater midge *Chironomus riparius* (Diptera, Chironomidae) – potential biomarkers

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The toxicity of Cerium-oxide nanoparticles (nano-CeO_2) on the freshwater midge *Chironomus riparius*, Meigen, 1804 was assessed by observing several biomarkers, from molecular to the ecological level. Experiments were designed using measured concentrations of nano-CeO_2 in the sediment, according to the OECD guidelines for testing of chemicals, in the laboratory setup. The full characterization of the CeO_2 nanoparticles was made and the concentrations of 2.5, 25, 250 and 2500 mg of nano-CeO_2 per kg of sediment were tested. Following parameters were investigated: nano-CeO_2 intake by the larvae, oxidative stress parameters, in vivo genotoxic effect, geometric morphometry changes and life trait parameters (developmental time, emergence, mortality and survival rate). The Spearman rho test showed that the increase of nano-CeO_2 content in the chironomid larvae was highly correlated ($rho=0.73$, $p<0.01$) with the increase of nano-CeO_2 in the sediments. At the lower biological level, toxicity was detected through significant ($p < 0.05$) DNA damage in the midges exposed to higher nano-CeO_2 levels (tested by one-way ANOVA). The toxicity was not detected at the developmental level, causing no observable effects on life traits. In addition, investigated oxidative stress parameters showed no significant differences between the treatments. There is a need for further investigation in order to understand causal relationships between molecular and higher-level responses to nano-CeO_2 exposure. Nevertheless, obtained results indicate that *C. riparius* could be used as bioindicator, providing valuable information for nano-CeO_2 risk assessment in freshwaters.

RS5_O21_Responses of lower trophic level consumers to an addition of silver nanoparticles: A whole lake ecosystem approach

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There has been a rapid increase in the use of silver nanoparticles (AgNPs), which is a concern due to their possible environmental impacts. While past studies have reported adverse effects of AgNPs on aquatic organisms, most of these studies have been on single species grown under laboratory conditions, which reduces our ability to translate these results to natural environments. This study evaluated the effects of long-term AgNP exposure on natural freshwater zooplankton, littoral microcrustacean and benthic macroinvertebrate communities. To examine the response of these communities to AgNPs, we released environmentally relevant (~10 ug/L) concentrations of AgNPs into a freshwater lake (Lake 222) at the International Institute for Sustainable Development – Experimental Lakes Area (Ontario, Canada) throughout the ice-free season of 2014 and 2015, and compared effects to natural variation observed within a nearby reference lake (Lake 221). Mixed-effects models and multivariate methods (ANOSIM, NMDS, BIO-ENV) were used to examine differences in microcrustacean and macroinvertebrate assemblages between lakes over time to examine whether an addition of AgNPs caused significant alterations in these invertebrate communities. Overall, we found little to no evidence to suggest that additions of environmentally relevant concentration of AgNPs negatively affected any of these communities. Instead, biodiversity metrics and community structure were primarily influenced by seasonal dynamics and nutrient concentrations in both lakes.

RS5_O22_Why are mayflies sensitive to salinity?

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The salinity is increasing in many freshwaters around the world because of a range of human activities – including agriculture, mining and road de-icing. Field, mesocosm and laboratory studies show that mayflies (Ephemeroptera) are particularly to sensitive to small rises in salinity. In fact evidence is emerging that many mayflies are adversely affected by salinity levels which cannot be explained by generally accepted theories of osmoregulation in aquatic animals. In this presentation, I will explore various conceptual hypotheses as to why mayflies are so salinity sensitive. Key to these hypotheses are the observation of an increasing rate of sodium and sulphate updates by mayflies studied as the external concentrations of these ions increases. These hypotheses have to do with the energy requirements of increased ion uptake, (localised) loss of internal pH regulation or (localised) ion toxicity. I advocate vigorous testing of these hypotheses to better understand the effects of increasing salinity on mayflies and thus better manage adverse effects of rising salinity levels in freshwater.

RS5_O23_Evaluating the impacts of treated and untreated hypersaline effluents from abandoned mines on freshwater ecosystems

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Abandoned mines cause serious environmental damage to surroundings, with considerable impacts on freshwater ecosystems. Impacts occur through uncontrolled discharge of polluted effluents containing contaminants with high salts concentrations. Currently, no real solution exists for this environmental problem, being a global pollution problem. This study evaluates the efficiency of an innovative treatment, proposed on Life DEMINE project, based on membrane processes, electrocoagulation and the combination of both, to decrease environmental impacts caused by mining effluents from abandoned mines on freshwater ecosystems, using aquatic biofilms as indicator of ecological impacts. We incubated natural biofilms from a reference stream in different microcosms under controlled temperature and light conditions. After two weeks of colonization, on cleaned and previously autoclaved cobbles, biofilms were exposed to treated and untreated effluents from Menteroda salt mine (Germany), mimicking the real dilution occurring when discharge into the aquatic ecosystems. Biofilms responses were measured at 1, 7 and 15 days after the exposure began. We observed a significant reduction of biofilm photosynthetic efficiency after 24h of exposure in all treatments that recovered one week later. Chlorophyll-a concentrations, diatoms and cyanobacteria community of aquatic biofilm were affected by all treatments compared to the control from 24h until the end of the exposure. Phosphate uptake capacity decreased significantly after 24h of exposure in all treatments but recovered one week later. These observations evidenced ecological impact of hypersaline mining effluents on aquatic ecosystems and the potential of the innovative treatment proposed to improve the quality of water bodies affected by abandoned mines.

RS5_O24_Cellular energy allocation in stygophilous amphipod *Synurella ambulans* from the hyporheic zone of the Sava River

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Hyporheic zone (HZ) is a unique habitat defined as a transitional zone or a contact between stream water and groundwater. It is located inside river sediment, where physicochemical and biological conditions are different from those in streams and groundwater. *Synurella ambulans* is a stygophilous amphipod crustacean inhabiting HZ, which is native to the Ponto-Caspian region, and Central and Eastern-Europe. The aim of the present study was to investigate the use of cellular energy allocation (CEA) methodology in *S. ambulans* as a potential indicator of environmental stress. CEA is physiological marker reflecting the organism energetics, calculated as a ratio between available energy, E_a (sum of total sugars, proteins and lipids, transformed into energy equivalents) and energy consumption, E_c (based on the activity of mitochondrial electron transport system, transformed into energy equivalent). Amphipods were collected from the HZ of the Sava River at two sampling sites: Jarun-Zagreb and Medsave-Zaprešić in October and December 2018. CEA values in Jarun population were not significantly different between October and December. In December, CEA was significantly lower in Medsave compared to Jarun population, which resulted in a lower amount of energy available for the population growth or reproduction. We discuss the possible correlation between the changes in CEA and abiotic environmental factors prevailing in the HZ (temperature, dissolved oxygen, concentrations of nutrients, metals/metalloids and dissolved organic carbon). This study presents the first results of CEA methodology applied on *S. ambulans* and an important insight into hyporheic processes at a local scale.

RS6 Fish (and other vertebrate) biology

RS6_O1_Reliability analysis of fish life-history traits reveals discrepancies among databases

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Trait-based approaches are increasingly used in community ecology, e.g., to understand the relationship between biodiversity and ecosystem functioning, environmental filtering or biotic responses to anthropogenic perturbations. However, little is known about the reliability of assigned traits and the consistency of trait information among different databases currently in use. Using 99 Iberian inland fish species, including diadromous and non-migratory native and alien species, we investigated in total 27 traits for their consistency among 19 different databases and identified least reliable traits, i.e. traits with high disagreement among databases. Specifically, we used generalized linear models and inter-rater reliability statistics to test for differences in traits among databases. We also calculated trait and species use, and data availability to identify species and traits that are best studied. Our results showed notable discrepancies for several traits. Unreliable traits, such as omnivory, invertivory, rheophilia or limnophilia, are mainly characterized as traits with scarce quantitative data availability, established by expert judgment and described without using a common methodology or definition. In particular, categorical/binary (e.g., rheophil vs. non-rheophil) traits showed significantly lower reliability, but higher data availability than continuously-scaled traits. Species with smaller distributional ranges and those described more recently, present lower use and data availability. We emphasize the importance of clear definitions and standardized measurement of traits for the improvement of future fish trait-based approaches.

RS6_O2_Scavenging behaviour of black bullhead (*Ameiurus melas*)

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Fish carcasses may represent important and easily accessible food resources in many aquatic ecosystems. Individuals of various omnivore species can highly benefit from exploiting them. Black bullheads are known to scavenge, but the details of such behaviour remain unclear. In this study, we investigated the size-dependent scavenging behaviour of black bullheads under laboratory conditions. We allocated black bullheads to small groups according to three size categories and offered them carcasses of either of two sympatric fish species matching in size with the scavengers, and observed their activity and feeding behaviour for 48 hours. We found that black bullheads were negligent to consume pumpkinseed (*Lepomis gibbosus*), whereas readily exploited bleak (*Alburnus alburnus*) carcasses. We characterized the phases of handling and consuming the carcasses in each size group and found that larger black bullheads tended to consume carcasses more efficiently. Scavenging behaviour might have contributed to the success of this species in invading new ecosystems.

RS6_O3_Effect of the parasite *Ligula pavlovskii* on the life history traits of the monkey goby (*Neogobius fluviatilis*), an invasive benthic fish in Lake Balaton (Hungary)

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The monkey goby is an invasive Ponto-Caspian fish in Lake Balaton, Hungary. Its current population is highly infected by the plerocercoids of *Ligula pavlovskii*. To investigate the effects of the parasite on the life history traits of the fish, we collected altogether 547 monkey gobies at two sites in the southern and the northern shore of the lake, once in a month from April to October in 2018. Mean monthly prevalence of parasite infection was 40.8% (SD=7.6%), while the parasite index (PI=100*parasite weight/fish weight) increased from May (5.6) to October (10.4). Fulton's condition factor was calculated based on the eviscerated weight of the fish. Gonadosomatic index (GSI) of the females and condition factor of both sexes showed a seasonal pattern, but did not differ between study sites. Both the presence and the intensity of the infection had a negative effect on the GSI. Condition factor was effected only at the highest PI levels (15<), but not by the presence of the parasite. Consequently, our findings indicate that the parasite infection influences primarily the energy investment in reproduction. We discuss the changes ligula infection causes in the spawning characteristics of monkey gobies. This study was supported by the GINOP-2.3.2.-15-2016-00004 project.

RS6_O4_Isotopic evidence for multi-decadal shifts in trophic ecology of the long-lived Australian lungfish

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Meeting the conservation challenges of long-lived species ideally requires ecological assessments encompassing appropriately long time scales. The use of dietary proxies, such as ratios of stable isotopes occurring in animal tissues that demonstrate progressive growth, has shown considerable promise to reconstruct the ecological histories of long-lived organisms. Here, we combine innovative radiocarbon scale-aging techniques with cross-sectional stable isotope analysis of carbon and nitrogen to reconstruct dietary histories for the threatened Australian lungfish (*Neoceratodus forsteri*) in the core of its remaining global distribution. Over a 65-year period, we found pronounced temporal shifts in the dominant energy sources assimilated by lungfish that coincided with a period of hydrological modification by dams and agricultural land-use intensification. In the Brisbane and Burnett Rivers, whose hydrology is substantially regulated by large dams, lungfish showed consistent trends of $\delta^{13}C$ depletion and $\delta^{15}N$ enrichment over time. This suggests that seston being exported downstream via regulated releases from impoundments may represent a carbon source that was previously unavailable, and has shifted the lungfish diet from benthic-dominated primary production typical of unmodified river systems, to pelagic carbon sources. By contrast, $\delta^{13}C$ values of lungfish in the unregulated Mary River were more stable through time, whereas $\delta^{15}N$ increased corresponding with the expansion of the dairy industry and increased nitrogen fertilization usage. In conclusion, we demonstrate how human activities have altered natural patterns in benthic vs. pelagic energy resources supporting Australian lungfish and demonstrate how detectable trophic signals in fish scales can reveal historical anthropogenic changes in riverine ecosystems.

RS6_O5_Fish muscle quality drops during spawning – seasonal changes in fatty acid composition of salmonid fish in a subarctic lake

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In subarctic lakes seasonal changes in light and temperature are extreme, potentially causing changes in diet and metabolism and thus the chemical composition of animals. Despite extensive fish fatty acid (FA) research over recent decades, we know little about seasonal changes of fish FA composition in subarctic lakes.We sampled fish (European whitefish), zooplankton (ZPL) and benthic macroinvertebrate (BMI) during three ice-covered and three open water months from a Finnish subarctic lake. FA analyses (mol% and mg/g) of fish muscle and invertebrates was conducted, fish size, stomach content and gonadosomatic index was determined.Whitefish changed diet from BMIs to pelagic ZPL from winter to summer, during the same time stomach fullness increased. Increased zooplanktivory in summer was detected also with fish muscle FA profiles (e.g. ALA, SDA). The gonadal growth of whitefish occurs in summertime continuing until the spawning. Physiologically crucial EPA, DHA and ARA in whitefish muscle drop ~60% during spawning in early winter and increased rapidly afterwards reaching maximum in mid-summer.Seasonal changes in whitefish muscle FA composition were modified by diet and reproduction physiology, latter being more powerful driver of the changes. Season-based variation in fish FA composition should be considered in long-term monitoring and future studies.

RS6_O6_Selective retention of algal polyunsaturated fatty acids along stream food webs and within fish organs

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Polyunsaturated fatty acids (PUFA) are fundamental dietary nutrients for all aquatic organisms, but are not distributed evenly among ecosystems. In particular, invertebrates in stream food webs are very poor in long-chain PUFA, such as docosahexaenoic acid (DHA), yet fishes are rich in DHA. This mismatch between dietary supply and physiological requirement of DHA in fishes encouraged us to examine trophic lipid trajectories in subalpine stream food webs. The aim of this field study was to investigate; a) the similarity of fatty acids (FA) between autochthonous (epilithon) or allochthonous (submerged and fresh leaves) resources and fish tissues (liver, muscles, brain and eyes), and, b) the FA compositions (as mass fractions) of fish tissues (liver, muscle and brain tissues, and eyes) relative to their potential diet sources. We tested the hypotheses that FA compositions of fish tissues are 1) more similar to algal than to terrestrial resources, and, 2) independent of sampling sites in these subalpine streams. DHA was only abundant in fish and absent in most macroinvertebrate, epilithon, submerged and fresh leave samples. The FA-composition in fish differed among organs, particularly from brain and eyes FA. The higher similarity of FA patterns in aquatic invertebrates with epilithic or periphytic algae than terrestrial resources suggests that these consumers depend predominantly on aquatic rather than terrestrial dietary nutrients. The high abundance of DHA in fishes, particularly in their neural tissues, suggests that fish hepatocytes synthesize DHA from dietary precursors and allocate DHA selectively to various organs.

RS6_O7_The effect of hydropower plant on fish stocks in two glacier-fed rivers in East Iceland

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Turbidity in glacier-fed rivers can be a considerable factor in limiting primary production, which consequently affects the living conditions for invertebrates and fish. The Fljótsdalur hydropower plant (2007), East Iceland, is run by water from two glacier-fed rivers. The power plant outlet is into a glacier-fed lake, Lake Lagarfljót. The effluent from the power plant has higher level of suspended solids than originally found in the lake, causing increased turbidity and reduced visibility. Contrary to Lake Lagarfljót, the turbidity and discharge of the donating River Jokla has decreased substantially. Fish populations in both Lake Lagarfljót and River Jokla were studied before and after onset of the hydropower plant. The abundance and growth rate of Arctic charr and brown trout have declined in Lake Lagarfljót. At the same time the opposite happened in River Jokla, where Atlantic salmon and Arctic charr have expanded their density and distribution. This has caused decreased value of the fishery in Lake Lagarfljot while River Jokla supports increasing angling fishery for Atlantic salmon. The environmental and biological changes experienced in those two rivers will be discussed, with the main focus on fish stocks.

RS6_O8_Evolutionary history of endemic fish species facilitating their survival in changing environments – a case study on genus *Telestes* in Croatia

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The genus *Telestes* comprises primarily freshwater fishes distributed mostly in the Mediterranean area. Recent investigation of the evolutionary history of the genus *Telestes* revealed that the origin of the genus occurred in southern Europe, where the oldest *Telestes* species are still present. Isolation of rivers in this karstic region facilitated allopatric speciation resulting in high number of *Telestes* species and great portion of endemics in freshwaters of Croatia and Bosnia and Herzegovina. Most of the endemic *Telestes* species have very small distribution areas, inhabiting a single river or few watersheds in a single karstic field, making them extremely vulnerable to all anthropological changes. In order to contribute to practical conservation of the endemic *Telestes* species through design of conservational measures that are likely to be the most effective in ensuring future viability and undisturbed evolutionary course of those species, we have investigated their population genetic structure and estimated their viability. Population viability analyses were carried out based on the current status of populations and their habitats, as well as recognized threats. Several scenarios included also potential threats or conservational measures. As the most dangerous threats for the future survival of the endemic *Telestes* species, climate changes and invasive species were recognized. However, high intraspecific genetic diversity revealed inside most of the investigated species turned out to enable most of the populations to cope with future changes and mitigate negative effects.

RS6_O9_Past, present and future of trouts in Žumberak-Samoborsko gorje Nature park

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Diversity of Croatian brown trouts (*Salmo trutta*) is still unknown on several levels, resulting in numerous taxonomic controversies and accumulation of conservation problems, especially in protected areas. The aim of this study was to determine genetic and spatial diversity of brown trouts distributed in Žumberak-Samoborsko gorje Nature Park (Croatia) and to predict stability of their populations for conservational purposes. In this work, we report on 73 analyzed samples collected on 27 localities in Nature Park. Phylogenetic reconstruction was performed using mitochondrial cytochrome *b* sequences in order to describe phylogenetic relationships and review taxonomic status of trout lineages present in Nature Park. Furthermore, evolutionary history of brown trout was analyzed using BEAST software. Effective population size and migration rate were estimated, as well as intraspecific and intrapopulation genetic diversity. Finally, viability of population was analyzed using Population viability analysis based on the current status of populations. Mitochondrial DNA revealed four evolutionary independent and genetically distinct lineages, comprising 17 different brown trout haplotypes, indicating exceptionally high genetic diversity for area of this size. Moreover, so-called Danube lineage (or *Salmo labrax*) of brown trout, included majority of the existing haplotypes making this Nature park an important area for conservation of this taxon. On the other hand, some localities showed extremely low genetic diversity and single haplotype domination as a probable consequence of habitat fragmentation and other anthropogenic pressures, causing conservational concern.

RS6_O10_Population genetic structure of *Salmo farioides*

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Freshwater fish species *Salmo farioides* (commonly called Balkan trout) was described in 1938 by Stanko Karaman based on morphological differences. It is distinguished from other species in genus *Salmo* in Balkan Peninsula by preanal and predorsal length. Its reported distribution range comprises streams of eastern Mediterranean slope from Croatia to Greece. Due to the lack of taxonomic research over the years, its distribution, population structure and diversity is still not known. The aim of this research was to confirm whether the Balkan trout really presents separate species, or it is only a morphotype. Furthermore, if it indeed is unique species, our goal was to reveal its intraspecific structure and estimate the intraspecific and intrapopulational genetic diversity. Conducted field research comprised Dalmatian rivers in Croatia. From the obtained samples, we have isolated genomic DNA and amplified gene for cytochrome b. Phylogenetic reconstruction was based on maximum parsimony, maximum likelihood and median-joining methods, whereas analyses of genetic diversity included calculation of genetic polymorphism measures. Furthermore, gene flow and effective population sizes were estimated using maximum likelihood approach. Our results corroborated the existence of the Balkan trout as an independent taxonomic unit, which was found in Dalmatian Krka, Zrmanja, Cetina rivers and the basin of the Neretva River. *Salmo farioides* seems to be genetically different and evolutionarily separated from other trout species distributed in the investigated area. Differences in genetic diversity and interconnections among populations, which are of great importance for the effective conservation for this endemic species, will be discussed.

RS7 Freshwater science in policy, management, monitoring and restoration

RS7_O1_A framework for automated anomaly detection in high frequency water-quality data from *in situ* sensors

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Monitoring the water quality of rivers is done increasingly using automated in situ sensors, but the high volume and velocity of the data renders manual anomaly detection unfeasible. We present a highly transferable framework for automated anomaly detection in high-frequency data from in situ sensors, using water-quality data from rivers flowing into the Great Barrier Reef. After identifying end-user needs and defining anomalies, we ranked anomaly importance and selected suitable detection methods. High priority anomalies included sudden isolated spikes and level shifts, most of which were classified correctly by regression-based methods such as autoregressive integrated moving average models. Classifications of drift and periods of anomalously low or high variability were more often correct when we applied mitigation, which replaces anomalous measurements with forecasts for further forecasting, but this inflated false positive rates. Feature-based methods also performed well on high priority anomalies and were similarly less proficient at detecting lower priority anomalies, resulting in high false negative rates. Unlike regression-based methods, however, all feature-based methods produced low false positive rates and have the benefit of not requiring training or optimization. Rule-based methods successfully detected impossible values and missing observations. We suggest that a combination of methods will provide optimal performance in terms of correct anomaly detection, whilst minimizing false detection rates. Furthermore, our framework emphasizes the importance of communication between end-users, freshwater scientists and anomaly detection developers for optimal outcomes with respect to both detection performance and end-user application.

RS7_O2_Twenty-five years of investments in water quality: An evaluation of the chemical and biological water quality of a lowland stream in the Zwalm River basin (Belgium)

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Since the early 2000s and the implementation of the European Water Framework Directive, a big step forward has been made to achieve a good ecological status of surface waters in Europe. To date, little is known about the response of biological life in small lowland streams under improving conditions for both water quality and habitat diversity. In this study, we investigated possible relationships between chemical water quality and aquatic biodiversity of the Zwalm River basin (Belgium) using a dataset of long-term measurements including the chemical and biological water quality parameters. Specifically, we wanted to know: 1) the evolution of water quality over the last three decades and 2) whether the improvement in water quality was reflected in a change of the macroinvertebrate and fish diversity and composition. We found that there was a significant improvement in the chemical water quality, likely due to the installation of wastewater treatment plants. Shortly after, an increase in the number and abundance of pollution sensitive macroinvertebrate taxa was observed, which was consequently also seen in the biotic index score based on macroinvertebrates. Despite a change in community composition observed for fish, no significant increase in diversity nor in the biotic index score of fish could be found. Hydromorphological restoration and free fish migration remain important key factors for diversity of fish species. Based on these results we provide guidelines (e.g., restoration of spawning beds) to optimize the investments made in river restoration and to achieve the good ecological status.

RS7_O3_The River Ecosystem Service Index (RESI)

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For centuries, rivers and floodplains offer a multitude of natural capital and ecosystem services, which are recently quite intensely used, e.g. for hydropower, navigation, agriculture, drinking water supply, or recreation and tourism. Nowadays, these intense uses are often competing for the same area and water body, and produce significant trade-offs. In addition, the management of rivers is regulated by several EU directives. Hence, any change of current management practice or uses will influence the availability and usability of several ecosystem services. In order to assess such effect on the ecosystem services provided by rivers and floodplains, we developed a novel non-monetized approach to quantify a wide array of ecosystem services. Our approach of the River Ecosystem Service Index (RESI) first collects and collated suitable geographic indicator data, and then applies algorithms to calculate scores of the availability of single ecosystem services ranging from 1 to 5. This already allows visualizing the distribution of specific ecosystem services along rivers and within floodplains, and to analyze their trade-offs. Furthermore, the availabilities of all studied ecosystem services may be summarized to an integrative index called the 'River Ecosystem Service Index' (RESI) (www.resi-project.info). The RESI may be used to compare complex river and floodplain management scenarios, including transparent inter-sectoral visualization, and may hence serve as a decision support tool for inter- and transdisciplinary communication. The RESI has been already been implemented in practice in the framework of an official regional planning prioritization procedure for a 80-km section of the Danube River in Bavaria (Germany).

RS7_O4_Challenges in linking water contamination, its impacts on freshwater biota and the consequences for ecosystem services delivery

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

RS7_O5_Non-native species and biomonitoring procedures: implications and new challenges for biotic indices calculation and reliability in river ecosystems

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Freshwater ecosystems face many threats in the form of reduced water quantity, poor water quality, loss of biodiversity and increasing number of invasive species. Ideally, aquatic biomonitoring tools are required to evaluate of all these critical changes. Currently, macroinvertebrate-based indices are globally the most widely used biomonitoring tools in fluvial ecosystems. However, little is known about the potential effects and implications of the presence of new non-native species for biotic indices calculation and the reliability of commonly used taxonomic metrics. This is especially relevant given that errors, incorrect classification or exclusion of taxa may have direct consequences for the management of freshwater systems. In this research the main constraints, challenges and implications of these issues are outlined and case studies from a range of European countries discussed. However similar challenges affect rivers and are faced by river managers globally and will potentially be amplified further in the future. Preliminary results from a specific project on the presence and implications of *Dikerogammarus villosus* and *D. haemobaphes* (Crustacea: Amphipoda) in UK rivers are also discussed. Bioassessment science needs to be open to improvements, and current tools and protocols need to be flexible so that they can be updated and revised rapidly to allow new scientific discoveries and developments to be integrated. This research highlights new ideas and challenges that need to be considered in the future development of riverine biomonitoring.

RS7_O6_Correspondance of taxonomic and functional trait biodiversity with natural flow regime classification

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It is widely recognized that flow regime is responsible for defining a wide range of river hydromorphological and physicochemical characteristics. Natural flow patterns also set the natural disturbance regimes (i.e. floods and droughts) in rivers, consequently playing a very important role in determining biological community structure and composition. However, the actual relationships between flow regime and biological communities are still not clear, and further research is needed. In order to assess the connection between biodiversity at large spatial scales and the natural flow regime, a dataset including benthic macroinvertebrates, fish and diatoms, and the respective physicochemical parameters was used. It gathered taxonomic information from more than 1000 survey sites throughout Spain, in rivers with a non-disturbed flow regime and of good ecological status, sampled between 2007 and 2015. This database was explored using ordination methods to outline biodiversity patterns, linking riverine biota and a natural flow regime classification previously developed. In this way, differences among the natural classes based on hydrology and biodiversity were detected. This approach allows outlining biological reference conditions for each hydrological class, investigating how the communities are linked to the hydrological aspects at large spatial scales, in a functional trait-based perspective. Furthermore, the functional differences identified among the surveyed sites, when combined with the natural hydrological classes, permit the arrangement of streams into similar groups, identifying practical management units and providing general guidelines for environmental flows.

RS7_O7_Effects of flow regime regulation on river habitats, riparian vegetation and fish and macroinvertebrate communities in a Pyrenean river (Catalonia, NE Iberian Peninsula)

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Life *Alnus* project (www.lifealnus.eu) is an EU program focused on the restoration of *Alnus glutinosa* riparian forests. This four-year project (2018-2021) is being developed in several Catalan river courses affected by the decline and deterioration of Mediterranean alder forests (91EO*). Attending the relationship between flow regime, riparian forests, river habitats and biodiversity, a field research study was implemented in order to establish the basis of structural and functional characterization of aquatic fauna communities (fish and macroinvertebrate populations) and both river bed and riparian habitat structure in a flow-regulated area. The study site is located in the Ter river at Camprodon municipality (NW Catalonia, Iberian Peninsula) comprising a river stretch affected by a hydropower plant. The water flow regulation associated with this hydroelectric exploitation was assessed by developing a before-after design, besides establishing an appropriate environmental flow regime. Several indexes (IHF, RBPS, RHS, ICF, QBR) and cartographic analysis have been applied, reflecting differences in river habitat distribution, diversity of substrate types and flow regimes, availability of refugees and riparian tree cover patterns, among others. Biomass-length relationships, genus to species taxonomical classification and a trait-based approach have also been calculated for both fish and benthic invertebrate indicating slight discrepancies between points. The obtained results suggest water flow regime and habitat quality as major determinants of macroinvertebrate and fish abundance and richness. Even so, further investigation is needed in this area, probably including different hydrological years and distinct water flow conditions.

RS7_O8_Macroinvertebrates, an important tool in bioassessment and water bodies classification strategy

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Macroinvertebrates are a arguably the most important biological element in the freshwater ecosystem assessment. Except their unavoidable participating in energy flow through benthic food webs, they are an effective indicator of water and ecosystem condition. Their indication power is based on thoroughly examined distinctions in sensitivity of taxa. Such elaborate examination stems from the fact that macroinvertebrates are easy to catch and study. They are sufficiently large to collect and identify. Furthermore, their limited areal and a relatively long life cycle enable environmental changes tracking. However, analysis of macroinvertebrate community structure in respect to the hydromorphological traits are still very few. Do they correlate at all? The aim of our study was to answer this question. Our research took place in Dinaric coastal ecoregion and included 21 sites. Following national classification, sites are divided in 5 groups, based on 3 criteria: altitude position, flow stability and water body size. In spring season, we took samples in accordance with the Water Framework Directive guidelines and identified the macroinvertebrates to the lowest possible taxonomical level. We used Asterics software for obtaining bioassessment metrics and water quality evaluation for further comparison and correlation within hydrological groups. Temporary and mountainous water bodies showed higher water quality and lower saprobity, comparing to the lowland larger rivers. Former habitats, not surprisingly, support higher diversity and number of taxa.

RS7_O9_Interaction between regional and local scale habitat quality in shaping benthic invertebrate communities — Implications for stream restoration practice

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It is still debated how local and regional-scale habitat quality (LQ and RQ, respectively) interact in shaping local stream communities. This topic is relevant for stream restoration, as it is a common strategy to improve local habitat conditions and expect a response in local communities. We hypothesize that RQ is of overriding importance for local communities. Benthic invertebrate community data and hydromorphological habitat quality data from 1087 stream sites in Germany were used to test this hypothesis. Analyses showed that RQ had a greater individual effect on communities than LQ, and effects of RQ and LQ interacted. Where RQ was either good or poor, communities were exclusively determined by RQ. Only in areas of intermediate RQ, LQ determined communities. Species pools in poor RQ areas were impoverished, resulting in insufficient propagule pressure for species establishment even at high LQ (e.g. restored) sites. Conversely, high alpha diversity and low beta dispersion indicate mass effects occurring in high RQ areas. Hence, abundant neighboring populations may help to maintain populations even at sites with low LQ. At intermediate RQ levels, communities were structured to the highest degree by habitat/environmental gradients. From these results, we conclude that local scale stream restoration projects will be most likely to lead to more natural stream communities when situated in intermediate RQ settings. Clustering of reach-scale restorations to expand areas of high RQ should be most promising, as mass effects are initiated that ultimately will also lead to more diverse communities beyond the actually restored river reaches.

RS7_O10_Hydromorphological river restoration: Does it work? Could we reach reference conditions?

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Hydromorphology is known to be a support for freshwater communities. By the way, the Water Framework Directive reporting takes into account this parameter, as important as water quality. Knowing this, many hydromorphological river restoration works have been achieved over the last 15 years. However, it is still difficult to assess the efficiency of these restoration measures: does it work? How long does it take to reach a new equilibrium? What kind of ecosystems could we expect after restoration? These difficulties are due to a lack of monitoring and moreover, a lack of standardized monitoring to allow multi-sites analysis. In addition, a serious gap between researchers and stakeholders is often reported. This leads to desynchronization between restoration works and monitoring, and to a lack of explanatory variables such as work details, other measures, problems occurring during the work phase and before/after. This statement initiated in France the Minimal Scientific Monitoring (MSM) project, aiming at restoration monitoring with standardized protocols and a standardized design (before-after-control-impact), with strong links between all people involved in the restoration project. These people include researchers, stakeholders, practitioners and technicians. MSM project is born from the partnership of French Biodiversity Agency (FBA), French water agencies and National Research Institute of Science and Technology for Environment and Agriculture (Irstea). These strong links allow the inclusion of explanatory variables, concerning the restoration works and parameters of the catchment. To enhance MSM project outcomes, we are now working on improving standardization, data storage and better project knowledge, from local practitioners to international researchers.

RS7_O11_Effects of dam decommissioning on stream biodiversity and ecosystem functioning

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Dam decommissioning is a booming activity in terms of stream and river restoration projects. During the twentieth century, more than 3,869 dams have been removed worldwide, and this activity is likely to increase, since many dams are approaching the end of their life expectancies. Nevertheless, little is known about the impacts and benefits of dam removal on stream biological communities and ecosystem functioning. We reviewed dam removal literature to identify published studies that contained empirical information associated with this activity. Literature search was carried out by a) tapping the key words “dam AND removal” and “dam AND decommissioning” in Google Scholar and Web of Science (WoS) databases, b) using the Dam Removal Information Portal (DRIP) of the Unites States Geological Survey (USGS) and c) following the “snowballing” technique. This search yielded over one hundred publications. Most of the identified works focus on low head dam removal projects and hydro-geomorphological aspects. There is a major gap regarding large-dam removal as well as the response of ecosystem functioning. With these data, we conducted a meta-analysis that allowed us to examine the evidence-based effects of dam decommissioning on stream ecosystem structure and functioning by testing whether there were any initial impacts and posterior benefits driven by this activity.

RS7_O12_Vertical distributions of limnological variables and water column stability in a regulated river (Nakdong, South Korea)

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Physical alterations in rivers, such as construction of dams and weirs are being carried out worldwide. Constructing of 8 weirs and dredging resulted in deepening of the Nakdong River (525 km) depth from 2 to 6-10 meters which may allow the river to be stratified. In this study we identified vertical distributions of water quality according to the degree of stratification. Field surveys of fall, spring and summer was conducted for 24 hours from November 2017 to August 2018, at two points in downstream of the River. A total of eight limnological variables were measured at intervals of one to three meters in depth over the entire water column. Relative Water Column Stability (RWCS) was calculated using the measured water temperature, and the relations of RWCS with meteorological and hydrologic variables were analyzed. In the summer, waterbodies of the two sites showed stratification with diurnal rhythm without complete mixing. The vertical differences and diurnal changes in water quality were higher than other seasons. The vertical differences of dissolved oxygen (DO) and nutrients were significantly correlated to RWCS. High concentrations of nutrients at the bottom have been observed when the bottom layer DO saturation was lower than 100%. The discharges of upstream weirs showed time-delayed influences on the downstream RWCS. Development of thermal stratification occurred when the discharge was lower than 50 m^3/s. Thus it is necessary to establish measures to manage the stratification in summer by regulating the scale and timing of the discharge from the weirs.

RS7_O13_Learning by doing in river restoration: easy to say, but difficult to apply

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River restoration is still a fairly young undertaking, but over the last three decades, it has become a worldwide initiative for promoting and conserving biodiversity in aquatic ecosystems. Substantial resources are being invested in river restoration and many measures have been monitored at the project level. However, the results have rarely been compared across projects, which would allow for an in-depth understanding of their effects, including the driving factors at the local- to catchment-scale. Programmatic monitoring and evaluation (ProME) is a new paradigm that builds on standardized surveys, centralized data management, and systematic cross-project comparison. ProME allows for collaborative learning at the regional or national scale, for a transfer of results across restoration projects and for adaptive management and monitoring. River restoration projects are known to be very complex and the outcome is often uncertain. Thus implementing a scientific paradigm as ProME into practical management, especially on a national level, can be very challenging in terms of funding, coordination, responsibilities and long-term commitment. Nonetheless, programmatic monitoring and evaluation will be implemented in Switzerland by 2020. Using this ongoing Swiss initiative as an example, I will present encountered challenges and lessons learned. Specifically, I will introduce selected tools for (i) facilitating interdisciplinary collaboration, (ii) involving different stakeholder groups and (iii) mediating iterative and adaptive discussions. These tools have proven to be effective for our purpose, but transferable to any complex project at the science-practice interface to help you maximize your chances of success.

RS7_O14_Catchment water quality in the first year immediately following and preceding restoration of a drained afforested blanket bog

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The restoration of drained afforested peatlands, through tree removal and drain blocking, is increasing in response to peatland restoration targets and policy incentives in the UK, which in turn reflect changed thinking and policies around tree planting on deep peat soils. In the short term, these intensive restoration operations may affect receiving watercourses and the biota that depend upon them. This study assessed the immediate effect of 'forest to bog' restoration by measuring water quality in streams and rivers for a 15 month period pre- and post-restoration, at a study site in the Flow Country peatlands of northern Scotland. We found that the chemistry of streams receiving drainage from restoration areas differed from that of control streams, with phosphate concentrations significantly higher (4.4 fold) in restoration streams when compared to results from the pre-restoration period. This led to a greater number of occasions (15% increase), when phosphate did not reach a target "good" status (based on EU Water Framework Directive guidelines) in rivers post-restoration, when compared to river baseline monitoring sites. While overall increases in turbidity, DOC, Fe, K and Mn were not significant post-restoration, they did exhibit an exaggerated seasonal cycle, with higher peaks occurring in summer months. We attribute these relatively limited, minor impacts to the fact that relatively small percentages of catchment areas (3-23%) were felled, and that drain blocking and silt traps were likely effective in mitigating negative effects. Future work should test, whether brash and needle removal could help reduce phosphate leaching.

RS7_O15_Riparian forest succession in a river island after a restoration project of replacing a poplar plantation (Sorral island, Ter river, Catalonia, NE Iberian Peninsula)

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The project area was located in the Sorral Island, in the medium – upper part of the Ter river catchment at Les Masies de Voltregà (NE Catalonia, NE Iberian Peninsula). This area has a land stewardship agreement between its landowner and the Center for the Study of Mediterranean Rivers – UVIC – UCC, to preserve its ecological status and biodiversity. The aim of this project was to assess the efficiency of a native trees species plantation associated to a riparian restoration project which started in 2010. The riparian vegetation plantation was evaluated before the elimination of a poplar plantation, that existed there for the last 15 years. In order to assess the importance of planting seedlings of native tree species, the island surface (3.4 ha) was divided into 70 parcels. 50% of the parcels were planted with native riparian species and the other 50% were left without planting. The evolution of the riparian vegetation in this river island has been studied over 8 years, and significant differences between planted and unplanted parcels has been observed. The elimination of poplars and the plantation of native riparian trees in the Sorral Island significantly improved the riparian vegetation quality. However, the distribution of species between planted and unplanted parcels led to conclude that the capacity of natural colonization by native species is limited, and the planting action has really been useful for the restoration of the riparian vegetation in this site.

RS7_O16_Effect of river restoration on life strategies in fish communities

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Assessments of river restoration are mostly based on taxonomic units, which may not be optimal as results are hardly comparable across geographic areas. The use of ecological traits may help to overcome these challenges. We used a dataset on 22 ecological traits describing fish life-history strategies to assess the restoration outcome in 134 river projects conducted in Switzerland, Germany and Finland, monitored for up to 15 years. Restoration increased functional diversity in the potamal river zone. In areas with low levels of anthropogenic land use, the peak of the restoration effect was reached already within one to five years after the restoration, while communities responded later in areas with higher levels of anthropogenic land use. In the potamal zone, a shift towards opportunistic life history strategists was observed. In the rhithral zone, in contrast, species with an opportunistic life strategy increased only in the first five years of restoration, followed by a shift towards equilibrium strategists at restorations older than 5 years. Restoration reduced the variability in community trait composition between river reaches suggesting that community trait composition within these zones converges. Independent of taxonomic units, traits can be used for the evaluation and comparison of restoration projects across geographical regions.

RS7_O17_Population structure of brown trout (*Salmo trutta*) and its relationship with environmental factors and macroinvertebrate biomass and diversity in a Mediterranean stream

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Brown trout (*Salmo trutta*) population from high mountain areas in Mediterranean river basins have been considerably reduced in the last decades. To elucidate the main factors which determine the condition of Mediterranean brown trout populations, the density and population structure of brown trout has been evaluated in the Vallferrera stream (Ebre river basin, Catalan Pyrenees). It has been related to the biomass and diversity of benthic macroinvertebrates, and both with environmental factors. Additionally, to assess a potential recovery of brown trout population, an experimental habitat restoration project in an altered stretch was performed. This restoration project aimed to increase the river habitat heterogeneity, specifically improving brown trout habitats. The project performed consisted in the addition of large wood pieces (longer than 2.5 m and wide between 20 to 46 cm) into the stream channel to enhance the habitat diversity. Results shown that several environmental and biological factors as such water temperature and benthic macroinvertebrates community (biomass and diversity) explain the brown trout population size structure and status. Therefore, we conclude that habitat restoration projects, such as this performed in this stream, are feasible solutions for river dynamics recovery at several levels: improving habitat heterogeneity, benthic macroinvertebrates diversity and brown trout population.

RS7_O18_The potential of long term fish removal in eutrophic lakes?

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Fish can be a source or sink of phosphorus. In average eutrophic cyprinid dominated lakes fish biomass is high, fishing intensity is low and it selectively avoids cyprinids. Could effective fishing represent a permanent sink and remove phosphorus from the lake ecosystem? We estimated the role of the phosphorus pool of fish biomass in long term fish removal carried out in eight Nordic lakes (surface area 145 – 15500 ha, retention time 0,2 – 4,9 years, external phosphorus load <0,1 – 0,6 g P $m^{-2}a^{-1}$, fish removal 0 – 240 kg $ha^{-1}a^{-1}$ and duration of fish removal from five to 20+ years). The phosphorus pool removed in fish biomass (FPout) was compared with parameters of nutrient balances. It was up to 25 % of the mean annual external loading, it could exceed 50 % of the mean total phosphorus (TP) concentration of the lake water, mean sedimentation of TP and TP content of outflow. The relative importance of FPout depended on the retention time and efficiency of fishing. By shorter retention time, even the highest catches [kg $ha^{-1}a^{-1}$] were lower compared with the external load, but their percentage of retention and annual outflow of phosphorus increased. Our results suggest that biomanipulation can in addition to the short term improvements also cost-effectively support long term nutrient removal from water bodies. The necessary river basin management measures reducing diffuse external loading are tackled e.g. in agricultural policy, but they affect at a slower pace than in-lake measures.

RS7_O19_Effects of habitat limitation on common barbel (*Barbus barbus*) recruitment – a probabilistic approach based on an age-structured population model

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Restoration of spawning and juvenile habitats is commonly used to restore fish abundances in rivers, although often with undesired results. Common river rehabilitation works usually do not account for functional connectivity of habitats, i.e. the interplay of habitat quality, spatial arrangement and accessibility. Therefore, a spatially explicit, age-structured population model was developed to study the effects of habitat limitations on Common Barbel (*Barbus barbus*), a lithophilic cyprinid. Using a Bayesian modelling approach, spawning and juvenile (0+) habitat availability was integrated in the model in a spatially explicit way. Model parameters and their uncertainty ranges were obtained from reviewing the existing literature. By using a probabilistic approach, the uncertainty of the processes can intrinsically be accounted for. We hypothesize that improvement of the fish stock can be reached only when a well specified ratio of spawning habitat to fry habitat exists. Model simulations using various scenarios of habitat availabilities show that abundance improvements will follow only when a good ratio of habitat types is provided, while even substantial improvements of either spawning or juvenile habitats will result in little or no increase of abundance. When targeting restoration of fish stocks, focusing only on one key life stage or process, without considering potential bottlenecks in other stages, can result in little to no improvement. With this work we provide a tool that could be used in river rehabilitation planning to estimate the amount of habitats required for improvements as well as to set benchmarks for rehabilitation success.

RS7_O20_Assessment of the degree of fragmentation in Irish river catchments

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This study is part of an EPA-funded national project (Reconnect) which aims to develop a validated methodology for prioritising the selection of man-made river obstacles for modification or removal to improve hydromorphology and connectivity in freshwater systems. The creation of a national river obstacle inventory is a logical first step in developing this prioritisation process. Obstacles to fish migration were identified in 10 river catchments in Ireland via a GIS desk study followed by field surveys. Almost 380 obstacles were mapped, half of which were road-river crossings (culverts, bridge aprons, fords and bridge floors). The remaining obstacles were weirs, sluices or hydroschemes. Only 10% of the obstacles mapped were natural obstacles. Further, the study revealed that approximately 1 in 7 road-river crossings identified by the GIS desk study are likely to be obstacles to fish migration. The degree of fragmentation was estimated in each catchment using the Dendritic Connectivity Index (DCI), focusing on Atlantic salmon, brown trout and sea lamprey. The DCI in each river catchment varied with species, highlighting the importance of considering multiple species with different life-history strategies when making management decisions relating to obstacle removal or modification.

RS7_O21_Accounting for uncertainty in defining a fishery's safe operating space (SOS)

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Successful management of commercial fisheries in aquatic ecosystems is not a trivial task and requires the balancing between sustaining the fish population, the catch and the ecosystem under varying environmental conditions. Definition of a fishery's safe operating space (SOS) can assist managers by providing the limits in which they can safely manoeuvre. There is, however, a large degree of uncertainty associated with future conditions of aquatic ecosystems and the environmental drivers acting upon them. Furthermore, aquatic ecosystem responses to environmental drivers are often unpredictable leading to a large degree of uncertainty, in many aspects, over various ranges of temporal scales. Hence, the reaction of the ecosystem to changes in the drivers is often hard to predict. The large degree of uncertainty, at multiple levels, further confounds the successful management of aquatic ecosystems. In order to address the difficulties associated with management under uncertainty we demonstrate an approach applied to the Lake Kinneret fisheries. First, we define the SOS for a key fishery in Lake Kinneret based on varying levels of fishing efforts, lake levels, and submerged vegetation all based on historical ranges. We do so by running multiple, long term scenarios, using Ecopath with Ecosim and Ecospace models developed for the lake. We then incorporate future uncertainty in the abundance of various food web components and evaluate the impact on our predictive capabilities and our ability to provide effective advice to the lake managers. Though the uncertainty impacts our predictive capabilities the results provide effective guidelines for lake managers.

RS7_O22_Challenges and opportunities for rehabilitation of streams in a rapidly changing country

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Over-exploitation of freshwater resources, channel modification and low-quality effluents, have severely affected aquatic ecosystems in Israel. This century-long degradation, has led to an irreversible deterioration of biodiversity and a significant loss of ecosystem services. In recent years, Israeli authorities have been putting tremendous efforts in the rehabilitation of streams. These include improved wastewater quality standards, replenishment of flow, and de-channelization. Such efforts have resulted in a significant improvement of water quality in many streams and overall enhanced their aesthetic value. However, in most cases, restoration objectives and the means to measure restoration success (i.e. ecological condition) are not determined a-priory. One of the main reasons for this lacuna is the lack of a coherent policy to monitor and assess aquatic systems. In 2015, the Ministry of Environmental Protection, the Nature and Parks Authority, and the Steinhardt Museum of Natural History at Tel Aviv University, have joined forces to establish the National Centre for Aquatic Ecology (NCAE). Its main goal is to develop and implement biological monitoring of streams, using the EU Water Framework Directive as a guideline. First results confirm that the vast majority of streams in Israel are highly degraded, particularly by water depletion, flow modification and pollution. As in many Mediterranean countries, the lack of 'true' reference conditions, and ongoing anthropogenic pressures, hinder the likelihood of restoring degraded streams and attaining a "good" ecological state. Practically, identifying 'hotspots' for biodiversity and ecosystem services will enable preservation of aquatic ecosystem relicts, particularly under demographic and climatic projections.

RS7_O23_Urban runoff overflows – an important obstacle in recovery projects of reservoirs

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All projects aimed to decrease eutrophication and its expression in lakes and reservoirs should deal with phosphorus loads from the drainage basin. The most of phosphorus is emitted by point sources (communal waste waters) in Czech Republic. Despite efficiency of phosphorus elimination during waste water treatment increased substantially situation of eutrophicated reservoirs doesn´t improve. One of the most important reasons could be episodic inputs of phosphorus from urban areas during precipitation. Five events were documented in the drainage basin of Hracholusky Reservoir near Plzeň. It was found that only 2-4% of P emissions of a town during a rain event could be assigned to properly treated communal waste waters. The rest P loads originated from sewerage overflows. It seems that P from overflows represents roughly the same amount of P as is emitted from WWTP during a year. It means that we have very difficult issue to cope with in our recovery projects: (1) We need to collect more (proper) data – it means that our monitoring programs should be changed or extended (intensive sampling using automatic samplers). (2) We need to enhance proper management of precipitation water in cities – it means green roofs and facades, infiltration, storage and reuse. Both the issues require more pronounced changes of general water paradigm in our part of Europe as soon as possible.

RS7_O24_An ounce of prevention is worth a pound of cure: Managing macrophytes for nitrate mitigation in canal networks

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Ditches and canals may work as effective filter of nitrate loads. However, at present, management practices do not take into account this ecosystem service and the strategies to maximize it. Here, we summarize recent findings about nitrogene removal in the drainage canal network of the Po River lowland (Northern Italy). By means of different experimental approaches (i.e. core incubations, N_2 open-channel method, N budget, upscale models) at multiple spatial scales (mesocosms, canal, basin) we measured N removal in presence and absence of macrophytes and parametrized the most important abiotic drivers of denitrification (e.g. NO_3- concentration, water velocity, temperature). Results proved that storage in plant biomass is only a small fraction of the total N removal in vegetated canals, due to the synergic action of macrophytes and bacterial communities, mostly via denitrification. Water velocity played a key role in regulating N dissipation in slow-flow vegetated canals, likely affecting diffusion from the water column to the bioactive surfaces and thus nitrates supply to denitrification. A GIS-based upscaling of denitrification in canals at different degree of vegetation recovery support restoration of aquatic vegetation as effective and low-cost tool to mitigate N pollution.

RS7_O25_The food-web perspective in multiple-stressor research and management

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Multiple stressors are increasingly affecting organisms and communities, with the potential to drastically modify ecosystems state and functioning. Freshwater ecosystems are particularly vulnerable to various stressor types and have for instance experienced high rates of species loss during the last decades. Most studies estimate direct stressors effects and their interactions on biological endpoints such as abundance, biomass or diversity of target organism groups. While this approach yields invaluable information for impact assessments, it may be limited in providing mechanistic understanding required for management and restoration of stressed ecosystems. A major limitation lies in its exclusive focus on direct stressor effects, whereby it ignores that organism groups are interlinked by trophic and non-trophic interactions. We present a perspective on how to include food-web characteristics and biotic interactions in analyses of multiple-stressor effects on ecosystems. Examples from our own experimental work and the literature show that biotic interactions can modify stressor effects, transfer stressor effects to distant organism groups, and/or create new stressor interactions. These examples also suggest that changes in biotic interactions can have effects of similar or greater magnitude than direct stressor effects. Our approach can be used when designing studies but it can also be applied to existing biomonitoring data produced with established and intercalibrated methods and/or to novel metrics used to describe ecosystem functioning, including trait information or stable-isotope measurements. The insights on food-web mediated effects gained via our approach can substantially increase mechanistic understanding of multiple-stressor effects and in turn the efficiency of ecosystem management and restoration.

RS9 Hydromorphology, hydrology, hydrogeology, hydrochemistry

RS9_O1_Hydromorphological monitoring of rivers in Croatia – main issues and problems

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With accession to the European Union in 2013 and prior acceptance and progressive implementation of the Water Framework Directive (WFD), Croatia undertook the commitment of monitoring and assessment of the hydromorphological status of its waters. In Croatia hydromorphological research and research on the effects of river engineering on the hydrology and morphology of rivers is scarce. Only recently, in January 2015, the document *Methodology for monitoring and assessment of hydromorphological* features was published. The presentation focuses on the first national fieldwork hydromorphological assessment which is in progress since the beginning of 2017 and have covered more than 300 water bodies. Results should be implemented in the monitoring scheme and river basin management plans for the period 2022-2027. In addition, main hydromorphological problems, i.e. pressures and alterations will be presented.

RS10 Interspecies interactions

RS10_O1_Parasitism affects the biodiversity-functioning relationship

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Large evidence indicates that biodiversity can affect ecosystem functioning. For example, species might complement each other on the processing of resources, enhance or suppress the activities of other species, or cause changes in biodiversity. However, one important group of organisms that has potential to enhance diversity effects – the parasites – has largely been neglected in biodiversity and ecosystem functioning (BD-EF) research. Here, we review the literature and show the importance of considering parasitism into BD-EF studies. Parasites can reduce host population size, affect species richness, and change dominance levels within the community. Parasites might affect species taxonomic and functional composition by suppressing some species or by opening up space for invaders. Parasites can also increase intra-specific diversity by changing host phenotype, including changes to host morphology, behaviour, and physiology. Given the ubiquity of parasites in freshwater systems, we propose that parasite–host interactions should be incorporated into the BD-EF studies to improve the accuracy of studies testing how biodiversity might affect ecosystem functioning.

RS10_O2_Thermal factor in digenean larvae transmission success

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Temperature has strong influence on life processes. Endotherms, having an endogenous mechanism of body heat regulation, are less dependent on ambient temperature than ectotherms. Also, their parasites are beneficiaries of the ability to maintain the temperature of host body at constant level. In ectothermic host-parasite associations the regulation of body temperature is possible, but only in a behavioral way. The parasite can affect the host behavior, that resembles the behavioral fever or anapirexia. Facing the climate change, the excellent model for studying the temperature-dependent transmission of parasites in freshwater environments are snail-fluke associations. The aim of the study was to confront the spread of Digenea in *Lymnaea stagnalis* and *Planorbarius corneus* populations living in thermally polluted lakes versus snails inhabiting lakes of a natural thermal regime, with the results of laboratory experiments. Comparison of parasitic prevalence in both types of lakes showed significant difference between host populations, suggesting the strong dependence between ambient temperature and Digenea transmission efficiency. Laboratory experiments indicated the ability of snails to generate behavioral fever. In addition, there was a causation between parasitic invasion and the thermal behavior of hosts. Breeding experiments at a constant temperature confirmed the hypothesis that beneficiaries of thermal behavior of snails are parasites. The results allow to explain the prevalence of Digenea in snail populations inhabiting the heated waters. Such waters are a useful micro-scale model for studying the influence of climate change on parasitic transmission.

RS10_O3_*Potamopyrgus antipodarum* (Gray, 1843) as a potential biological control agent for swimmers' itch

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Increasing number of swimmers' itch from year to year, as well as alarming data on bird schistosomes migration in mammalian body leads us to undertake study on methods that may eliminate the risk for recreational water bodies. Removal of waterfowl and freshwater snails (hosts of bird schistosomes) gives limited positive effects, whereas chemical methods such as the use of molluscicides may have a dangerous impact on local fauna. Limited precision of the first larval stages (miracidia) transmission to hosts have been the inspiration for the research on the impact of alien snail species, which does not have influence on native molluscs, but it will prevent the transmission of parasites. The main objective of the planned research is to check whether the presence of *Potamopyrgus antipodarum* (Gray, 1843) in recreational water bodies can be natural protection against swimmers' itch. Experimental infection of *R. balthica* by miracidia of *T. regenti* in the presence of increasing density of *P. antipodarum* individuals was carried out. Our preliminary study indicates that the presence of non–host snails in the neighborhood of native host snails can effectively affect parasite transmission success of miracidia of bird schistosome.

RS10_O4_Non-native molluscan hosts and their parasites (Trematoda: Digenea, Aspidogastrea) in Poland

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In the last few decades non-native species, including molluscs, have been considered as key drivers of changes in ecosystem, including biodiversity loss. The success of colonization of exotic molluscs is largely connected with human activity, characteristics of new habitats and biological traits of the species. Interspecific interactions play also a crucial role in the establishment of exotic taxa in new areas. There is an extensive literature on predation or competition between native and exotic taxa, while the data on parasitism are insufficient. This may be due to several reasons, among which the complexity of life cycles of many species of parasites and the lack of comparative parasitological data from native areas of exotic hosts are essential. The aim of our study was to check whether exotic for Poland species of molluscs, including *Potamopyrgus antipodarum*, *Physella acuta*, *Menetus dilatatus*, *Dreissena polymorpha*, *Dreissena bugensis*, *Sinanodonta woodiana* and *Corbicula fluminea* can act as first or second intermediate hosts for digenean trematodes, or can be final hosts for aspidogastrean trematodes. We have found 4 species of trematodes (*Aspidogaster conchicola*, *Phyllodistomum* sp., *Rhipidocotyle campanula* and *Sanguinicola* sp.) and *Echinostome metacercariae* in collected molluscs, except for *P. acuta* and *C. fluminea* having no parasites. Further research will allow to assess whether exotic for Poland molluscs infected with trematodes can decrease the prevalence in native molluscan hosts populations and cause the 'dilution effect'. This work was partially supported by the grant of the National Science Centre, Poland No. 2017/25/N/NZ8/01345.

RS10_O5_Shallow lake multitaxonomic diversity: relative influence of environmental and biotic relationships

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Niche processes patterning local species assemblages encompass both environmental filtering and species interactions. However, although largely studied in aquatic ecosystems, biotic interactions are rarely considered for their role in community structuring, especially at a multitaxonomic level. Here, we aimed quantifying the relative influence of biological, physical and chemical factors on the community structure of macrophytes, phytoplankton, epiphytic diatoms and micro-meiofauna in a shallow lake ecosystem. To this end, we seasonally sampled 6 littoral stations around Lacanau Lake (France) during one year. At each station, phytoplankton composition was determined, macrophyte composition and phytoplankton biomass were estimated on 12 permanent plots, and 3 samples of epiphytic diatoms and micro-meiofauna were removed from 5 macrophyte species. We used structural equations to model taxonomic composition/richness and biomass of each biological group, their relationships and the relative influence of physical and chemical factors. We found that macrophyte composition was primarily patterned by physical factors whereas both chemical and physical factors influenced macrophyte biomass as well as phytoplankton biomass and diversity. Macrophyte composition was also found to influence phytoplankton richness. Diversity and biomass of epiphytic diatoms and micro-meiofauna were mainly explained by chemical factors and a strong relationship was found between these two groups. Overall we also observed that, drivers of taxonomic diversity and biomass usually varied within biological groups, suggesting that different processes influence community's structure. By modeling (a part of) the functioning of a shallow lake ecosystem, this study stressed the importance of considering multitaxonomic approaches to better understand processes patterning aquatic biodiversity.

RS10_O6_Model-based analyses of fish data provide empirical evidence for strong effects of species interactions on community composition in lakes

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The contribution of species interactions such as predation, competition and facilitation to forming local communities is an intensely discussed topic in ecological research. Clear evidence for strong effects from interactions for local community composition is mostly limited to case studies, whereas the few systematic across-community comparisons have provided ambiguous results. The major methodological challenge is to disentangle the effects of geographical and abiotic predictors from those caused by species interactions. We applied a model-based approach on fish community composition in >1800 European lakes, to find empirical evidence for contributions of species interactions to fish community composition. We ran Bayesian ordination and regression analyses of multivariate presence, biomass and size data of fish from these lakes by taking into account lake productivity, morphometry and geographical position. We show that there are several positive and negative correlations between the about 30 frequent species in the presence/absence matrix, which cannot be explained by geographical and abiotic factors. Furthermore, several pairwise correlations of biomass or mean size of the six dominant species occurring in >350 lakes remained strongly negative even after accounting for the effects of abiotic covariates, hence suggesting that predation and competition are important drivers of fish community composition in lakes.

RS10_O7_Trait based zooplankton selection of small whitefish (*Coregonus wartmanni*) and invasive three-spined stickleback (*Gasterosteus aculeatus*)

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Predation behaviour includes many different aspects, but the main driver for it is ratio between gained energy and time/risk spent. Fish are visual predators and they often go for the biggest prey they can consume according to their gape size, so their prey selection is changing significantly as they grow. Time matching of fish ontogeny and prey availability is important for interpretation of interspecies interactions and has an important ecological impact, altering zooplankton community and influencing zooplankton midsummer decline. But only size of the prey is not the only driver for fish predation, different zooplankton antipredator traits like spine size, evasiveness, conspicuousness or even eye size play important role to fish selection. We conducted prey selection, prey uptake and functional response aquaria experiments with different fish sizes (20 mm – 80 mm) in order to study: a) how planktivory fish change their predatory preferences among different zooplankton species during seasons of their first year of growth and their energy benefit of such a selection, b) how prey selection and functional response differs between Lake Constance native whitefish (*Coregonus wartmanni*) and invasive three-spined stickleback (*Gasterosteus aculeatus*) and c) how is selection linked to predator – prey traits. Our results suggest that although average size of consumed zooplankton is increasing with fish size, predation on the biggest zooplankton species occur already at early life stage of fish. We discuss importance of predator – prey size ratio and evaluate some species – specific antipredator traits of zooplankton.

RS10_O8_*Gammarus fossarum* determines species composition of macroinvertebrate communities: evidence from a three-level experiment

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Thanks to the recent development in feeding behaviour of freshwater amphipods, *Gammarus fossarum* is now regarded omnivorous rather than a simple shredder of leaf litter. *G. fossarum* is common in springs and upper courses of flowing waters, where its dominant possible prey are larvae of chironomids (Diptera: Chironomidae) and other Diptera. Despite all the evidence about its omnivory, the impact of *G. fossarum* on local communities has not been demonstrated so far. We use a three-level experiment to show how *G. fossarum* affects macroinvertebrate communities in Carpathian spring habitats. (1) In a laboratory experiment we offer *G. fossarum* several chironomid species that differ in tube protection to estimate their vulnerability to predation. (2) In a field experiment we introduce *G. fossarum* to enclosures to measure the community composition change due to the predation pressure. (3) We verify the observed patterns in natural community data collected from the western Carpathian spring fens. Consistently across all three levels of the experiment, we observed that *G. fossarum* changed the species composition of the macroinvertebrate fauna by selective predation, with free living chironomids and soft-bodied organisms such as oligochaete worms or larvae of *Atrichopogon* sp. being the most depleted. As *G. fossarum* is one of the least aggressive amphipod species, an even stronger impact of other amphipods may be expected. The study was supported by the Czech Science Foundation (project no. P505/16-03881S).

RS10_O9_What doesn't kill you, makes you stronger: Frequency of chronic predation risk determines changes in physiology of aquatic prey

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Predator pressure is a fundamental factor responsible for evolution of prey species. Under predation risk, prey individuals relocate available resources to defence mechanisms, limiting growth and reproduction. To maximize the effectiveness of defence reactions, prey increase their metabolic rate, which is related to high energy expenditure and oxidative damage. Therefore, effects of chronic predator pressure are often different than those of acute stress episodes due to exhaustion of available resources or activation of specific compensatory mechanisms. The relationship between the frequency of contacts with predators and activation of compensatory mechanisms is not known. To test the effect of low and high frequency of predation risk events (1 or 8 per day) on prey physiology, we exposed two gammarid species, *Gammarus jazdzewskii* and *Dikerogammarus villosus*, to perch kairomones for one week. To estimate prey condition, we determined levels of total antioxidant status (TAS) and oxidative damage measured as lipid peroxidation (TBARS), as well as concentrations of heat shock proteins (Hsp70) and glycogen. Both species exposed to low frequency predation risk exhibited decreased TBARS level and higher glycogen concentration. Also, stressed *G. jazdzewskii* demonstrated a lower TAS level in both predation risk frequencies and lower Hsp70 level in the high predation risk frequency treatment. We demonstrated that predation risk frequency determined physiological responses of prey. Moreover, we showed that low predation risk could improve the physical condition of prey compared to unexposed individuals. Our study was supported by the grant of the National Science Centre, Poland No. 2016/21/B/ NZ8/00418.

RS10_O10_Metabarcoding as a tool to determine feeding behavior – is the European pond turtle a threat for other endangered species ?

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Knowledge of feeding strategy and food preferences is one of the milestones of the natural history of a species and is essential to optimise conservation programs. The European pond turtle (*Emys orbicularis*, L. 1758) is the only freshwater turtle living in Switzerland and ranked as critically endangered on the Swiss Red List. Its diet is still unclear, considered by some studies as carnivorous, often scavenger and sometimes vegetarian. We conducted analyses of Emys' diet by developing a new method of global DNA amplification and metabarcoding analysis, using universal PCR primers to determine the species occurring in the faeces. The analysis of the diet of this species was conducted during its whole activity period (April to September) in the natural reserve of Moulin de Vert (Geneva, Switzerland) to determine if there is a shift in food intake during whole activity period and if diet varies between adults/juvenile and males/females. Furthermore, four different populations were sampled during the month of July to detect possible difference in food consumption. Moreover, this study not only determined the nutritional needs for the European pond turtle, but also demonstrated that this species is not a threat to its environment (predation on other threatened species such as amphibians). Globally, we were able to demonstrate, using the European pond turtle, that the genetic analyses of faeces could be an efficient tool to determine trophic networks with a very high level of precision.

RS11 Invasive species

RS11_O1_Does the invasional meltdown exist in the exotic Ponto-Caspian community in Europe?

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The “invasional meltdown” (IMD) is a prominent hypothesis in the current debate on the ecology of biological invasions. It assumes that the presence of invasive species facilitates the establishment and amplifies impact of subsequent invaders due to the dominance of positive over negative interactions among aliens. We experimentally evaluated the existence of IMD using the exotic Ponto-Caspian community in Europe (goby fishes, dreissenid mussels, amphipod crustaceans and their parasites) as a model. We found that: (1) Mussel colonies protected amphipods against predators and were actively preferred as a habitat by some amphipod species; (2) Mussels formed suitable feeding grounds for gobies due to the increase in prey density in their colonies; (3) Gobies preferred to feed on native rather than Ponto-Caspian amphipods, which can promote the latter in competition with their native counterparts; (4) Gobies modified the behaviour of alien amphipods, facilitating their coexistence; (5) More competitive amphipod species stimulated migrations of weaker competing species, which can hasten spread to new areas; (6) Parasitic microsporidia modified the behaviour of their sympatric amphipod hosts, affecting their interspecific interactions and habitat preferences, which can determine the coexistence of species in occupied areas. Thus, the number and strength of synergistic interactions within the community seem to support the occurrence of IMD. Nevertheless, a leading and dominating role of one species, the zebra mussel, in shaping most of these positive interactions challenges the universal character of the IMD phenomenon in biological invasions. Our research was supported by NCN grants 011/03/D/NZ8/03012 and 2012/05/B/NZ8/00479.

RS11_O2_Exotic freshwater fish invasions – dynamics and effects

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During the last year and a half, research in our unit has focused on the effects of exotic fish invasions on the native communities of the Italian peninsula. We produced a significant amount of publications, which we try to link and summarize in this talk. We offer a broad scale view on the dynamics and effects of freshwater fish invasions in Italy, with a particular focus on the Po River basin. First, we illustrate some of the invasion process outcomes, with a focus on dispersion pathways and distribution patterns, including the existence of exotic hotspots. We also present some long-term trends in species introduction and dispersion, as well as discuss some of their potential drivers, offering potential explanations on the patterns observed. Drawing from the outcomes of our most recent work, we outline how some potential new invasions could be happening under the radar and how some aspects of past introductions might have been overlooked and underestimated. Ultimately, we also show how these invasion processes affect native freshwater fish diversity at different scales and the ability to achieve environmental quality targets under the Water Framework Directive.

RS11_O3_Round goby vs. marbled crayfish – some notes to interactions between two important invaders

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Aquatic biodiversity is threatened by spreading of alien invasive species of different origin. Round goby *Neogobius melanostomus* represents Ponto-Caspian invaders and belongs to the most problematic invasive fish species in recent years in Europe. Round goby affects freshwater and brackish ecosystems. Round goby already invaded large European rivers such as Danube, Rhine, Vistula and Volga similarly as coastal waters near their mouths. Similarly, marbled crayfish *Procambarus virginalis* is a representative of highly invasive crustaceans, originating from North American continent. Marbled crayfish is relatively recent danger for aquatic ecosystems but already widely distributed over European continent. These two species are relatively small, bottom-dwelling species usually associated with crevice habitats. In general, they use similar niche and similar shelters. The questions opened were: If and how big crayfish can serve as a food of round goby, and how similarly sized crayfish and round gobies compete for shelters? Round gobies were in general able to swallow relatively large crayfish juveniles with not high selectivity for small or large ones, when three sizes were offered. In the experiment with similarly sized couples of crayfish and round goby, round gobies were more aggressive and more successful in competition for shelter. Crayfish were able to resist their attacks but when soft bodied after moulting, their size was not an obstacle to eat them. Finally, we made pilot studies to open the broader exploration of their interaction in near future.

RS11_O4_Is there a positive effect of an invader? Recognition of heterospecific alarm cues between an alien Ponto-Caspian goby and a coexisting native cyprinid fish

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Alarm cues released from damaged prey tissue after a predator attack indicate high predation risk. Such information can invoke a widespread response of potential prey individuals, including heterospecifics that are able to use the signal. Their odds to benefit from heterospecific signals increase when the species are closely phylogenetically related and/or coexist and share the same predators. Given this, biological invaders may support and/or benefit from assemblages of their native counterparts. Using a laboratory behavioural assay, we tested within and between species responses of two coexisting for a short time fish species (alien and native) in European waters, the monkey goby *Neogobius fluviatilis* and gudgeon *Gobio gobio*, to damage-released alarm cues (skin extract). We found that the two species differed in their responses. The gudgeon responded to both signals, but its response to conspecifics was much stronger compared to that elicited by heterospecifics. The goby responded to conspecifics only, and this response was weaker than that of the gudgeon. Our results suggest that the native species might benefit from the presence of the alien species by receiving more information about the environmental predation risk. Our research was supported by NCN grant 2016/23/B/NZ8/00741.

RS11_O5_Ecological impact of the round goby *Neogobius melanostomus* (Pallas, 1814) towards hard-bodied benthic prey in dependence upon its type, ratio and density: functional response in lab

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The highly invasive fish – round goby (*Neogobius melanostomus*; RG) significantly alters food webs in newly invaded ecosystems with special emphasis upon macrozoobenthos assemblages forming the most important component of RG diet. We investigated the foraging efficiency and capacity of the RG juveniles (TL = 50-62 mm) in dependence on prey type, density and ratio using functional response approach in the experimental conditions. We used two hard-bodied preys. Native waterlouse (*Asellus aquaticus*; W) that occurs in RG diet and non-native marbled crayfish (*Procambarus virginalis*; MC) that is successfully invading European freshwaters. The latter represents also model species for assessment of RG feeding impact upon crayfishes, including native ones, because RG recently often enters big rivers tributaries inhabited by indigenous crayfishes. Both preys were offered either separately or in 3 different ratios (1:1, 3:1 and 1:3 of W:MC) and in 6 densities. With both prey species, the RG exhibited type II functional response, with significantly higher search rate for MC. In both 3:1 ratios, the RG killed significantly higher number of prevailing prey, regardless of prey type, whereas in all 1:1 ratios no differences in non-consumptive mortality and eaten prey number were found. To sum up, it seems that RG as a predator decides upon prey availability only, regardless of prey species, i.e. the most impacted macrozoobenthos organisms in newly invaded regions by RG are those reaching the highest abundance. This non-selective prey consumption may be consider one of key advantage of RG for successful establishment and spread in a new environment.

RS11_O6_The role of human in the distribution of *Phoxinus* (Cyprinidae): tracking introduction pathways and first molecular evidences of the European minnow in the Douro Basin (Iberian Peninsula)

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Biological invasions are a major threat to global biodiversity. Freshwater ecosystems are particularly prone to introductions, and the number of non-native species has increased exponentially during the last decades. The Iberian Peninsula is no exception, and all major basins are currently inhabited by several non-native species. However, knowledge is often lacking regarding the history of introductions, which hinders a quick assessment and implementation of possible management actions. In this study, 966 individuals of the genus *Phoxinus* were detected in 10 out of 138 stream sites sampled across the Douro Basin in 2017 and 2018. A total of 26 individuals were barcoded using the cytochrome c oxidase subunit I (COI) marker. Our results revealed the first record of *Phoxinus phoxinus* in the western Douro, with haplotypes closely matching those from the population from Charente River (southern France). The remaining 21 individuals sequenced from watercourses in eastern Douro were genetically confirmed to be *P. bigerri*, the species previously reported in the region. We show evidence of two distinct introduction pathways: a more recent introduction of *P. phoxinus* following documented human immigration trajectories between France and Portugal, and more ancient introductions of *P. bigerri* due to fishing practices between nearby streams from Spain. Our study highlights the value of molecular approaches for early detecting new introductions pathways and tracking spread history, which can be relevant for preventing future introductions.

RS11_O7_Habitat use of invasive monkey goby and pumpkinseed in Lake Balaton (Hungary)

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Detailed knowledge on the habitat preference of invasive fishes and the bias of different fishing methods in determining their population dynamic parameters are essential in fisheries management, ecology and conservation. This study was conducted to determine the distribution and habitat use of the invasive monkey goby and pumpkinseed in the littoral zone of Lake Balaton (Hungary), and to compare the relative efficiency of electrofishing and fyke netting in determining their abundance. In general, both species preferred anthropogenically modified habitat types (rip-rap shorelines and harbours) compared with natural reed habitats. However, sampling gear and habitat interaction terms were significant. This study, which includes the first detailed data about the habitat use of the highly invasive monkey goby in lakes, suggests that invasive species may benefit from the alteration of the littoral zone of lakes. It also highlights that reliance on single gear surveys can be misleading in assessing habitat use and population structure of invasive fishes.

RS11_O8_Double threat – can global warming increase physiological cost of antipredator response of native and invasive gammarids?

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With global communication and trade routes, invasive species are common. Often less susceptible to native predator pressure, the invasive species pose a threat to the native ones, both in inhabiting their ecological niche and also as new predators. The raising water temperatures can make it harder for native species, such as *Gammarus jazdzewskii*, to survive, especially in conditions of high predator pressure whereas Ponto-Caspian *Dikerogammarus villosus*, having broader temperature tolerance and effective defense strategy will be able to function well in a changed environment. To check how global warming and predation may affect native and invasive species, gammarids were tested in a temperature range 17–23°C in the presence or absence of perch kairomones. Since stressors in the form of raised temperature or predator presence induce oxidative stress, we assayed metabolic rate, total oxidative status, total antioxidative status and heat shock protein concentration along with the concentration of malondialdehyde – an indicator of lipid peroxidation (indicating oxidative damage). The two tested species have a different tolerance to raised water temperature and anti-predator strategy. *D. villosus* tolerates broad range of temperatures, whereas *G. jazdzewskii* prefers the cooler environment. Moreover, invasive species suffer lower cost of defense reaction then native one. Therefore, interaction between non-optimal temperature and oxidative damage generated by predation risk will promote the invasive species in the changed environment. This hypothesis will be discussed during presenting the conducted research and its results.

RS11_O9_Distribution and ecology of peracarid crustaceans in the River Danube – insights from the 3rd Joint Danube Survey

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The dataset of the 3rd Joint Danube Survey (2013) offered valuable insights into the distribution and ecological interactions of peracarid crustaceans in the river. The combined presence-absence data of all three sampling methods used during the survey (multi-habitat sampling, kick-and-sweep, and dredge) allowed the analysis of longitudinal distributional patterns in the river with special emphasis on the range expansion of Ponto-Caspian species. Based on the quantitative data of the multi-habitat sampling, we further examined the habitat preferences of the species using RDA-based variance partitioning between environmental and spatial explanatory variables. The analysis comparing invasive and non-invasive Ponto-Caspian species indicated the affinity to hard substrates as the main factor of invasion success within the group, which allowed the assessment of future invasion risks. Another study focusing on the three *Dikerogammarus*-species indicated current velocity as the main axis of niche differentiation among them, providing explanation for their peculiar distributional patterns. A similar analysis could not explain the abundance patterns of *Chelicorophium*-species effectively; however, considerable interspecific differences in the filter mesh size indicated the decisive role of the size distribution of suspended food particles. Yet another study was aimed at revealing the mechanisms by which coevolved Ponto-Caspian peracarids can coexist with *Dikerogammarus villosus*. The results showed several different strategies, often related to morphological and behavioural characteristics.

RS11_O10_Possible roles of killer shrimp (*Dikerogammarus villosus*) in relation to invasive crayfish

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Freshwater ecosystems are facing establishments of alien species, which, in certain cases, exhibit invasive characteristics. The impacts of particular aliens on native communities have been often highlighted. However, the number of aliens is permanently increasing. As a result, novel and often unexpected species compositions of alien and native species are established. Invasive species can negatively act in synergy when several of them co-occur. Naturally, invaders can also affect each other. This study assessed the potential of an invasive amphipod, the killer shrimp *Dikerogammarus villosus* (Sowinsky, 1894), which is native to the Ponto-Caspian basin, to cope with other established invaders in European waters, the North American crayfish (signal crayfish *Pacifastacus leniusculus* (Dana, 1852) and marbled crayfish *Procambarus virginalis* Lyko, 2017. These species increasingly co-occur in the European freshwaters. The main goal of this study was to demonstrate that killer shrimp, beside its role as a prey organism of larger crustaceans, can significantly influence their stocks by predation on their eggs, hatchlings and free-moving early juveniles. Experimental work confirmed that killer shrimp is capable to predate on crayfish eggs and hatchlings even directly on female's abdomens, where they are incubated and presumably protected. Hatchlings and early juveniles of signal crayfish were affected, while marbled crayfish was affected more (smaller size of juveniles) and even by eggs consumption due to their smaller size and thinner egg shells. The results confirmed killer shrimp as dangerous invader with an ability to influence even the populations of larger freshwater crustaceans.

RS11_O11_Riverbank burrowing by signal crayfish (*Pacifastacus leniusculus*): quantifying rapid behavioural change in native and invasive populations

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Crayfish are globally one of the most prolific invaders of freshwater habitats as a result of their environmental plasticity and adaptive behaviours. In its native North American range, signal crayfish (*Pacifastacus leniusculus*) are considered a non-burrowing species. However, in the UK signal crayfish burrow prolifically into riverbanks, causing deleterious ecological and geomorphological effects. However, we do not currently know what biotic or abiotic factors control this rapid evolution in behavioural change. A series of mesocosms were constructed containing simulated river banks to allow the burrowing behavioural responses to be quantified and the factors controlling burrowing activity characterised. Specifically, the experiments aimed to examine how the availability of refuges and crayfish population density influenced burrowing activity. Four crayfish populations were examined – two in the UK comprising a site where burrowing was extensive and another where burrowing did not occur; and two populations from the USA – one from within its native range and another where signal crayfish have been recently introduced. At low population densities, the availability of refuges significantly reduced the propensity for crayfish to burrow by up to 100%, however this affect was reversed at high densities. There was no significant difference in burrowing response between the two established UK populations and the native USA population, however the recently introduced USA population constructed significantly larger burrows (260%) under every treatment. These results suggest that all signal crayfish have the ability to burrow, but that conditions at the invasion front drive the expression of this change in behaviour.

RS11_O12_Can season and parasite infestation change the behaviour of zebra mussels?

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The zebra mussel *Dreissena polymorpha* is one of the best-known invasive aquatic species. It was shown to exhibit a number of defences against adverse environmental factors, but the potential impact of season and related reproductive effort on its responses is not known. We checked how selected biotic factors (alarm substance secreted by injured conspecifics and the presence of the gammarid *Dikrogammarus villosus* naturally occurring in mussel colonies) affect mussel valve gaping in July and November. We assumed that in July mussels exhausted by intense reproduction, should be less sensitive to stress factors than individuals tested in November. After behavioural experiments, we checked the stage of gonad development of each individual with histological methods to confirm inter-seasonal differences. Unexpectedly, we also observed echinostomatid metacercariae (Digenea) on histological slides. Thus, we took their presence into account as an additional factor potentially affecting mussel behaviour. Compared to November, in July we noted more frequent valve movements in females and more time spent with widely open valves in both sexes. Irrespective of season, mussels responded to gammarids by spending less time with widely open valves. A similar response to the alarm substance was shown only in November. Moreover, parasite-infected mussels showed a higher number of valve movements. Our results suggest that such factors as season and parasite infection should be taken into account in future studies on this species. Moreover, mussel responses to mechanical irritation (by gammarids) seem stronger than those to predation cues. Our study was supported by a National Science Centre grant 2015/17/N/NZ8/01653.

RS11_O13_Consequences of river bank stabilization for the abundance and secondary production of invasive macroinvertebrates in a large river

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Invasive species are colonizing freshwaters worldwide due to (i) enhanced connectivity and (ii) anthropogenically altered local habitat conditions, i.e. river bank stabilization, which have been shown to drive their long-term establishment and impact on the ecosystem. However, the role of such habitat modifications on the abundance and biomass of invasive species is difficult to quantify as natural reference sites are often lacking in modified rivers. Here, the Mulde River (Germany) represents a unique opportunity to assess the effects of bank stabilization, as it is one of the very few larger European rivers not used for navigation, thus exhibiting near natural reaches alongside common rip-rap installations. We hypothesized that rip-rap installations proliferate the occurrence and secondary production of invasive benthic macroinvertebrate species. To test this, we studied species richness in three river reaches with varying shoreline engineering; one with natural, non-modified banks, one with rip-rap installations on the cut banks but a natural slip-off bank and one with rip-rap installations on both banks. We found an increasing abundance of invasive species with the extend of engineered shoreline structures, with *Dikerogammarus villosus* and *Potamopyrgus antipodarum* dominating the macroinvertebrate community in the reach with two rip-rap banks. Measurements of secondary production of those species are ongoing and we expect both community biomass and secondary production to be strongly driven by these invasive species in the modified river reaches. Thus, we expect a much higher functional importance of invasive species for benthic invertebrate food webs in modified rivers reaches compared to natural reaches.

RS12 Karst

RS12_O1_Impacts of calcium carbonate deposition on phosphorus availability in aquatic ecosystems

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Calcium carbonate ($CaCO_3$) deposition is a common phenomenon in groundwater-fed systems and is often linked to low phosphorus availability. However, whether or not $CaCO_3$ deposition causes nutrient-stress to microbes living in streams remains unknown. Here, we compare results of experimental reductions of photosynthetically-induced $CaCO_3$ deposition in oligotrophic streams with (Garden Canyon, Rio Mesquites) and without (Ramsey Canyon) active $CaCO_3$ deposition. In the canyon streams, we measured nitrogen (N) and phosphorus (P) spiralling patterns. In Garden Canyon, P uptake lengths increased in response to shading and upstream shading lead to a decrease in N uptake lengths downstream, suggesting $CaCO_3$ deposition causes P-limitation of phototrophs in this system. In Ramsey Canyon, N and P responded to shading: N uptake lengths increased and P uptake lengths decreased, suggesting P-limitation of heterotrophs. Surprisingly, other measures of nutrient limitation (e.g., nutrient amendment bioassays, periphyton biomass nutrient content) indicate N-limitation of primary production in both streams. In Rio Mesquites, shading led to decreases of P uptake, but not all microbial communities were limited by P for growth. Therefore, while our results support the role of $CaCO_3$ in decreasing phosphorus bioavailability, they also highlight the importance of considering indicators of nutrient limitation at multiple scales.

RS12_O2_How will the macroinvertebrates cope with the projected environmental changes

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The Plitvice Lakes National Park is the oldest, largest and best-known national park in Croatia, listed on the UNESCO List of World Heritage sites. Global changes, including mass tourism however, exert some pressures on the habitats therein, mainly through changes in organic matter load and in hydraulic conditions. One of the best ways to monitor the extent of the changes is by studying macroinvertebrate assemblages. Macroinvertebrates are a heterogeneous group that are central in energy and matter cycles in aquatic ecosystems. The aim of this study was to compare the composition of macroinvertebrate communities and amount of organic matter at different habitats within the Plitvice lakes. The samples of macroinvertebrates were taken at the spring of Bijela rijeka and at the tufa barrier Labudovac at habitats with different flow conditions – fast and slow flow. At the spring, physicochemical parameters were constant throughout the year and at the tufa barrier, they oscillated seasonally. At the barrier site, level of organic matter and total number of individuals were higher, but total number of taxa was lower than at the spring. At both locations, number of taxa was higher in fast-flowing areas. Results of this study should contribute to understanding how humans impact macroinvertebrate assemblages and organic matter dynamics. Furthermore, these results can support conservation decision making and help minimize negative effects of global changes and human impact in these important habitats.

RS12_O3_Interdisciplinary approach for sustainable management of reactivated channels along Skradinski buk tufa barrier

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Skradinski Buk is the seventh, final and longest tufa barrier in National Park Krka, Croatia. Despite numerous actions ensured by National Park protection category, uncontrollable growth of an invasive plant species *Ailanthus altissima* (Mill.) Swinge resulted with dried water channels along the Skradinski buk barrier. Removal of A. altissima reactivated five channels, which had been dried for decades. The invasive species was first removed during summer 2017, followed by several repetitive removals in the following months. Samples of periphyton and tufa were collected monthly, in the period from October 2017 to December 2018, from two control sites and five revitalized water channels, using a core sampler. In the frame of multidisciplinary research, physico-chemical, biological and geological parameters were measured. Reactivated channels showed higher nitrites concentration, lower pH and dissolved oxygen concentration caused by higher organic matter content originating from forest soil developed on tufa barrier during dry phase. Periphyton community showed more diversity in reactivated streams in comparison to control, presumably due to lower competition and predatory rates and/or intensive organic matter decomposition processes. Results of granulometric analysis displayed variations in grain size depending on season. During autumn and winter, more intensive rainfall and higher water erosion washed away sandy and muddy particles leaving only lithified tufa remains at all sites. Environmental data and periphyton assemblage patterns indicate establishment of stable conditions in the reactivated channels of Skradinski buk tufa barrier. Our results emphasize the need for interdisciplinary approach in long-term and sustainable management of the tufa barriers.

RS12_O4_Perennial phenology patterns and ecological traits of Dixidae (Insecta, Diptera) in lotic habitats of a barrage lake system

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Dixidae are important ecological components in freshwater ecosystems. They are merolimnic insects with larvae and pupae living in aquatic habitats. The goals of this study were to determine the phenology patterns and main ecological factors that influence Dixidae and to analyse their preference for microhabitats. Adult Dixidae were collected monthly in the period from 2007 to 2014 at 10 sites in the Plitvice Lakes National Park. Adult specimens were collected using pyramid-type emergence traps. A total of 1271 Dixidae were collected during eight years of study belonging to five species of the genus *Dixa. Dixa submaculata* was the dominant species at the spring and upper reach of Bijela rijeka Stream and the upper reach of Crna rijeka Stream. *Dixa nebulosa* was dominant at the Kozjak-Milanovac tufa barrier site. *Dixa puberula* was the dominant species at the rest of the sites. *Dixa puberula* and *Dixa submaculata* were univoltine, bivoltine or trivoltine, depending on the site, while *Dixa nebulosa* was univoltine. The highest diversity was recorded at the tufa barrier Kozjak-Milanovac, and the highest number of species (four species), was found at the upper reach of the Crna rijeka Stream. The greatest number of specimens was recorded at the Labudovac tufa barrier, 128 specimens in 2014. Water temperature is the main ecological factor that influences the phenology of Dixidae at the tufa barriers and lower streams. *Dixa puberula* prefers moss as a substrate and a faster water velocity.

RS13 Lakes, reservoirs and ponds

RS13_O1_Global-scale patterns in the seasonality of freshwater lakes

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Aquatic primary production, phytoplankton biomass and composition vary over multiple temporal scales in response to changing climatic conditions, nutrient availability and interspecific interactions. Recurring seasonal patterns are dominant features of this temporal variation, but much of what we know about seasonal change in freshwaters comes from studies of single sites, or networks of sites, where in situ monitoring schemes exist. However, bio-optical data from satellites could transform the scale at which freshwater ecosystem states and processes are investigated, making it possible to build a global-scale conceptual framework of patterns and drivers of seasonality in lakes. Here, we present results from the GloboLakes (http://www.globolakes.ac.uk/) project, which aims to make this ambitious leap. Analysing monthly chlorophyll-a data from ~1000 lakes across the world, from 2002 to 2012, we show systematic variations in satellite data availability with geographic location, elevation and lake type. Taking this into account we show, nevertheless, that the amplitude of seasonal variation in phytoplankton biomass varies not only across the world, but also with lake morphology and the extent of human impacted land-use in catchments. These results will provide a global–scale benchmark against which future changes in seasonality, with environmental change, can be assessed.

RS13_O2_Drivers of zooplankton assemblages in temporary ponds between different latitude and climate

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Temporary ponds are characterised by seasonal and interannual water level fluctuation, and are often exposed to anthropogenic impacts i.e. nutrient leaching, fish invading, waste deponia, and landfill caused by tourism expansion. Due to their small depth, area and volume, succession of these aquatic ecosystems leads to terrestrification. However, these ponds increase landscape heterogeneity and are known to be hotspots of species diversity, especially of aquatic invertebrates. Zooplankton is a significant part of invertebrate biodiversity in these habitats, and plays a pivotal role in the trophic network between primary producers and higher-level consumers. We assessed zooplankton assemblages in temporary ponds of different European latitudinal and climatic regions: Poland versus Croatia, and continental versus Mediterranean, respectively. The main goals were: (i) to analyse the impact of macrophyte coverage, fish and length of hydroperiod and (ii) to distinguish regional or climate specific environmental factors affecting zooplankton. The results indicated that biotic drivers mainly influenced zooplankton assemblages: phytoplankton biomass and macrophytes positively, while the presence of fish affected animals negatively. Rotifers, otherwise often neglected in zooplankton studies, in both groups of ponds, significantly supported biodiversity zooplankton diversity, especially semiplanktonic species in macrophyte-covered ponds. Salinity is indicated as a regional specific driver, i.e. in the Mediterranean region it negatively impacted species diversity. Cladocera and Copepoda were the most vulnerable to fish predation whilst Rotifera were less affected. The results suggested the significant importance of zooplankton for the essential preservation of these specific ecosystems, supporting sustainable development and the conservation of species and landscape diversity.

RS13_O3_Whole-lake ecosystem metabolism in two contrasting Estonian lakes

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Lake Nohipalo Mustjärv and Lake Nohipalo Valgõjärv are two small (22.2 ha and 7 ha respectively) water bodies in Southeastern Estonia. Mustjärv is a dystrophic dark-colored (Secchi depth 0.4 m) soft-water, shallow (max depth 8.9 m; mean 3.9 m), dimictic system. Valgõjärv, located only 500 m away, represents an oligotrophic, light-colored (Secchi depth 4.5 m) soft-water (HCO_3^- < 80 mg L^{-1}), shallow (max depth 12.5 m; mean 6.5 m), dimictic lake. Both lakes were equipped with Onset HOBO dissolved oxygen (DO) and water temperature/light loggers since late autumn 2015 to capture high-frequency changes of measured parameters in several depths over the two years period (until mid-October 2017). Using continuous data of DO, global irradiance, and water temperature, we estimated whole lake net ecosystem production (NEP), community respiration (CR) and gross primary production (GPP) within Bayesian framework. Ice cover lasted between 91 to 150 days in those two winters. Both lakes were stratified up to 200 days in open water periods. Studied lakes acted strongly as net heterotrophic water bodies in under-ice conditions, caused by the light limitation which turned the GPP close to zero. Epilimnion of both lakes turned to net autotrophic conditions for open water periods, while metalimnion switched between net auto- and heterotrophy. Hypolimnion of Mustjärv had enough oxygen (> 2mg L^{-1}) more than 63% of the time while in Valgõjärv, bottom of the lake, lacked oxygen for almost 72% time of the study period.

RS13_O4_Nitrogen in Estonian lakes – expected impacts and knowledge gaps

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The relative role of nitrogen (N) and phosphorus (P) reduction to control eutrophication in lakes continues to be debated. A strong statement made in 2008 by famous Canadian lake researcher David W. Schindler and co-authors about the irrefutable leading role of P provoked immediate criticism from leading US scientists Robert Howarth and Hans W. Paerl arguing that diminishing only P inputs has not been effective for eutrophication reduction in estuarine and coastal ecosystems, and both N and P control is needed. The debate that has lasted over 10 years by now, has not discredited the importance of P control but displayed also plentiful evidence on wide-ranging significance of N reduction to recover lake ecosystems. So far, Estonian limnologists have been generally P-believers and N manipulation as a tool for lake water quality management has been largely neglected. The faith into P management has been based mainly on the post-socialist experience – sharp reduction of N loading brought back cyanobacterial blooms to Lake Peipsi. Moreover, in the N-rich alkalitrophic lakes (e.g. Lake Äntu Sinijärv), P concentration is low due to bounding with Ca and water is exceptionally clear without any eutrophication symptoms. It is now the time to revise our P-centred opinion as recent piling information is suggesting the critical need to consider also N in lake management plans. In SEFS we will present N and P dynamics and trends in Estonian lakes, analyse the connections with phytoplankton community and evaluate the potential scenarios of eutrophication management.

RS13_O5_Changes in the macrozoobenthos of a small northern lake from 2002 to 2017

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Long-term macrobenthic data from a small lake (area 0.5 km^2, maximal depth 32 m, mean depth – 12 m) in the North Karelia (Northwestern Russia) were analyzed. Samples were taken at three sites situated in littoral (depth 0.5 m), sublittoral (8 m) and profundal (30 m) zones mainly during ice-free period (as a rule 5 times a season). Macrozoobenthos was dominated by amphipods (*Gammarus lacustris*, *Gammaracanthus loricatus* and *Monoporeia affinis*) and a few chironomid species. All dominant taxa showed practically synchronic interannual variations. Mean annual biomass of macrozoobenthos varied from 2 to 12 g WW m^{-2} at littoral site and from 1 to 3.0 g WW m^{-2} in the deeper areas of the lake. The maximum values were observed in 2003 – 2004 and 2014 – 2015 and coincided with years of high phytoplankton development. Apparently, the main role in forming of dynamic of lake communities was played by processes in the catchment area determining primary production. The most probable mechanism connected with changes in nutrients inflow from watershed due to interannual variations of atmospheric precipitations and overwinter processes generally associated with alternation of positive and negative phases of the Arctic Oscillation. Winter near-bottom oxygen conditions at the end of ice-covered period also governed the development of macrozoobenthos in the deep-water areas of the lake.

RS13_O6_The effect of changes in water residence time and stream inflow temperature on stratification dynamics and mixing in a small temperate lake

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Water residence time (WRT) is a key determinant of lake ecosystem functioning, affecting the supply of nutrients and organic matter, the time available for in-lake processes to occur, and for biotic communities to develop. The physical effects of changing WRT, including stratification dynamics, are currently less well understood than the chemical and biotic effects. The duration, strength and timing of stratification can affect processes such as the mixing of chemicals in the water column, nutrient internal loading and the light climate experienced by primary producers. This study utilises the General Ocean Turbulence Model (GOTM), calibrated using data from Elterwater, a small lake in the UK, to investigate the effects of WRT and inflow-temperature changes on in-lake temperature dynamics and stratification. Initial results show that longer WRTs increased summer average temperatures, decreased winter average temperatures and increased summer water-column stability. At shorter WRTs, the length of summer stratification was marginally shorter but the total number of time steps for which the lake is stratified increased. Drivers of these patterns, including the heat flux exerted by the stream and its contribution to the overall heat budget of the lake, will be discussed. An understanding of the effects of WRT is vital to the projection of impacts of future changes in local and global patterns of stream discharge upon lake ecosystem functioning.

RS13_O7_Understanding sediment transport processes – coupling erosion with reservoir siltation

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Sediment or suspended solids are the main factor limiting reservoirs lifetime and deteriorating water quality. Sediment originating from the soil loss in agricultural land or the bare soil in a watershed, ends settling downstream in a reservoir where the flow velocities become minimal. For a better understanding of the processes and a better estimation of sediment input, we implemented a multiple methodology approach of modelling and monitoring, first by calculating the eroded material and then by finding the actual sediment mass that was reaching the reservoir. The research area is Passaúna Reservoir in southern Brazil, located southwest from the metropolitan area of Curitiba. We calculated the soil loss in a monthly basis by using monthly R factors and monthly vegetation cover data from Sentinel 2 satellite system. For checking the plausibility of the RUSLE we also conducted sprinkling experiments in 1 m2 plots in agricultural lands. A monitoring station was installed at the entrance of the reservoir for measuring the actual sediment input. The station collected mixed water-sediment samples in a two weeks basis during one year. For a long term sediment mass balance also the actual sediment volume in the reservoir was measured by extensive hydroacoustic and sediment sampling campaigns. From the comparison of the methodologies, RUSLE is underestimating the actual sediment input. The main issue seems to be related to the sediment delivery ratio (SDR). With the actual sediment input and the modeled erosion we derived local, specific SDR for a precise estimation of the total sediment input.

RS13_O8_Calcite precipitation, a major driver of carbon fluxes in lakes and reservoirs

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The precipitation of calcium carbonate is a relevant process in the carbon cycle of lakes and reservoirs. It can imply a significant burial of carbon into lake sediments, as well as strongly determine CO_2 dynamics whereby interactions with the inorganic carbon equilibria have direct effects on the concentration of dissolved inorganic carbon (DIC) species, including CO_2. Recent evidence suggests that calcite precipitation could be a major source of CO_2 in lakes of high alkalinity, leading to CO_2 supersaturation. In lakes calcification is tightly coupled to primary production, apparently due to a nucleation effect of picophytoplankton. While the geochemical importance of calcite precipitation as a driver of air-water CO_2 fluxes is well established for marine systems, its role on carbon dynamics in freshwater systems is traditionally assumed to be negligible, under the assumption that most lakes have too low alkalinity for these processes to be relevant. In this communication we will review past and recent evidence of the important role of calcite precipitation in driving carbon dynamics in freshwater systems, identifying alkalinity thresholds that allow synthesizing its role on a global scale.

RS13_O9_A strong variation of δ13C signal over the years in oligotrophic reservoir

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Stable isotopes analyses (SIA) is an important tool for addressing complex issues in freshwater ecology and providing deep insight into ecosystem functioning. However, the spatial and temporal variability can be challenging for data interpretation. We thus investigated temporal variation of stable isotopes signal in Nýrsko reservoir, a canyon-shaped, oligotrophic reservoir in West Bohemia region, Czech Republic. All biological units and environmental features of reservoirs' ecosystem were sampled for three years from 2014 to 2016 for assessing drivers responsible for stable isotopes variation. Results indicated differences in $\delta^{13}C$ and $\delta^{15}N$ in each species/functional group over the years. While in fish and in crayfish the differences in $\delta^{13}C$ were 3-5 ‰ and 4 ‰ respectively, in zoobenthos were much higher, reaching 10 ‰ over the years. However, the $\delta^{15}N$ variability were quite similar across the species/functional group (2-4 ‰) during the study period. Moreover, when we assessed the contribution of the different food sources of each target organism (Bayesian mixing model run in MixSiar-package), any significant changes in main food sources for species or functional group were found over the years. We assume that variation in stable isotopes signals is not due to changes in trophic chain. Our preliminary results suggest that flooded area of reservoir is a major driver of variation in stable isotope signal, however, more environmental factors need to be tested to confirm or deny this hypothesis.

RS13_O10_Zooplankton in Mediterranean ponds – some implication for conservation measures

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Small water bodies e.g. ponds have several important ecosystem functions, such as landscape heterogeneity and increase of local and regional biodiversity. Shallow ponds are often only freshwater habitats on Mediterranean islands. We sampled zooplankton (Rotifera, Cladocera, Copepoda) together with macrozoobenthos, fish and macrophytes in twenty small ponds situated on Rab, Dugi otok and Korčula island (Adriatic Sea, Croatia, Europe). Also, water samples were collected in order to obtain detailed physico-chemical parameters. The main aims were to determine impact of top predators (fish or invertebrates), and main abiotic factors that shaped zooplankton in small ponds. Fish presence strongly reduced zooplankton density and diversity, and especially negatively affected Cladocera and Copepoda. Macrophytes had dual influence on zooplankton: dense macrophyte coverage supported high density of semiplanktonic species, while low macrophyte coverage provided high density of euplanktonic rotifers and cladocerans. Also, macrophytes diminished predatory influence of macrozoobenthos on plankton assemblage. Out of abiotic factors, increased salinity was most important factor and it negatively affected species diversity. Our results have shown that fishless ponds with mixture of macrophyte stands and open water support higher invertebrate diversity. Habitat heterogeneity is one of the most important driver in formation of "healthy" ponds and in slowing down inevitable succession. Thus, maintaining of mosaic habitats should be considered as one of the key elements in future conservation and management of small isolated ponds.

RS13_O11_Wind and lake characteristics drive algal growth in a large and turbid delta lake (lake Markermeer) after oligotrophication

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Nutrient concentrations in lake Markermeer, a large and shallow lake in Rhine delta in the center of the Netherlands (700 km^2, average depth 4 meter), have strongly declined in the last decades due to effective water quality management in the catchment. However, chlorophyll levels did not change accordingly. Nowadays, dissolved nutrients are specifically provided by mineralization processes in the sediment, and algal growth is stimulated by wind induced resuspension of these sediments. Previously, we found that resuspension leads to the formation of limnetic aggregates with high phosphatase activity, making resuspension a key process in the ecological functioning of this large lake. Since resuspension is driven by wind and lake characteristics, spatial and temporal differences are expected that need to be taken into account to be able to estimate whole lake productivity. Therefore, we performed high resolution sampling during a whole year over a 13 km long transect covering both macrophyte dominated shores and bare sediments in the middle of the lake. Large differences in resuspension were observed, related to weather conditions and the presence of macrophytes in the growing season. We established relationships between resuspension, underwater light conditions, nutrient availability and algal densities. With these relationships we show how after decades of re-oligotrophication, wind and lake characteristics now drives algal growth in this lake delta lake.

RS13_O12_Phytoplankton community dynamics in Basque reservoirs: pigment and microscopic approaches

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From May 2018 to February 2019, eight Basque reservoirs belonging to the water-supplying network of the Bilbao Bizkaia Water Consortium (CABB) were studied. Along five campaigns, field data, biotic and abiotic samples were taken. The phytoplankton community was described through traditional counting under light microscope. Also their seasonal pigment dynamics were analysed with High Performance Liquid Chromatography. Results generally showed similar patterns in the structure associated to their common oligo-mesothrofic state and their limited algal biomass. Diatoms, cryptophytes and chrysophytes dominated the spring communities while green algae and cyanobacteria thrived in the warmer campaigns. Special attention was paid to the thriving of potentially harmful cyanobacteria such as *Microcystis aeruginosa* or *Planktothrix isothrix*, which showed, isolated bloom episodes in some of the systems. As for the pigment community, fucoxanthin, alloxanthin, lutein, zeaxanthin and Chlorophyll *b* were identified as major pigments, accordingly to that observed in the countings.

RS13_O13_Development of macroinvertebrate based index for monitoring and assessment of Croatian man-made lakes

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Man-made freshwater habitats have been widely used to modify the environment for human benefit, including irrigation, flood control or electricity generation purposes. This is the first effort to establish a biomonitoring method for these habitats in Croatia. Benthic macroinvertebrates were sampled during low water level periods from July to September in 2016 or 2017, applying a modified proportional stratified sampling approach. The study encompassed a total of 31 man-made lakes, of which 16 were located in the Dinaric Western Balkan ecoregion (ER 5) and 15 in the Pannonian Lowland ecoregion (ER 11). The majority of these sites are reservoirs built on smaller or larger rivers, while several are anthropogenically-impacted natural lakes (e.g. Pološko Blato, Sakadaš, Njivice) or artificial lakes and gravel pits (e.g. Ponikve, Šoderica Koprivnica, Rakitje). Pearson's correlation analysis was used to test the relationship between environmental variables, stressors and macroinvertebrate metrics. CCA was conducted in order to test the strength of selected metrics to environmental variables and pressures, but also to determine the presence of redundant metrics. Reference conditions for two lake types were estimated by the hindcasting procedure using multimetric linear regression of stressors, abiotic parameters and biological data. Three benthic invertebrate metrics, the number of families, the Margalef diversity index and the abundance (%) of Chironomini were finally extracted as the most significant, responding to fish stocking, non-natural land use in drainage area and Chl *a* concentration. The final index was expressed as the arithmetic average of the above three metrics.

RS13_O14_Man-made vs. natural lakes: a story told by chironomid community

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Standing water bodies can be both natural and man-made. The latter can be used for the production of electric energy, irrigation or flood control and are often created by flooding an existing river valley thus causing a decrease in macroinvertebrate diversity of the area. The Chironomidae family (Insecta: Diptera) is widely distributed and often among the most abundant taxa in benthic macroinvertebrate communities of standing water bodies, and are frequently used in the ecological quality assessment of freshwater habitats. The main goal of this study was to determine whether man-made lakes can support the same amount of chironomid diversity as natural lakes and what criteria must be met. Both man-made and natural lakes were studied. Littoral macroinvertebrate samples were collected from May to October 2016/2017 in 21 man-made lakes and from July to September 2018 in 7 natural lakes of the Dinaric Western Balkan ecoregion, using the standard lake littoral sampling method. A total of 680 samples were analysed, and more than 130 000 individuals belonging to more than 80 taxa were found. Chironomid abundance was significantly higher in man-made lakes. No significant difference was observed in species richness and diversity indices between man-made and natural lakes. Within man-made lakes, the ones with short water retention time and high water-level fluctuations had significantly lower chironomid abundance and species richness, but there were no differences in diversity indices. Man-made lakes of the Dinaric karst with longer water retention time and low water-level fluctuations can potentially serve as natural lakes for chironomid community.

RS13_O15_Non-invasive phosphate removal from the lake water – principles, efficiency and non-target effects

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In this study we present preliminary results of efficiency and non-target effects of a novel non-invasive method developed for phosphate phosphorus (P) removal from the water of eutrophic lakes. Principle of the method is use of laminates consisting of a natural solid P inactivation agent – calcite (Cc) fixed onto a neutral material. When placed in the water column, laminate reduces P concentration in the water due to P sorption onto Cc. Laminate is then removed from the water together with Cc and sorbed P which allows for a sustain P elimination. Preliminary experiments with natural ground calcites (BET surface area of 10-20 m^2/g) showed that P concentration of 1 mg PO_4/L may be reduced by 60% at Cc dose of ca. 0.3 g/L within 24h. However, ca. 40% (by mass) of the Cc is lost from the laminate in the water due to falling out of Cc grains and/or their dissolution indicating that about 40% of the fixed P remain in the solution as P sorbed to Cc and/or precipitated with calcium compounds. Performance of the laminates is affected by initial physio-chemical conditions determining rate of Cc dissolution. Possible non-target effects are slight increase in calcium concentration and alkalinity in the lake water after laminate application at low temperatures (5-10°C). Further works on optimal Cc fixation allowing for its permanent binding in the laminate and high exposure in the solution are in progress.

RS13_O16_Effects of increased water level and salinity fluctuations on littoral macroinvertebrate assemblages in the shallow Vrana Lake in Dalmatia (Croatia)

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The shallow Vrana Lake (max depth -3,9 m a.s.l.) is the largest natural lake in Croatia by surface area. It is located in the Dinaric karst in close proximity to the Adriatic Sea to which it is directly connected by the Prosika canal, constructed in the 18th century. Climate change caused increased fluctuations of water level during the last two decades resulted in increased lake water salinity fluctuations from oligohaline (<1-4 ‰) to mesohaline levels during dry years (maximums: 2008 – 11,3‰; 2012 – 18,2‰) when seawater inflow increased through the Prosika canal and the karst ridge between the Lake and the sea. The aim of this work is to present the effects of increased water level and salinity fluctuations on the macroinvertebrate assemblages in the littoral zone of the Lake. Samples of benthic macroinvertebrates were collected using hand net at four sites along the southern coast of the Lake in the period 2011-2018. All available physicochemical parameters and hydrological data were also collected and analyzed. The recorded values of water level and salinity in the study period were the lowest/highest extremes in more than 50 years of data records. Macroinvertebrate assemblages showed site-specific and pronounced changes, from brackish water taxa domination during the high salinity and recovery phases to the freshwater (oligohaline) phase. Suitability of different groups as indicators of increased salinity was examined for the purpose of adaptive water level management which should be implemented after the reconstruction of the Prosika canal with movable gate.

RS13_O17_The depth distribution of Oligochaeta (Annelida) assemblages in two barrage lakes

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Freshwater oligochaetes have an important role in aquatic ecosystem and food web functioning, as they are (in general) easily-caught and highly-nutritious prey for predatory invertebrates. They help transform energy resources that are not accessible to many invertebrate consumers, such as dead organic matter in hypoxic and anoxic habitats, into viable biomass. Lake depth zones are characterized by different environmental factors influencing specific oligochaete assemblages. Profundal and sublittoral assemblages are usually affected by nutrient deposition and oxygen deficiency, while littoral communities are more exposed to hydromorphological pressures. We wanted to test how these oligochaete assemblages differ between zones of different nutrient deposition rates and environmental parameters. Our hypothesis was that most oligochaete species show clear preferences towards these zones which will result in very different assemblages among them. Sampling of the profundal and sublittoral zone was conducted with an Ekman sampler, while the littoral zone was sampled with benthos hand net in two barrage lakes – Brljan and Visovac. Kruskal–Wallis H test was used to determine differences in specific oligochaete species abundances with regard to depth zones. Bray-Curtis similarity and cluster analysis showed how oligochaete assemblages affiliate by depth zones rather than lake-system. Profundal assemblages of different lakes had similarity of 50%, while littoral assemblages had 40% similarity. *Stylaria lacustris*, *Nais variabilis* and *N. pseudobtusa* showed preferences towards littoral zone, *Aulodrilus pluriseta* for sublittoral zone, while *Limnodrilus hoffmeisteri* and *Potamothrix heuscheri* showed preference for profundal zone.

RS13_O18_Autonomous data intensive monitoring technologies for the calibration and validation of remote sensing models

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Automatic high-frequency autonomous monitoring technologies allow us to acquire high amounts of data. This new data intensive approach has been proven useful for detecting episodic events related to phytoplankton dynamics thanks to its enhanced spatiotemporal resolution. These autonomous sensors are being increasingly deployed in buoys in lakes and reservoirs all over the world, having also the potential for being used as data sources for calibration and validation of Remote Sensing Models (RSM) for the retrieval of optically active constituents in water. The known relationships between spectral reflectance at different wavelengths and chl-*a* concentration have been generated and extensively validated with in situ data obtained through classic extraction methods, but less with in-vivo fluorometric measurements like those implemented in the chl-*a* probes deployed in these autonomous platforms. With the objective of validating the suitability of these new data intensive monitoring devices for generating RSM for the satellite imagery freely distributed by ESA and NASA we conducted a research in a Spanish reservoir continuously monitored with an EXO2 YSI multiparametric probe. For the same purpose, a sampling with an aquatic AUV (Ecomapper, YSI) was also conducted simultaneous with the overpass of Sentinel 2 and Landsat 8. The obtained results showed weaker relationships with the fluorometric in-vivo data for most of the applied empirical algorithms and also highlighted the extremely importance of an accurate calibration of the deployed sensors and of the QA/QC protocols for these data to be used in intercalibration and validation exercises of chl-*a* RS products at a global scale.

RS13_O19_Human impact intensity affects pond biodiversity along gradients of abiotic conditions

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Identifying the anthropogenic drivers of biodiversity loss in ponds is important since ponds serve as biodiversity “hot spots” within regions. Previous studies on ponds biodiversity were mainly focused on the effects of anthropogenic factors on specific community in ponds, leaving the effect of multiple stressors on several trophic levels unknown. In this study we evaluated simultaneous effects of human activities and abiotic factors on the diversity and density of macrophyte, benthic and epiphytic macroinvertebrate and fish communities. In order to integrate different types of anthropogenic activities we developed an index for human impact. We assessed the relationship between human impact and abiotic factors and biodiversity in ponds by means of linear mixed effects models. The diversity and density of macrophytes, as well as the diversity of epiphytic macroinvertebrates were negatively related to high intensity of human impact. In contrast, fish density was positively related to high human impact intensity. Further, the diversity and density of the majority of communities were negatively related to proximity of a river but positively related to connectedness with other ponds. This implies that pond connectedness with surrounding ponds might mitigate the negative impact of anthropogenic pressure on communities by creating additional habitats. Our findings suggest that pond conservation policies should encourage management procedures that minimize the negative impact of human activities on ponds biodiversity.

RS13_O20_The relationship between epiphytic macroinvertebrate communities and macrophyte biomass

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Macroinvertebrates play a major role in the littoral zone of lakes. They control the biomass of algae, recycle detrital material and provide a crucial link from primary production through to fish. There are many studies that associate the macroinvertebrates composition with physical and biological variables, but there are relatively few studies showing the relationship between macroinvertebrate community composition and macrophyte biomass. The statistical relationship between macroinvertebrate-macrophyte biomass (dry weight) and some environmental variables was investigated. Samples of macrophytes were collected from Uluabat Lake (Bursa/Turkey), during June, July, August, October and November 2014; June, July and August 2015. Samples were taken with a mesh bag sampler that is a modification of the folding quadrat. Water temperature (T°C), pH, electrical conductivity (EC) and dissolved oxygen (DO) were measured in situ by Hach-Lange multi probe. Diversity metric (Shannon-Wiener) and richness metric (Total Taxa Richness) were evaluated. *Myriophyllum*, *Ceratophyllum*, *Potamogeton*, *Cladophora*, *Vallisneria* macrophytes were determined in Uluabat Lake. Numbers of epiphytic macroinvertebrates ranged from 1 to 165 individuals on macrophytes and dry weight of macrophytes ranged from 0,15 to 4,45 gr. The results of this study suggest a strong correlation between Mollusca and the macrophytes.

RS13_O21_Cascading effects of fish stock and resource stoichiometry on biodiversity of shallow hypertrophic fishponds

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Shallow manmade fishponds in south Bohemia (Czech Republic) were used for fish production for centuries. Their ecosystems have changed dramatically – the excessive nutrient loading and high fish stock increased their trophy. The results of ten sampled fishponds suggested their hypertrophic status at present, while their plankton structure and dynamics reflected the actual size/age class of fish stock consisting predominantly of common carp. Planktivorous fish (both young carp and weedy fish) remarkably reduced the abundance, size, and species diversity of crustacean zooplankton, in particular large daphnids, whereas larger carp itself did not cause such a strong top-down effect. Moreover, preliminary estimates of weedy fish (CPUE) clearly suggested negative relationship between density of weedy fishes and absence of large daphnids. Fish predation apparently reduced their reproduction by selective foraging either on larger or otherwise conspicuous females. On the other hand, the daphnids could mitigate certain top-down effect and sustain dense populations if they were not limited by phosphorus. Favourable resource stoichiometry (seston C:P ratio <170) coincided with well-growing *Daphnia* populations, whereas this keystone species was virtually absent in some fishponds where the seston ratio surpassed a critical threshold (~250) for their optimal growth. All other plankton components, i.e. phytoplankton, bacteria, ciliates, and rotifers showed rather high abundance and diversity, and suggested a reasonable intensity of various microbial processes and interactions and their impact on water quality in the recent hypertrophic ecosystems.

RS13_O22_Mitigation of cold water pollution using a novel thermal curtain: potential impacts on fish populations.

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Hypolimnial releases from large thermally stratified reservoirs can severely modify downstream river thermal regimes by reducing water temperature. This ‘cold water pollution’ can often be 12-16°C cooler than natural river temperatures, with effects persisting for hundreds of kilometres downstream of reservoirs. A novel, cost-effective ‘thermal curtain’ has been installed at Burrendong Dam in Australia to mitigate thermal pollution of the Macquarie River, where river temperature is often reduced by 16°C and rapid temperature changes can occur when water releases are transitioned from spillway to outlet releases. The goal of this research was to determine how the thermal curtain may affect the thermal regime of the river system and examine its possible effect upon freshwater fish survival, growth, development and physiology. Experiments on three species of Australian larval freshwater fish measured growth and developmental responses to different water temperatures and determined the effect of rapid temperature reductions upon mortality and swimming ability. Fish growth was impeded at cooler temperatures, highlighting the importance of mitigation of cold water pollution. A rapid reduction in temperature by 10°C caused almost complete immediate mortality; smaller drops in temperature caused a reduction in swimming ability and often caused delayed mortality. Results will be compared against river temperatures measured downstream of Burrendong Dam to determine the effect of the curtain on larval fish. The potential success of this novel thermal curtain could result in similar structures being used to mitigate cold water pollution in other affected regions.

RS14 Large rivers

RS14_O1_Multiple stressor effects on benthic macroinvertebrates in large European rivers – a typology-based evaluation of faunal responses as a basis for future bio-assessment

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Most of the very large rivers in Central Europe have been severely altered by human activities in various ways such as flood protection, damming and navigation among others, resulting in a general lack of reference sites and their aquatic communities required for bio-assessment approaches according the EU Water Framework Directive. The aim of the study is to select biological metrics for a multi-metric macroinvertebrate assessment method based on a pan-European typology of very large rivers. Thus, very large European rivers were typified into physiographic groups based on abiotic descriptors considering river- and catchment-characteristics, discharge, climate and geology. Based on macroinvertebrate samples from 25 European countries and 94 rivers respectively, river type-specific faunal assemblages from best available sites were identified as reference communities to assess the impacts of different stressors. Faunal composition distinctly responded to river type-specific stressor combinations. Depending on regional pressures, the type of stressors, stressor intensity and frequency differed between the river types. In total, we selected eleven core metrics including diversity metrics as well as newly generated metrics to assess significant responses to multiple stressors in very large rivers. In presence of additive stressor-effects, the metric responses generally indicated a considerable community turnover. Neozoa dominance correlated strongly with navigation being a major pressure at very large rivers. Potential candidate metrics were designated, proposing a basis towards the development of European river type-specific assessments for very large rivers.

RS14_O2_Processes contributing to the maintenance of CO_2 and CH_4 super-saturation in a large boreal river

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Large rivers play a significant role in the global carbon cycle as most are net CO_2 and CH_4 sources to the atmosphere over long distances. However, the processes sustaining super-saturation of CO_2 and CH_4 in large rivers are still not adequately understood. We address this issue in the 8th Strahler order river La Romaine in Eastern Canada, which is characterized by super-saturation of CO_2 (median: 662 ppm, interquartile range (IQR): 563 to 747 ppm) and CH_4 (median: 16 ppm, IQR: 10 to 26 ppm) along its entire lower portion (>300 km). The main objective of this study was to explore the relative contribution of tributaries, groundwater inputs, and in-stream metabolism to the sustained super-saturation of CO_2 and CH_4 in the La Romaine River. We estimated ambient metabolism in the river and measured the partial pressure of CO_2 (pCO_2) and CH_4 (pCH_4) along the river main stem, tributaries and in groundwater. We further combined the ambient pCO_2 and pCH_4 with discharge measurements and estimates of lateral inputs within a mass balance approach to explore the drivers of the observed super-saturation. The river features that drive the CO_2 and CH_4 super-saturation within our study system are potentially transposable to other large boreal rivers systems. This emergent insight improves our fundamental understanding of how major river systems function within the carbon cycle, and our capacity to predict how this functioning may change in future scenarios of climate and hydrologic change.

RS15 Invertebrates

RS15_O1_Ecological and evolutionary physiology of aquatic beetles: coping with multiple stressors in inland saline waters

PhD awardee

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In inland aquatic ecosystems, two types of habitat constraints are among the most influential on the evolution of biological traits of aquatic invetebrates. On the one hand, the contrasting stability between lotic and lentic habitats has a strong influence on their dispersal ability and physiological tolerance. On the other, abiotic stress constitutes an important filter for species' occurrence. This thesis is contextualised within such *habitat templet* framework, adapted to inland waters of arid and semiarid areas where temperature, salinity and temporality are the main abiotic factors shaping macroinvetebrate diversity and distribution. By combining comparative physiology and evolutionary biology approaches, this thesis explores physiological and behavioural traits of congeneric species of aquatic beetles with contrasted habitat preferences within the fresh-hypersaline gradient and between lotic and lentic waters. The general aims are to i) understand how tolerance to natural stressors is shaped by the main habitat constraints in these systems and ii) shed light on the mechanisms for salinity tolerance, its evolution and interaction with other co-ocurring stress factors. The results obtained show that lotic species, especially those restricted to freshwaters, might be more vulnerable to environmental changes than their lentic relatives. Evidence for interactive effects of multiple stressors and evolutionary links between tolerance to salinity and desiccation in some water beetle lineages is also reported. These results have contributed to understand patterns of diversification and habitat occupation by aquatic insects in inland waters and provided novel insights into the evolution of salinity tolerance, a key trait for the colonisation of saline waters.

RS15_O2_Do the trait profiles of macroinvertebrates converge across different biogeographic regions?

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Aquatic ecologists have compiled comprehensive databases on macroinvertebrate traits over the last decades. Traits can be linked to environmental drivers to establish mechanistic explanations of assemblage composition and species distributions. However, spurious and inconsistent trait-environment relationships may arise when trait interactions are ignored, given that the whole organism, not an individual trait, responds to its environment. In fact, evolutionary processes, such as natural selection, have likely selected for multiple traits simultaneously that together provide adaptation to changing environmental conditions, so-called trait profiles. For example, the combination of rapid growth and obligate diapause provides adaptation to habitats with predictable intervals of short favorable conditions and long adverse conditions. We compiled and harmonized trait data from different biogeographic regions (Europe, North America, Australia, New Zealand, and Bolivia) to allow for large scale trait analyses. We analyzed the global trait database for potential trait interactions and established trait profiles. Using hierarchical cluster analysis, we defined groups of organisms with similar trait profiles, i.e. trait profile groups (TPG). For these TPGs, we identified the most important traits for TPG selection using Random Forests. Moreover, we compared the TPGs across regions to evaluate convergent evolutionary adaption in macroinvertebrates across biogeographic regions. We discuss our results and point out future perspectives on the usage of trait profiles in assessing trait-environment relationships.

RS15_O3_Stoichiometric traits predict the composition of macroinvertebrate communities: Extending the Growth Rate Hypothesis to species development

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Ecological stoichiometry seeks to understand the ecological consequences of elemental imbalances between consumers and their resources. Therein, the well-accepted Growth Rate Hypothesis (GRH) states that organisms exhibiting rapid growth have higher phosphorus (P) demand (and thus lower C:P and N:P ratios) than slowly growing ones, due to a higher allocation to P-rich ribosomal RNA. However, the ecological consequences of GRH have rarely been investigated at the ecosystem level, and the effects of elemental imbalances in ecosystems on community structures remain largely understudied. In this study, we investigated whether macroinvertebrate stoichiometric traits (e.g. C:P and N:P ratios) can be linked to their development traits (e.g. “life span”, “voltinism” and “reproduction frequency”) and whether these stoichiometric traits can predict macroinvertebrate community assembly under different nutrient situations. We allocated more than 400 European taxa to different groups defined using available information about the three development traits. Further we sampled 21 invertebrate taxa in six streams exhibiting varied levels of nutrient availability, quantified their abundance and measured their stoichiometric traits. We found significant relationships between the development trait-based groups and the stoichiometric traits of taxa. Taxa with low C:P and N:P ratios were associated with faster development groups and tended to occur at higher proportions in nutrient-rich streams. In contrast, communities from nutrient-poor streams were dominated by slowly developing taxa with high N:P ratios. Our results highlight that extending the GRH to species development rate might give some insights about the mechanisms by which streams nutrient concentrations influence macroinvertebrate community composition.

RS15_O4_Functional homogenization of aquatic invertebrate communities in central Europe over 25 years

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Biotic homogenization is a prominent aspect of the ongoing biodiversity crisis. It consists in increased spatial and temporal similarity among communities and can occur at different levels of the biotic organization, from the phenotypic and genetic level, to species-compositional and functional level. We studied whether stream benthic invertebrate communities have undergone a process of functional homogenization. For that, we analyzed the changes in the functional organization of benthic invertebrate communities over 25 years (1990-2014), for a large dataset of samples (n > 3700) that were collected in central European low-mountain streams. We found a strong reorganization of stream invertebrate communities, with significant changes in functional composition for the five groups of studied traits: feeding groups, substrate, flow and stream zonation preferences and saprobic traits. Although the overall functional diversity did not change significantly, we recorded a decrease in functional diversity for substrate, flow and stream zonation preferences and for saprobic traits, which indicate a reduction of community niches. We also recorded a significant overall decrease in community functional specialization and in functional spatial β-diversity. These results indicate a loss of specialist taxa and an increase in functional homogenization. The recorded functional homogenization concerned both response traits (i.e. those traits that reflect the response of species to environmental factors) and effect traits (i.e. those traits that reflect the effects of species on the ecosystem). Therefore, the ongoing functional homogenization may translate into a decline of community resilience and loss of functions.

RS15_O5_Benthic grazer and shredder communities suffer from agricultural induced degradation. Does functional redundancy help to keep up ecosystem functioning?

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Intensive agricultural land use is one of the urgent problems of impaired morphology and ecological quality of small rivers as well as their restoration as part of the major goals of the Water Framework Directive. Ongoing decline of riverine biodiversity affects the maintenance of crucial ecosystem functions. Functional redundancy (FRed) may bean "insurance" for communities to keep up ecosystem functioning under anthropogenic stressors due to similar or equivalent contributions of organisms to ecosystem processes and functions. Identifying and understanding FRed could therefore be a powerful tool in preserving river ecosystems. This study aimed at estimating FRed among benthic grazer and shredder macroinvertebrate communities in small Saxon streams impaired by intensive agricultural land use. We investigated riffle and pool habitats at near-natural and disturbed sites. The functional community structure of grazer and shredder species was evaluated using measures of functional trait diversity (FD). We assumed that the structures of the communities in their specific functional trait spaces exhibit negative gradients of FD from near natural to disturbed sites and indicate functional impairment of the communities. Indeed, the species and functional diversity was lower at agricultural induced sites, with shredder communities being stronger affected than grazer communities. Within the communities we identified FRed among the species. Although at disturbed sites greater distances between species clusters in functional trait spaces indicate lower potential for FRed, functional redundant species still occurred in some communities maintaining ecosystem functioning. We propose to include FD and FRed into river quality assessment to better advice restorative actions.

RS15_O6_Fine sediment impacts on macroinvertebrates: The current state of knowledge

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The excessive erosion, transportation and deposition of fine sediment is considered a significant threat to aquatic systems globally. Considering macroinvertebrates significance in biomonitoring practices, and the emergence of sediment specific biomonitoring tools, the aim of this review was to extract evidence of macroinvertebrate responses to fine sediment. Through following a review method adapted from Systematic Maps and Rapid Evidence Assessment, we aimed to review the existing literature, quantify the breadth of evidence, analyse the types of responses described, and appraise this through assessment of the article by weighting based on the study design. A total of 8832 articles were extracted from peer-reviewed databases. After the screening process, 131 articles were retained for evidence assessment. Using a weight of evidence approach, Chi-squared analysis was used to determine associations between macroinvertebrate responses. Linear modelling was used to determine significant predictors of evidence quality. Results showed a global imbalance of evidence with most research conducted in temperate regions. The majority of evidence was related to articles quantifying deposited, as opposed to suspended sediment. The weight of evidence showed burrowers were more likely to have a positive effect in response to fine sediment, whereas shredders were more likely to respond negatively. We end by making recommendations for future research. There needs to be a focus on the production of high-quality research with robust study designs focusing on the mechanisms driving macroinvertebrate responses.

RS15_O7_Dams modify energy flow pathways and food-web structure in fluvial ecosystems

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Dams exert a strong regulation of river discharge and, depending on the purpose of the reservoir (e.g., hydropower, drinking water supply, irrigation), this regulation results in different alterations of the natural flow regime. Irrigation reservoirs have been associated to the flow stability and the flow regime reversion (i.e., low flow in winter and high flow in summer), whereas hydropower reservoirs to rapid sub-daily flow fluctuations of large magnitude. Hydrological alteration can have strong effects on the abundance, distribution and diversity of organisms that inhabit fluvial ecosystems, through the modification of several ecosystem characteristics (e.g., habitat diversity, substrate stability or basal resources). The effects of large dams on macroinvertebrate community composition have long been examined, however, effects at food-web level, which evidence how energy and matter flow through the fluvial ecosystem, remain understudied. In order to analyze how the hydrological alteration affects the availability of basal resources for macroinvertebrate communities and its effects on the energy flow pathways and food-web structure, we selected 12 rivers (7 flow-regulated, 5 natural) in northern Spain. We determined the availability of in-stream produced (e.g., algae) and terrestrial (e.g., leaf litter) food resources and analyzed macroinvertebrate food-web structure and its dependence on these resources based on stable isotopes (2H & 15N). Our preliminary results showed the dominance of in-stream produced food resources in flow-regulated streams, which widened and lengthened the food web and shifted the energy flow pathways, from a detritus-based food web in natural streams to an algae-based food web in flow-regulated streams.

RS15_O8_Response of macroinvertebrate drift to hydropeaking – simulations of flow and up-ramping velocities in flume and field experiments

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Storage hydropower plants cause severe unnatural fluctuations in discharge and water levels (i.e. hydropeaking) that negatively affect aquatic organisms. Passive drift of aquatic macroinvertebrates that are not adapted to the resulting harsh hydraulic conditions, such as high shear stress, high flow velocities and rapid water level increases (i.e. up-ramping velocity) during hydropeaking events is a well known response. However, there is still a lack of quantification of macroinvertebrate drift and related key hydraulic forces. Therefore, we present preliminary results of a comprehensive study that combine flume experiments with five different up-ramping velocities at three different peak discharges (and corresponding flow velocities) and field experiments mimicking flume hydraulic conditions that combine three different up-ramping velocities at two different flow velocities in three hydropeaking rivers. Results from both experiments indicate taxa- and trait-specific drift responses, with surface dwelling taxa drifting significantly more frequently than those associated with the interstitial. Significantly higher drift of lentic taxa was only found in the flume experiments. Moreover, the flume experiments indicate that especially low flow velocities and low up-ramping velocities reduce drift rates. Field experiments confirmed that drift primarily occurs during the up-ramping phase of a hydropeaking event, but increases in macroinvertebrate drift were not associated with detectable up-ramping and flow velocities thresholds. More detailed analyses that consider drift in parallel sampled reference reaches and benthic densities in hydropeaking reaches may help to confirm or correct these contradictory findings, which ultimately have consequences for the definition of hydraulic thresholds relevant for the implementation of mitigation measures.

RS15_O9_Effect of water level fluctuations on the survival and migrations of macroinvertebrates from freshwater near-shore habitats

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Water-level fluctuations are an important factor affecting the living conditions of the bottom fauna in near-shore zones. Emersed organisms exhibit physiological or behavioural responses to such environmental stress. The presented set of studies aimed at determining: (1) the community composition of a sandy near-shore zone of a dam reservoir with common water level fluctuations; (2) survival, horizontal migrations and burrowing of the inhabitants of this zone experimentally exposed to a water level decrease. The macrofauna of the sandy land-water interface was relatively poor in terms of abundance and diversity, confirming its harsh conditions. In laboratory, gastropods *Planorbarius corneus* and *Viviparus viviparus* exhibited multiple adaptations to water level reductions: high resistance to substratum drying, horizontal migrations and burrowing. They were able to migrate over a long distance (0.5 m) provided the water level decreased gradually, sudden water level reduction decreased their activity. Other species exhibited single adaptations: horizontal migrations (gammarids *Gammarus fossarum*, *Dikerogammarus haemobaphes*) or high resistance to drying (a gammarid *Pontogammarus robustoides*, gastropods *Bithynia tentaculata*, *Physa acuta*, *Potamopyrgus antipodarum*, a chironomid *Stictochironomus sticticus*). Finally, a gammarid *D. villosus* and oligochaete *Potamothrix moldaviensis* did not exhibit any responses to the water level decrease. A mesocosm experiment showed that natural drying of the surface layer of sandy sediments in summer at a moderate air temperature resulted in the total fauna mortality after ca. 24 days. It confirmed the high resistance of *S. sticticus* and very low survival of *P. moldaviensis*. Our work was supported by an NSC grant NSC N N304 306840.

RS15_O10_Re-oligotrophication and invasive species impact littoral invertebrates in a large, pre-alpine lake: long-term isotopic evidence

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The effect of lake eutrophication and re-oligotrophication on lake food web structure of the pelagic zone is well described. However, its long-term effect in the littoral zone is not explicitly defined. Because the littoral system could also regulate energy in aquatic systems, studies on the mechanisms of the littoral zone are essential to understand the ecosystem. We measured the isotope values of six native and five invasive invertebrate species exhibiting different feeding strategies (filter feeder, grazer and predator) from a 15-year collection to determine the pattern of changing $\delta^{13}C$ and $\delta^{15}N$ values in Lake Constance, Germany. During this period (2000-2015), the total phosphorus concentration in the lake decreased almost two fold from 14 to 8 µg /L and several non-native invertebrate species such as *Dikerogammarus villosus*, *Limnomysis benedeni* and *Katamysis warpachowskyi* invaded the littoral zone of the lake. Changes in $\delta^{13}C$ and $\delta^{15}N$ of littoral invertebrates could be linked to either a shift in their feeding pattern and/or to changes in the length of the littoral trophic chain. In Lake Constance, changes in isotope values are closely correlated to mean annual phosphorus values. Hence, the variation of $\delta^{13}C$ and $\delta^{15}N$ during the last and a half decade reflects the responses of the lake to changes in phosphorus concentration as mirrored in the littoral zone.

RS15_O11_Evaluating the taxonomic and functional diversity of stream benthic invertebrate assemblages: morphological versus DNA metabarcoding approaches

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DNA metabarcoding is a novel molecular-based alternative for ecosystem monitoring. Our main objective was to test the ability of DNA metabarcoding applied to invertebrate assemblage samples to assess the ecological status of wadeable streams, at a large spatial scale. We compared taxonomic structures of macrobenthic invertebrate assemblages provided by both classical morphology-based and DNA metabarcoding-based identification on: (i) a set of taxonomic and functional metrics; and (ii) the I2M2, a WFD-compliant multimetric index for the ecological assessment of French wadeable rivers. We focused on how metabarcoding could allow to save time spent on taxonomic identification and organism counting by directly applying a DNA metabarcoding approach on sorted organisms sampled with a standardized – and traditional – method. Three different sets of primers were used for DNA metabarcoding in order to maximize taxon detection. We compared the values of individual metrics and of the multimetric index obtained by both approaches. Preliminary results, from a set of streams routinely monitored by French environmental agencies, have shown that DNA metabarcoding–based values of the I2M2 and metrics were positively and significantly correlated to corresponding values provided by the morphological approach. Our results also highlighted the importance of combining different sets of primers in the DNA metabarcoding approach, to limit taxonomic errors (i.e. false detection and/or absence of detection). These promising results advocate for integrating DNA metabarcoding in the ecological assessment of stream ecological status at a large spatial scale.

RS15_O12_Aquatic survey in the driest European country: Building a public aquatic macroinvertebrate DNA barcode reference library for Malta

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Maltese Islands are very poor in surface freshwaters due to geological and climatic conditions and various anthropogenic activities. In addition to the very few natural but highly intermittent streams, some man-made or strongly modified waterbodies (e.g. artificial ponds and canals, reconstructed wetlands) and rock pools represent the aquatic habitats. The aquatic macroinvertebrate fauna is little known and our knowledge is highly unbalanced: while hundreds of records are available on Odonates, almost nothing is known from other groups. Although the taxonomy, ecology and water quality assessment are increasingly moving towards the use of DNA-based methods, there was no aquatic invertebrate barcoding activity in Malta, so far. The aims of this study were to collect new records, revise recent knowledge on freshwater macroinvertebrate fauna of Malta using traditional and novel methods, validate species occurrences by DNA records, explore unknown species and finally to provide a checklist and a barcode reference library as powerful basis for DNA-based water quality assessment. In 2018, we visited 80 sampling sites on all the three bigger islands, morphological identification of Crustacea, Mollusca, Ephemeroptera, Odonata, Heteroptera, Coleoptera, Trichoptera and Diptera: Chironomidae resulted in occurrences of more than 115 species. 45 species have been reported here for the first time from Malta. All the species has now been subjected to DNA extraction, amplification and sequencing of the COI barcoding marker in order to build the database, validate species occurrences and explore the presence of plausible cryptic taxa. Project was supported by EFOP-3.6.1.-16-2016-00004, 20765-3/2018/FEKUTSTRAT and DNAqua-NET CA15219 STSM39774 grants.

RS15_O13_Assessing different components of biodiversity across a river network using eDNA

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Understanding individual components of biodiversity and differentiation between communities are at the heart of many ecological studies. Environmental DNA (eDNA) has been suggested as a novel technique to measure biodiversity, however, we do not yet understand how it assesses different components of biodiversity and how it compares to previously established approaches. We used a spatially structured field survey to sample may-, stone-, and caddisfly genera with eDNA and kicknet methods at 61 sites distributed over a river network. We extended these two contemporary approaches with historical records, allowing a comparison of various diversity measures from catchment to site level and giving insights in how these measures are affected by network-specific properties. On the catchment scale, both contemporary methods, detect a high percentage of the overall historically documented gamma diversity. We find a good overlap between the two contemporary methods on the regional scale but at individual sites, we find highly congruent values of local alpha richness between the two approaches with indication that integration of eDNA over space is larger at sites with higher discharge. The two contemporary methods showed discrepancy of community composition at the individual sites, demonstrating complementing rather than identical information with respect to genus identity. Contrary to our assumption, this discrepancy was not correlating with any other network property.

RS15_O14_eDNA monitoring of benthic invertebrate community and utility for environmental assessment in Japanese rivers

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For sustainable river use, establishing simple and objective monitoring and evaluation methods is required. In this study, we focused on benthic invertebrates as indicators of river health and examined availability of eDNA output for environmental assessment. To meet this aim, we surveyed the community structures using eDNA metabarcoding (mtDNA, CO1) and conventional surber net sampling. The field samplings were conducted at the six reaches located the upper, middle and lower streams of the two Japanese rivers from May to December, 2016. Taxonomic identification was performed at family level in both morphological and molecular-based methods. Subsequently, the EPT and Diptera indices were calculated using the relative richness of taxa and abundance obtained by both methods. As a result of eDNA metabarcoding, 93 families were detected as benthic invertebrates and this number was around 3-times greater than in the conventional method (especially Coleoptera, Diptera, Hemiptera) while there were 5 families that eDNA could not detect. We demonstrated that the spatial and seasonal trends of EPT and Diptera indices founded on eDNA, especially based on read number and OTU-richness, were mostly consistent with those founded on conventional method. These results suggested that quantitative information obtained from eDNA metabarcoding could be usable for environmental assessments.

RS15_O15_Caddisfly, the underwater architects of gravel-bed rivers

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The creation of structures is an important mechanism by which animals can adapt to their environment. Many caddisfly (Trichoptera) larvae build intricate cases from silk and fine sediment. Cases increase the fitness of caddisfly individuals (an example of extended phenotype engineering) and allow them to survive the turbulent hydraulic conditions in gravel-bed rivers. The construction of cases by caddisfly larvae may also have zoogeomorphic effects, changing the distribution and mobility of fine sediment. However, the magnitude or significance of sediment use by caddisfly communities has never been measured. We quantified the mass and size distribution of mineral sediment use by whole communities and individual taxa of case building caddisfly from riffles at three sites on a gravel-bed stream. The abundant and diverse caddisfly community was dominated by case building taxa. There was considerable variability in case design between these taxa, with median sediment use ranging from 0.17 mm for early instar taxa, up to 4 mm for some pupal cases. The total mass of sediment used by the caddisfly community averaged 38 g m^{-2} and was dominated by Glossosomatidae which used 64% of sediment. Consequently, case building caddisfly have the potential to affect the distribution and mobility of substantial quantities of sediment over a wide range of sizes. The results provide novel insights into the specific grain sizes and quantities of fine sediment particles used by caddisfly larvae, which represents an important step towards understanding their potential zoogeomorphic effects.

RS15_O16_The role of crenal morphology in shaping water mite (Acari: Hydrachnidia) assemblages in karst springs

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Many studies emphasized the role that water mites play within the invertebrate communities of spring habitats, both regarding species diversity and the significance within the crenal food web. In undisturbed natural springs with permanent surface or subterranean flow, water mites are nearly always present and usually display high diversity. This study aimed to determine whether significant differences in water mite assemblages between rheocrene and limnocrene karst springs could be detected in terms of species richness, diversity and abundance, but also in different ratios of specific synecological groups: crenobiont, crenophilous and stigophilous water mite taxa. Our research was carried out on four limnocrene and four rheocrene karst springs in the Dinaric karst region of Croatia. Seasonal samples (20 sub-samples per sampling) were taken at each spring during 2014 with a 200 µm mesh net, taking all microhabitat types with coverage of at least 5% into consideration. Water mite abundance was found not to differ between morphological spring types. The higher values of species richness and diversity indices, usually associated with rheocrenes, were indeed significantly higher in rheocrenes when compared to limnocrenes. The higher shares of crenophilous and crenobiont water mite individuals were in this case found in limnocrenes. A higher ratio of stygophilous taxa was found in rheocrenes indicating a higher degree of groundwater/surface water ecotone influence. Within this research, 40% of identified water mite species (eight out of twenty) were recorded for the first time in Croatia, thus highlighting a huge gap in water mite knowledge of Croatian karst springs.

RS15_O17_Coarse detritus and organic matter content in muddy sediments affect the structure of Chironomidae larvae and abundance of Oligochaeta in shallow water bodies

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The aim of this study was to find the factors limiting the occurrence of Chironomidae larvae and Oligochaeta in central parts of shallow, eutrophic water bodies of different types (macrophyte and phytoplankton dominated shallow lakes; large, shallowed bays of deep lakes and old river beds). The research was carried out for several years. The macrozoobenthos structure, some abiotic parameters of water (6 parameters) and bottom sediments (5 parameters) were studied. There was a significant correlation between the volume of coarse detritus (particle diameter larger than 480 µm) contained in the surface (0-5 cm) layer of muddy bottom sediments and the majority of parameters characterizing the structure of chironomid larvae. At sites where the volume of the analysed fraction was less than 5 cm^3 per 100 cm^3 of fresh sediments, the number of taxa, diversity and density of Chironomidae larvae were very low. With regard to Oligochaeta, it was hypothesized that the limiting factor of their occurrence in shallow water bodies may be too low abundance of available food. To verify this, the amount of organic matter in the surface (0-5 cm) layer of sediments was examined. The results are presented in two ways: as percentage of organic matter per unit dry mass of sediments (standard) and as dry mass of organic matter per unit sediment volume, of fresh bottom sediments. The results confirm that one of the major factors limiting the occurrence of Oligochaeta in the studied water bodies is the amount of organic matter in bottom sediments.

RS15_O18_Selective feeding by grazing mayfly nymphs in headwater streams

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Besides quantity, the quality of periphyton is crucial for consumers in stream food webs. The nutritional quality of periphyton is largely defined by its composition because nutritional value differs between algal taxa. Aquatic lichens, often abundant in headwater streams, appear to be less edible because of the crustose growth form and cyanobacteria are in general of low nutritional quality. Consequently, primary consumers might selectively feed on high quality algae, i.e. diatoms and red algae, and avoid lichens and cyanobacteria. However, knowledge on selective feeding of benthic grazers is scarce. In this study, we therefore analyzed food choice of grazing mayfly nymphs in four mostly pristine headwater streams in German low mountain ranges via stable isotope and fatty acid analysis. The periphyton communities of the studied headwaters varied in quality based on their composition. Large discrepancies in the fatty acid composition of periphyton and grazing mayfly nymphs indicated highly selective feeding. Only the fatty acid profiles of periphyton samples with high proportions of high quality algae were similar to those of the mayfly nymphs. In general, mayfly membrane lipids contained a larger proportion of polyunsaturated fatty acids (PUFA) than storage lipids. However, at the site where cyanobacteria dominated the periphyton, grazer membrane lipids lacked the usual high proportion of PUFAs, indicating a physiological response to nutritional deficits. The fact that at this specific site, the mean macroinvertebrate biomass was lower compared to all other sites could indicate that the high abundance of cyanobacteria has a negative effect on higher trophic levels.

RS16 Macrophytes

RS16_O1_Carbon forms, nutrients and water velocity filter hydrophyte and river-bank species differently: A trait-based study

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Theory of trait-based plant community assembly has been developed and tested predominantly in terrestrial ecosystems. Studies investigating the functional trait composition of aquatic plant communities and their relation to environmental determinants remain scarce. Due to macrophytes are essential components of aquatic ecosystems the detailed knowledge of their trait-based assembly is crucial for their management. We identified how plant functional traits respond to environmental gradients in streams and rivers in the Danube River Catchment, Hungary. We studied the processes governing community assembly along major environmental gradients related to carbon and nutrient limiting factors as well as physical strain. We used six continuous traits (leaf area, specific leaf area, leaf dry matter content, seed mass, seed shape, woodiness). We calculated community-weighted mean and standardised effect size of functional diversity for each community, and investigate which environmental factors explain the changes in community-weighted mean and functional diversity. All analyses were conducted for aquatic and riverbank species separately. Our study showed that environmental filtering acts on certain functional traits, thus shaping the assembly of communities. We found that the effect of habitat filtering significantly increased toward higher pH, indicating the response of functional traits to carbon limitation. Results also showed that higher productivity of streams lead to trait convergence among riverbank species, and the larger functional dissimilarity among hydrophyte species is likely to increase the diversity of resource acquisition strategies.

RS16_O2_Functional traits diversity of macrophytes explain nitrogen cycling in wetlands

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The tight association between freshwater plants (macrophytes) and their associated microbial communities play a key role in denitrification and other ecosystem processes associated with N cycling, but we currently lack a mechanistic understanding of how the diversity and composition of plant traits regulate microbial activity and N removal process. In a mesocosm experiment, we investigated how functional trait diversity i.e. functional trait dissimilarity (FDis) and community-weighted mean trait values (CWM) of macrophytes regulate abundance of bacterial denitrification genes (nirS and nirK) and potential denitrification activity associated with macrophytes, together with plant N accumulation. Structural equation modelling showed that both FDis and mean trait values directly affect N accumulation, while for denitrification, a direct effect was only observed for CWM. The FDis indirectly affected denitrification by influencing denitrification gene abundance. These findings improve our mechanistic understanding of N-cycling in freshwaters dominated by macrophytes and have broad ecological implications for management of freshwater habitats targeting enhanced ecosystem services by increasing functional diversity of relevant traits in macrophyte assemblages.

RS16_O3_Key factors sustaining alternative stable states between submerged and free-floating plants

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Both submerged macrophytes and free-floating plants are able to sustain alternative stable states. It is obvious, that shading effects of free-floating plants is the strongest limiting factor on submerged macrophytes. However, there is not a single study has been done regarding to the limiting factor resulted by submerged macrophytes on floating plants. In the present study we demonstrated that free-floating plants (*Lemna gibba*) growth was found to be strongly reduced by submerged macrophytes (*Ceratophyllum demersum, Elodea nuttallii*). These submerged plants reduced N, P, Fe and Mn concentrations of the medium drastically moreover they increased the pH above 10. Subsequent additions of nutrients and pH neutralization removed the growth inhibition of duckweed. This growth inhibition is, therefore, concluded to be due to pH increase and N, P and Fe removal. Of the four factors significantly inhibiting duckweed growth, increase in pH was the strongest depletion of N was second, followed by reduction of P and Fe. Along an artificial pH gradient (pH 7-11) above above pH 10.5, the growth was completely stopped. In field conditions in submerged plants dominated stands, the diurnal changes of pH in the water body was followed. Chemical composition of the water showed that alkaline pH due to photosynthetic activity of submerged plants was the main inhibiting factor for the growth of floating plants. Therefore, it can be concluded that under high nutrient levels, alkaline pH generated by submerged plants is a potential key factor that sustains the stable dominance of submerged vegetation against floating plants.

RS16_O4_DEMETHER: an integrated tool to model the spatiotemporal dynamics of submerged aquatic vegetation

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Macrophytes are pivotal in many hydrosystems. They provide multiple ecological functions and influence the physical, chemical and biological components of aquatic ecosystems. However, proliferation of macrophytes in freshwaters may lead to recurring problems for users and stakeholders, especially in urban areas (water activities hindered, clogging of water intakes, olfactory pollution, etc.). Understanding their growth and dynamics is then an important issue, particularly in a context of global change. The development of operational tools able to simulate and foresee the spatial distribution of macrophyte meadows is therefore crucial to support effective management programs. The DEMETHER project aims to provide such a tool, based on a mechanistic model to predict the spatio-temporal dynamics of submerged aquatic vegetation in response to different scenarios of climate change and increased pressure on water resources. We will describe the different components of the project under development: i) a multi-species numerical model including the main processes involved into the dynamics of submerged aquatic vegetation and using data from 2D hydrodynamical simulations; ii) an experimental set-up measuring the photosynthetic and respiratory activities by oximetry, allowing the model to be adapted to species of interest; iii) a method for automatically mapping macrophytes, that combines high-resolution satellite imagery with machine learning algorithms allowing for a monthly monitoring and model calibration. We will also present the first results of the DEMETHER project for one of our research sites on the Garonne river (France).

RS16_O5_Seasonal and regional variability of carbonate precipitation in charophytes and vascular plants

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In freshwater ecosystems a significant amount of carbon may be sequestrated by aquatic macrophytes which uses soluble bicarbonates as a source of CO2 in photosynthesis. As a result calcium carbonate is precipitated and stored in sediments. We aimed to compare carbonate precipitation by charophytes and vascular plants in two Polish regions differing in environmental and climatic conditions, Lubuskie Lakeland (W Poland, lower trophy and milder climate) and Masurian Lakeland (NE Poland, higher trophy and cooler climate). In each region two hardwater lakes were selected, one dominated by charophytes and another by vascular macrophytes. Each lake was sampled (3 sites) in summer (July) and autumn (November) 2017, then in spring (April) and summer (July) 2018. In each site the biomass samples were analysed for dry weight and calcium carbonate content – separately for each species. Additionally, physical and chemical parameters were analysed in water taken from above the plants. In all lakes charophytes were significantly more effective in dry weight production and $CaCO_3$ precipitation than vascular plants. Most of the studied variables differed region-to-region. Both for the vascular plants and charophytes significantly higher values of dry weight and calcium carbonate content were found in the lakes of W Poland. Although a similar pattern of seasonal variability of dry weight and calcium carbonate content was found in both regions, the season-to-season variability in E Poland was insignificant. In both regions significant correlations between the calcium carbonate content and water properties were found. This work is supported by the National Science Centre (Poland) — grant 2016/23/B/NZ8/00635.

RS16_O6_Periphyton contributes to declining charophyte communities in oligo- and mesotrophic temperate hardwater lakes

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Charophytes are key components in temperate hardwater lakes, but have declined due to eutrophication since more than 100 years. This process seems to continue in many lakes despite an overall reduction in nutrient loading. Periphyton, a major factor for macrophyte decline in eutrophic lakes, has hardly been discussed in studies focusing on charophyte decline in oligo-mesotrophic lakes. We compared the periphyton development of 11 temperate oligo-mesotrophic hardwater lakes with a decline in charophyte communities during recent decades. We tested whether periphyton biomass correlates with charophyte decline and whether bottom-up or top-down control prevail. Periphyton biomass, stoichiometry and invertebrate grazer abundance were measured on artificial substrates exposed inside and outside of fish exclosure cages for 4 weeks in July and August. Fish community composition and biomass were investigated using multimesh gillnetting. Periphyton biomass was significantly correlated with the degree of charophyte decline. Evidence for top-down control was found in three lakes showing significantly lower periphyton biomass and higher invertebrate grazer abundance inside of fish exclosures. Perch (*Perca fluviatilis*) was the dominant fish species in the investigated lakes. Mean individual biomass of perch feeding on invertebrate grazers (< 15 cm) was positively correlated to periphyton biomass. Chironomid biomass was also positively correlated with periphyton biomass suggesting a bottom-up control of periphyton by nutrient availability. We conclude that periphyton can significantly contribute to the decline of charophytes in oligo-mesotrophic hardwater lakes. Nutrient loading, a major control factor of summer periphyton biomass in the investigated lakes, often remains unnoticed in early stages of eutrophication.

RS16_O7_*Potamogeton* meadows support shallow lake benthic communities

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Trophic state and sediment resuspension strongly influence development of submerged macrophyte meadows in large and shallow lakes. In lake Markermeer (700 km^2, 4m depth), which is very turbid during most part of the year, dissolved nutrient concentrations have strongly declined the last decades, while the submerged macrophyte *Potamogeton perfoliatus* is widely expanding on the western shores of the lake. These extensive and dense meadows limit human uses of these lakes (e.g. boating) and pondweed is therefore currently removed in a large scale by mowing. However, submerged macrophytes can also serve as an important habitat and potential food source for aquatic species in this ecologically impoverished lake. Therefore, we aim to determine the characteristics and the role of pondweed meadows as suitable habitat and food source in this Natura 2000 lake. Characteristics of *Potamogeton* meadows were examined using aerial drone photography and field sampling, the macroinvertebrate community structure inside and outside meadows was determined, and a stable isotope food web analysis was performed. *Potamogeton* meadows emerged from June onwards in irregular patches along the coasts reaching densities up to 200 shoots/m^2. Significant higher abundances were found for most macroinvertebrates taxa inside pondweed meadows compared to outside, while *Potamogeton*-derived carbon was incorporated in various macroinvertebrate taxa. We conclude that overall *Potamogeton* meadows were not only important as habitat, but also served as a direct food source for macroinvertebrates supporting secondary productivity of the lake. Removal of submerged macrophyte meadows can thus influence food availability for Natura 2000 target species (fish and birds).

RS16_O8_The role of groundwater supply alongside the riverbed on the development of Water Crowfoot vegetation

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The aim of the study was to evaluate the impact of supply of water alongside the riverbed on the development of the populations of various Water Crowfoots. These plants are valuable elements of river communities and play an important function in the river fluvial system. Moreover, the abundance of *Batrachium* communities characterise rare natural habitat types encompassing natural and near-natural running waters which are protected under the EU Habitat Directive. Among the major environmental factors stimulating growth of various Water Crowfoots is the so-called underflow of water in the hyporheic zone, i.e. the flow of water alongside the riverbed where mixing of groundwater and surface water take place. The influence of this element has never been verified precisely because of difficulties in its measuring. We tried to challenge this problem by using unique equipment (gradientmeter and filtrometer). We have estimated several elements of underflow of water in the hyporheic zone as well as a range of hydraulic parameters in places with abundant Water Crowfoots. Furthermore, complex hydromorphological, hydrochemical and botanical survey was carried out at every river site. We have detected significant groundwater supply in case of 66.7% sites. On the other hand 27.6% sites showed infiltration and 5.7% were neutral (no water exchange). In this way we have shown that groundwater supply is an conducive factor to the development of Water Crowfoot vegetation but it is not compulsory habitat element. The study was supported by the National Science Centre – project 2016/23/B/NZ9/03600.

RS16_O9_Relating response and effect traits in amphibious species contrasting to nutrient levels and light exposure

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Stream ecosystems have been affected by a complex mixture of stressors resulting in a range of anthropogenic impacts and climate change, which have influenced aquatic plant communities. It has been shown that aquatic plants respond to abiotic factors with morphological changes (response traits), however, the understanding of the underlying response mechanisms of these responses and their impact on physiological performance is still limited. In this study, we demonstrate how response traits of amphibious species (*Butomus umbellatus*, *Berula erecta*) change along a gradient of nutrient concentration and light conditions and examine the relationships between plant morphological responses and their effects on multiple aspects of physiological performance (effect traits). Plants were grown in mesocosms (90 L plastic tubs) for 14 weeks during summer 2018. They were exposed to two factors: nutrient enrichment (five different nutrient concentration levels), and shading (0% and 50% shading). At the end of the experiment, response traits were measured, including plant height, number of leaves, plant dry and fresh weight (roots and stem), leaf chlorophyll content and tissue C:N:P concentrations (roots and stem). Also, photosynthesis-irradiance responses were tested by comparing Pmax, the light saturation point, light compensation point, dark respiration rate, and quantum yield, together with Relative Growth Rate (RGR). We expect to find changes in plant morphological traits and physiological performance with different nutrient and light conditions, but even more novel to this study we also expect to find an ecologically relevant relationship between response and effect traits.

RS17 Microbial ecology

RS17_O1_Unraveling heterotrophic ecosystem function in river networks: interactions among microbial function, community and organic matter

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Transformations of organic matter during transport through river networks are a result of physical as well as biological processes. Laboratory and ecosystem-scale studies have identified benthic biofilms as main players of biotic in-stream carbon transformations. However, linkages between their community composition (CC), functional capabilities and molecular composition of organic matter on which they thrive remain to be explored at larger spatial scales. In this context, we analyzed bacterial CC, extracellular enzyme activity as a proxy for heterotrophic functioning, bulk biofilm respiration and dissolved organic matter (DOM) at 42 sites of the ~7000 km^2 river network of the Vjosa in Albania and Greece collected during spring 2018. We hypothesize that: i) mean and variance of benthic biofilm CC, diversity and functioning depend on the stream size; ii) gradients of the biofilm diversity and CC affect spatial variation of the investigated functioning proxies, and iii) both CC and functioning correlate with organic matter properties. Our findings suggest that benthic biofilm CC and diversity strongly differ among investigated headwaters, whereas they become more similar with the increasing stream size. Furthermore, our results suggest that local functioning, i.e. extracellular enzyme activity is affected by CC. However, the diversity-functioning relationship does not yield spatially obvious pattern across the river network, and it is likely to be influenced by the available DOM resource pool, which shows clear spatial patterns at the river-network scale. Mutual interactions are suggested, where DOM resources may drive both CC and functional capabilities of benthic biofilms, which in turn are responsible for DOM transformations.

RS17_O2_Leaf it up to the microbes? Unravelling litter decomposition in urbanised streams

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Streams are fuelled by microbial decomposition of leaf litter from riparian vegetation. However, urbanisation has altered the quality and quantity of leaf litter sources to streams (i.e. native vs exotic plant species). Here we aimed to determine 1) the formation of microbial biofilms on exotic versus native leaves, 2) how biofilm community structure relates to nutrient release from leaf litter, and 3) how decomposition of litter is effected by water nutrient levels. Single and mixed treatments of *Eucalyptus camadulensis* and *Salix ferrisa* leaves were incubated in three water types (undisturbed catchment – low in nutrients, urbanised catchment – high in nutrients, and deionised water – control), under controlled light and temperature conditions for seven days. 16S rRNA and ITS sequencing revealed strong differences in bacterial and fungal communities between exotic and native leaves, and this was dependant on the nutrient concentration of stream water. *E. camadulensis* was associated with polyphenol decomposing bacteria and greater relative abundance of fungi. Further, FISH-CSLM indicated that fungi likely assists bacteria in the colonisation and decomposition of leaf litter, particularly for *E. camadulensis*. Initial stream water chemistry (SRP, DIN, DOC) and composition of leaf leachates appear to drive bacterial community structure and function, likely owing to C:N:P limitation and bioavailability, which could impact ecosystem function on a wider scale. *E. camadulensis* and *S. ferrisa* are known to be either invasive or native to riparian communities in both the northern and southern hemispheres, thus these findings have global implications for stream management.

RS17_O3_Influence of N:P ratio and nutrients concentration on intra and extracellular geosmin production SS5

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Cyanobacterial blooms are increasing globally because of multiple factors, such as nutrients enrichment and increased water temperature. This increase in cyanobacterial blooms could be associated with the appearance of toxic and nuisance secondary metabolites. Taste and odor compounds (T&Os) are troublesome in waterbodies, because they influence the consumers' satisfaction and confidence of drinking water. Critical incidents in drinking water have become a universal issue, but exact causes and the conditions under which T&Os are produced are unclear. Despite diverse organisms have been identified as T&O producers, cyanobacteria have been described as the most relevant group with numerous strains and metabolic pathways identified. Among the substances produced by microorganisms, geosmin is commonly responsible for earthy and musty odor in drinking water. The aim of this study is to evaluate the influence of different N:P ratios on the intra and extracellular geosmin production under oligotrophic and eutrophic conditions. The study was performed in 18 microcosms under controlled conditions and lasted for 45 days. Three different N:P ratios were evaluated: 4:1, 16:1 and 56:1; at low and high nutrient concentrations. Nutrients and geosmin concentration were analyzed in water once a week, as well as biofilm samples that were taken to analyze the photosynthetic efficiency, community, chlorophyll a content, AFDM and geosmin concentration. The preliminary results agree with our hypothesis that lower N: P ratio under eutrophic conditions would favor the geosmin production in biofilm. These results evidenced the N:P ratio as one of the key factors controlling the geosmin formation in biofilms.

RS17_O4_Effect of salinity on the aquatic and sedimentary microbial communities related to methane and sulphate in Mediterranean lakes

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In this work, we have analysed the structuring effect of the environmental variables on the aquatic and sedimentary microbial communities of 60 lagoons from the Mediterranean area of Spain with NGS techniques. These lagoons are classified in 20 different typologies, and also they follow a strong salinity gradient. In our work, we have analysed the effect of salinity on the structure of microbial communities, focusing on methanogenic archaea, methanotrophic bacteria and sulphate-reducing bacteria, and the relationship between these groups of microorganisms. Our results show that salinity is the most important defining variable in the structuration of microbial communities both in water and sediment through the environmental gradient studied. There is a clear separation between the prokaryotic communities of high salinity and low salinity environments. Also, the three groups of microorganisms we have focused on have completely different relationships with salinity. Methanogenic archaea and methanotrophic bacteria are negatively affected by salinity, showing a high decrease in their populations among high salinity environments. On the other hand, sulphate reducing bacteria can tolerate high salinities, showing stable assemblages as salinity increases. In conclusion, our results indicate that salinity is an important environmental variable for shaping the structure of aquatic and sedimentary microbial communities from different Mediterranean lakes of Spain, and that its effect on the microorganisms can be completely different depending on the group of microorganisms.

RS18 Molecular ecology, phylogeny and evolutionary studies

RS18_O1_From bulk to specific diet source tracking in aquatic food webs – the trophic value of d^{13}C and d^{2}H in fatty acids from various sources and consumers

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Bulk stable isotopes and fatty acids (FA) are commonly used as diet source indicators in organisms of aquatic food webs. Stable carbon ($\delta^{13}C$) and hydrogen ($\delta^{2}H$) isotopes can be used for assessing the origin of dietary organic matter and subsequently as subsidies to consumers if the natural abundance of stable isotope ratios differs distinctly among diet sources. However, insufficient $\delta^{13}C$ or highly variable $\delta^{2}H$ separation between various sources, e.g., terrestrial and aquatic primary production, limits the use of these bulk stable isotopes as source biomarkers. Here, we present an additional approach that combines stable isotopes and FA, i.e., compound-specific stable isotopes (CSSI), in food sources and consumers. This CSSI approach benefits from the fact that the C-H bonds in FA are chemically irreplaceable and can thus indicate, based on $\delta^{13}C$ and $\delta^{2}H$ values of FA, where dietary FA have been synthesized. Thus, in addition to being able to quantify FA or algal, bacterial or terrestrial diet sources retained in consumers ('classical trophic FA biomarker use'), CSSI values can also indicate, a) where FA originated from, and, b) how consumers convert precursor FA to target FA, particular in various organs and tissues of larger consumers such as fish. Results on CSSI values in stream macroinvertebrates suggest that their polyunsaturated FA are periphyton-derived and DHA (22:6n-3) in fishes, produced in hepatocytes from the dietary precursor EPA, is differently allocated from the liver to other tissues and organs.

RS18_O2_A comparison of eDNA sampling with traditional fyke net sampling for European eels, *Anguilla anguilla*, in Irish lakes

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The European eel, *Anguilla anguilla*, is classified as critically endangered (IUCN Red List). In the UK the population is estimated at less than 5% of numbers observed in the 1980s and this trend is reflected throughout Europe. The EU Eel regulation (EC 1100/2007) established measures for the recovery of *A. anguilla*, to be implemented through eel management plans, but a lack of baseline data has restricted the implementation of habitat improvement strategies. In Ireland, Inland Fisheries Ireland is responsible for the protection, management and conservation of the inland fisheries. A dedicated eel monitoring team uses fyke net surveys and/or electrofishing to generate data about the European eel population. These are both reliable methods but require technical skill, are invasive, selective, and have the potential to underestimate total numbers. Environmental DNA (eDNA) techniques are potentially powerful tools for the ecological monitoring of eels in low population environments. Using a method developed at UWE for the identification of *A. anguilla* eDNA from 1L surface water samples, we compared the recovery of eels using fyke nets at five inland lakes with the intensity of eDNA recovered from surface water samples at the same locations. Water samples were analysed for *A. anguilla* eDNA before and after fyke net fishing for 24 hours and compared with the recovery of eDNA from shore side sampling. The results of the field validation of the eDNA survey are presented that demonstrate the success of these methods, sampling for *A. anguilla* eDNA in high, medium and low eel populations.

RS18_O3_Isolation of southern Italian basins promoted genetic and morphologic variability in fluvio-lacustrine barbel populations (Osteichthyes, Cyprinidae)

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Italian peninsula is considered to be a biodiversity hotspot, where freshwater fish fauna is characterized by high levels of local endemicity. Within the cyprinid species of *Barbus* genus, two fluvio-lacustrine species are endemic and widely distributed throughout Tyrrhenian and Adriatic basins, with an allopatric distribution. *B. plebejus* inhabits north up to middle Adriatic basins while *B. tyberinus* is widespread in all central-northern basins draining into the Tyrrhenian Sea. Although barbel populations are also found in the southern Italian district, up to now, no genetic and morphologic investigations were carried out in this region. This work aims to study the presence and distribution of barbels in southern Italian basins focusing on the role that local isolation may have acted on their evolution and persistence. In the present study, we examined sequence variation at two mitochondrial loci (cytochrome b, D-loop) and performed geometric morphometric analysis of body shape along with the measurement of 11 morphometric and meristic characters on 197 barbels from eight populations. Through the analyses of phylogeny, population genetic structure, distribution and characterisation of morphological variability, we provided evidence of two local evolutionary lineages, suggesting that the isolation of southern Italian hydrographic basins act as one of the most relevant driving factors in increasing local endemicity.

RS18_O4_NGS corroborates cryptic diversity within the Epiros riffle dace (*Telestes pleurobipunctatus*)

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The geological history of the Ionian basin is genuinely complex and it has deeply influenced aquatic species evolution. The Ionian's inland waters host the largest proportion of the Greek endemic ichthyofauna. The Epiros riffle dace (*Telestes pleurobipunctatus*, Leuciscidae, Cypriniformes) is an Ionian endemic distributed from southern Albania (Butrint lagoon catchment) to Western Peloponnese (Alfios River basin). We applied the NGS method of ddRAD (double digest restriction-site associated DNA) sequencing to study the evolutionary relationships between *T. pleurobipunctatus* populations. 99 individuals from 11 river basins were analyzed, covering the known distribution range of the species. Genome wide data have confirmed the existence of five well supported allopatric lineages, revealed previously based on mtDNA analyses: Alfios lineage, Evinos-Kotichy-Pinios lineage, Acheloos lineage, Arachthos lineage and Northwestern lineage (Acheroon-Kalamas-Kerkyra-Butrint). Occurrence of two lineages was detected in the Louros river basin. Taxonomic revision of this species complex is urgently needed. Our results should be taken into account for the conservation management of *T. pleurobipunctatus* species complex.

RS18_O5_To be or not to be *Padogobius*

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Gobies (Gobiidae, Gobiiformes) are a remarkable group of fishes, not only due to the great number of species, but also due to their great diversity and extraordinary ability to colonize different types of environments. The majority of species inhabit marine coastal waters and are benthic and small-sized. Within the Gobius-lineage, one of the three evolutionary groups of gobies distributed in the Mediterranean and East-northern and East-central Atlantic, at least two events of switch to freshwater lifestyle occurred. One of the documented switches happened in the ancestor of the speciose Ponto-Caspian clade benthophilines, and the other, in the ancestor of the genus *Padogobius*. This genus comprises two species, inhabiting freshwaters of northern and central Italy and northern Croatia, and having allopatric distribution. As some previous studies pointed to the possibility that this genus might not be monophyletic, we analysed two mitochondrial and three nuclear markers in order to clarify the evolutionary relationships between the two species considered to belong to the genus *Padogobius*, and their relationship with the other genera of the Gobius-lineage. All results unambiguously showed that *Padogobius nigricans* (Tyrrhenian Sea slope) is actually a species of Ponto-Caspian genus *Neogobius*, while the genus *Padogobius* is monotypic, comprising only *Padogobius bonelii* (Adriatic Sea slope), and that the neighbouring distribution of the *N. nigricans* and *P. bonelii* is not a result of their common evolutionary history. But how did N*. nigricans* get so far away from his congeners?

RS19 Plankton

RS19_O1_Oligotrophication of Lake Balaton over a 20-year period and its implications on the relationship between phytoplankton and zooplankton biomass

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Lake Balaton, the largest lake in Central Europe, went through severe oligotrophication during the past two decades. Both the biomass and species composition of phyto- and zooplankton have been monitored during this process with appropriate temporal resolution. Besides, Lake Balaton is also characterized by a remarkable trophic gradient along its longitudinal (southwest-northeast) axis, and available data spread spatially over this gradient. Using these long-term datasets, we explored the relationship between phytoplankton and zooplankton biomass over the past two decades. Zooplankton biomass was characterized by wet and dry weight, while chlorophyll *a* (Chl *a*) concentration was used as a proxy for phytoplankton biomass. Parallel to the ongoing decrease of phyto- and zooplankton biomass in all basins, we also found a good linear relationship between the biomass of these planktonic classes over a range of 8 to 20 microgram/L annual mean Chl *a* concentration. However, below 8 microgram/L annual mean Chl *a* concentration, the zooplankton biomass positively deviated from such linearity. We discuss this finding in term of changes in some corresponding physicochemical parameters (like transparency) during oligotrophication as well as changes in the species composition of the phytoplankton community. Implications of oligotrophication for the fish stock of the lake are also discussed.

RS19_O2_Impacts of the predatory cladoceran *Bythotrephes longimanus* on zooplankton communities in Austrian Alpine lakes

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Although spreading and establishment of species beyond their native range is a natural phenomenon, it has rapidly increased due to human activities. While many invasive species are well studied in the invaded areas, detailed knowledge about the same species in their native area are often lacking. The apparently lower impacts in the native range are often credited to long time co-evolution, however, this assumption is rarely tested. Here we present a study on the large predatory cladoceran *Bythotrephes* (= spiny water flea), currently invading North American lakes. We investigate its impacts in a part of the native range, the Austrian Alpine lakes. We test a hypothesis that *Bythotrephes* has significant direct and/or indirect effects on several parameters of zooplankton communities in two lakes with and two lakes without *Bythotrephes* presence. In 2018, we conducted a biweekly sampling from May until November on each of the selected lakes to determine seasonal development of *Bythotrephes* and prey populations, together with several limnological parameters. Detailed study of vertical structure and migration patterns of both *Bythotrephes* and its potential prey was performed twice in the season at day and night by a combination of in situ video and high frequency Acoustic Doppler Current Profiling systems. So far, our data suggests that *Bythotrephes* reached densities higher than those reported as having caused significant effects on zooplankton communities in North American lakes. Further the presence of *Bythotrephes* may have influenced vertical distribution of cladocerans forcing them to cooler strata, leading thus to lower birth rate.

RS19_O3_Molecular gut content analysis of the predatory cladoceran *Bythotrephes longimanus* in Austrian Alpine lakes

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Bythotrephes longimanus, the spiny water flea, is native to lakes of Northern Eurasia and the Alps in Central Europe. In the 1980s, *Bythotrephes* was introduced to North America, where it has caused lasting changes in zooplankton communities in numerous lakes, first and foremost by significantly decreasing the biodiversity and biomass of North American microcrustaceans. Far less is known about *Bythotrephes* impacts on food webs and its feeding preferences in its native region. In this study, the in situ diet of *Bythotrephes* from two Austrian lakes was investigated using Molecular Gut Content Analysis approaches. Species- and genus-specific quantitative PCR (qPCR) assays targeting short (<200 bp) fragments of the mitochondrial cytochrome oxidase I (COI) region were designed and validated for the most abundant cladoceran and copepod prey species occurring in the studied lakes. Using these assays the seasonal gut content of *Bythotrephes* in each of the Alpine lakes was determined. While some microcrustaceans (e.g., the copepod *Eudiaptomus gracilis*) could be detected frequently in the guts of *Bythotrephes*, others, e.g. the cladoceran *Bosmina (Eubosmina) coregoni*, do not seem to be part of its regular diet. Preliminary results suggest that *B. longimanus* is selective in its diet either due to feeding preferences or differential prey avoidance behavior by prey species.

RS20 Surpassing aquatic boundaries

RS20_O1_How direct and indirect effects of agricultural stressors propagate from aquatic to terrestrial ecosystems

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Low order streams are common in agricultural landscapes and they are closely connected to their riparian areas via energy fluxes of material and organisms. These aquatic-terrestrial ecotones host considerable biodiversity. Agrochemicals applied to the surrounding fields can enter the streams by spray drift, surface run-off and drainage at ecotoxicological relevant concentrations. Further stressors related to agricultural activity, including elevated nutrient and fine sediment input and habitat degradation often co-occur and can jointly affect aquatic ecosystems. Effects on aquatic organisms that provide important ecosystem functions e.g. leaf litter decomposition, can potentially propagate to higher trophic levels, ultimately modifying relationships in aquatic-terrestrial food webs. To analyze and quantify these partly indirect effects, we used Structural Equation Modelling (SEM) on a dataset on 22 Romanian streams surrounded by agriculture, ranging from low to high intensity. Based on assumed linear relationships between involved organism groups, SEM allowed for testing competing hypotheses about complex relationships and the relevance of direct and indirect effects of interacting stressors. We included the following biological responses: leaf litter decomposition, aquatic macroinvertebrates, emerged aquatic invertebrates, riparian spider communities, carabid beetle, chilopod and diplopod communities, as well as physico-chemical parameters, habitat properties and pesticide toxicity of the streams. We discuss how the agricultural stressors affect different trophic levels and ecosystems through direct and indirect effects.

RS20_O2_Migratory gulls as vectors across the aquatic boundary

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Water birds are neither truly aquatic, nor truly terrestrial, and are important for maintaining connectivity between aquatic and terrestrial ecosystems. They are important vectors of nutrients and contaminants, as well as a whole spectrum of plants, invertebrates and microbes. This vectoring occurs at the landscape scale during daily movements (e.g. between a lake and nearby fields), and at regional and continental scales through migratory movements. We illustrate this with examples from the Lesser black-backed gull *Larus fuscus* wintering inland in wetlands of Andalusia, Spain. Gulls are important vectors between freshwater and land, e.g. moving nutrients and seeds out of rice fields onto land, or importing nutrients, contaminants and antibiotic-resistant bacteria from landfills into lakes and reservoirs. This can be quantified with precision via a movement ecology approach. We quantify the role of an increasing number of gulls in guanotrophication of Fuente de Piedra Ramsar site, the most important wintering site for LBBGs in Andalusia. Whilst crossing the aquatic-terrestrial boundary, gulls can also bring new species and genotypes from afar. In agricultural landscapes, this includes the importation of weeds and herbicide/pesticide-resistant genotypes. Many species dispersed by gulls and other water birds are themselves able to live in water and on land (e.g. aliens such as *Crassula helmsii* and *Cotula coronopifolia,* weeds such as *Juncus bufonius*). The role of gulls in the spread of antimicrobial resistance (AMR) is of particular concern, as landfills are vital nodes that act to connect all the major wintering sites of LBBGs.

RS21 Streams

RS21_O1_Tributary effects on the ecological responses of a regulated river to an experimental flood

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Experimental floods are operational measures designed to restore flow variability and mitigate dam impacts on rivers. Flow-sediment interactions during experimental floods represent strong ecosystem drivers, influencing nutrient dynamics, and metabolic and functional properties. Thus, it is important to understand how different sediment inputs influence abiotic and biotic responses to experimental floods. Tributaries are points of discontinuity that can generate major changes in the environmental conditions of a river, affecting biotic structure and determining functional differences between upstream and downstream reaches. Ova da Cluozza is an unregulated tributary, which adds substantial amounts of water and sediments to the river Spöl, a regulated alpine river located in Switzerland. This study examined how sediment properties, and ecological resistance and resilience, differed upstream and downstream of the confluence in response to an experimental flood. Methods included a combination of high-resolution drone mapping techniques and field surveys before, after and during the flood to quantify changes in relevant functional and structural ecosystem properties. Preliminary results showed comparable responses of physical-chemical parameters during the flood. Sediment respiration differed among sites per se and in response to the flood. Habitat turnover quantified by drone images was greater in the downstream sites. Biotic samples indicated differences in upstream/downstream invertebrate communities and primary production, suggesting differences in resistance and resilience to the experimental flood. Overall, the results of this study contribute towards understanding the prominent role of sediment regime in hydropower impacts mitigation.

RS21_O2_Effects of an experimental flood on floodplain microbial assemblages in regulated rivers

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The alteration of natural flow and sediment regimes for hydropower production is a major factor driving river structure and function. Experimental floods are becoming more common as operational measures to restore flow variability and mitigate reservoir effects on river floodplains downstream of dams. Microbial assemblages play key roles in the functional ecology of floodplain ecosystems by dictating biochemical and metabolic processes as well as nutrient cycling. Thus, it is important to understand how experimental floods affect microbial assemblages in regulated floodplain rivers. Using terminal restriction fragment length polymorphism (T-RFLP), we compared spatio-temporal properties of microbial assemblages of aquatic-terrestrial floodplain sediments at two hydrologically altered (residual, hydropeaking) river sections before and after an experimental flood as well as microbial drift in suspended sediments during the event. A river floodplain with a natural flow regime served as a reference. Results revealed distinct seasonal differences in microbial assemblages among floodplain habitats but not across hydrological regimes. The experimental flood resulted in a mix of aquatic-terrestrial microbes as well as upstream reservoir-based microbes through increases in lateral and longitudinal hydrological connectivity. Importantly, the flood effects on microbial assemblages downstream of the dam were transient, lasting a matter of weeks. The results suggest pronounced resistance and resilience of floodplain microbial assemblages to single flood events, indicating the magnitude, duration and frequency of experimental floods should be strongly considered towards mitigating flow effects in regulated floodplain rivers.

RS21_O3_Spates reduce the persistence of macroinvertebrate communities in tropical streams

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Disturbance by spates are thought to be one of the main forces structuring stream macroinvertebrate communities. Spates reduce abundances of species although recolonization of depleted patches is fast. Accordingly, stream communities in rainy seasons should be variable as its state will depend on the time since the last spate. In contrast, communities in dry seasons should be more deterministic as lack of disturbances would allow species sorting to drive communities to a single (equilibrium) state. We sampled stream macroinvertebrates in five streams twice a year (rainy: December-March; dry: July-August) during five years (1997-2001) to assess whether: (1) there are distinct and recurrent rainy and dry communities and; (2) communities in seasons of low environmental variability (dry season) are more persistent and similar to each other over years than communities in seasons of high environmental variability (rainy season). For the five streams, all 10 samples collected in each stream over five years were classified in a single group. Dry samples tended to cluster together at high similarity levels and were nested within rainy samples. We assessed persistence with Kendall's coefficient of concordance (W) and found that persistence was higher in dry than in rainy communities. There was a decrease in community concordance with time, although the decrease was nearly four times larger in dry than in rainy seasons. Results support the view that stream communities vary along the year from a non-equilibrium state during the rainy season when disturbance by high flow is frequent, to an equilibrium state during the dry season when flow is stable.

RS21_O4_Composition and functioning of streambed biofilm related to environmental gradients and interacting stressors

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Microbial activity within streambed sediments is one of the key drivers of ecosystem processes in lotic ecosystems. These substantially contribute to global and regional fluxes of carbon and nutrients that are strongly affected by climate change and other human-induced pressures and stressors. To better understand the response of stream ecosystem functioning and changes in biogeochemical processes to interconnected stressors, such as temperature and organic pollution, laboratory and field studies were carried out using metagenomics and metabolic measures such as respiratory potential and community-level physiological profiling. Specific meta-communities were identified at reference and highly polluted sites and corresponding patterns in microbial functioning were observed. The bacterial families that were abundant only at highly polluted sites were Bacteroidaceae, Lachnospiraceae and Porphyromonadaceae (as identified by using 16S rRNA gene sequencing). Increased degradation of polymers originating from pharmaceuticals and cosmetics was observed along the pollution gradient. In the laboratory, a shift in microbial community functioning was observed along gradients of temperature and nutrients. The study demonstrated underlying structural-functional linkages along pollution gradients and overriding effects of temperature that, with increased nutrient inputs, induce shifts in streambed functioning.

RS21_O5_Hydrological events mobilize dissolved organic carbon and soil microbes into small streams

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Small headwater streams are well connected with the surrounding landscape, interlinking terrestrial biogeochemical cycles to the river network. At the same time, they constitute an important reservoir of microbial life but the origin of this diversity is not well understood. Headwater streams are dynamic systems, influenced by environmental changes, and variation in dissolved organic carbon (DOC) can be observed throughout the year and after specific events such as summer storms and snowmelt. We aimed to characterise the dynamic transfer of DOC and microbial life from catchment soils to streams by sampling six first-order streams and three soil samplers collecting hillslopes runoff at two different depths located in the Oberer Seebach catchment in Austria, over a period of 18 months. We found a strong variation in DOC concentrations and bacterial abundances measured by flow-cytometry, with the highest values occurring during high flow events. Also, a strong correlation was found between DOC concentrations and bacterial abundances across all streams and seasons. In soil water, ranges were higher and a similar correlation slope between DOC and bacterial abundance was found. Furthermore, the dissolved organic matter quality analyses with fluorescence spectroscopy suggested tighter connectivity of soils and streams during high flow. Overall, our results show that soils provide a dynamic and relevant influx of microbes to first order streams and that streams are able to maintain higher bacterial abundances than soils. We propose that the dynamic and repeatedly occurring inoculation of small streams by soils is relevant for microbial community dynamics of downstream fluvial networks.

RS21_O6_Nutrient enrichment enhances seasonal variation of stream diatom communities

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Nutrient enrichment degrades water quality and threatens aquatic biota. However, our knowledge of (dis)similarities in temporal patterns of biota among sites of varying level of nutrient stress is limited. We addressed this gap by assessing temporal (among seasons) variation in algal biomass, species diversity and composition of diatom communities in three streams that differ in nutrient stress but are otherwise similar and share the same potential species pool. We monitored three riffle sections in each stream bi-weekly from May to October. Temporal variation in water chemistry and other environmental variables was mainly synchronous among riffles within streams and often also among streams. We found significant differences in diatom community composition among rivers and, although less so, among riffles within streams. Algal communities in the two nutrient-rich streams were more similar to each other than to those in the nutrient-poor stream. Community metrics – taxon richness and Shannon diversity – did not differ consistently among the streams, and did not vary synchronously at any spatial scale. Temporal variation in diatom community composition was related to nutrient (particularly phosphorus) enrichment, with variation in community composition increasing with increasing phosphorus concentration and decreasing nitrogen:phosphorus ratio. The high temporal variation within streams and sites, and the lack of temporal synchrony, suggest that single sampling at a single site may be insufficient to assess and monitor a complete stream water body reliably.

RS21_O7_Evaluating the uncertainty on stream ecological assessment by an invertebrate-based index: effects of index construction and operator skill level

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The I2M2 is a multimetric index based on benthic macroinvertebrate assemblages and used in the assessment of the ecological quality of French wadeable streams. It is compliant with the requirements of the Water Framework Directive, has been successfully intercalibrated with other European invertebrate-based indices, and has been standardized for field sampling and laboratory work to allow uniform use at the national scale. In this study, our objective was to assess the uncertainty on the I2M2 index value. We investigated both the uncertainty related to the construction of the index and the uncertainty due to inter-operator variability. Specifically, for the application of the standards, we studied how the similarity, or absence thereof, of the skill level of the operators (including sampling experience and/or taxonomic knowledge) may influence the final ecological assessment of a stream. We showed that the skill level of the operator influenced the structure and composition of faunal data necessary for the calculation of the index value, at both the sampling and laboratory steps. But the robustness of the index construction mitigated the effects of such variability on the final stream ecological assessment. This study highlighted how a robust index construction coupled with field and laboratory step standardization were important for the overall reliability of a biotic index, especially for long term monitoring of stream ecological health.

RS21_O8_Food quality drives macroinvertebrate community composition in lowland streams with differing in catchment land-use

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Land use affects lowland streams via altered allochthonous inputs and nutrient loads, leading to changes macroinvertebrate community composition. Although these effects are well known, the underlying mechanisms remain unclear. Here we hypothesize that altered sediment food quality drives macroinvertebrate community composition in lowland streams. To test this, substrate cover, sediment composition and sediment fatty acids were measured to determine food quality in lowland streams surrounded by five different land use types: forest, extensive grassland, intensive grassland, crop, and urban. Macroinvertebrate community composition was related to differences in food quality. Our results showed that high quality food characterized by woody debris, CPOM and higher C/N ratio resulted in a higher abundance of EPT species in forest streams, while in crop and urban streams a low food quality characterized by high relative amounts of microbial fatty acid in the sediment was associated with higher *Chironomus* sp. and worm abundance. In conclusion, food quality is land use specific and drives macroinvertebrate community composition.

RS21_O9_How much of leaf breakdown is attributable to invertebrate ingestion and secondary production?

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The breakdown of leaves in streams and the role of invertebrates in leaf processing have been studied extensively. The amount of leaf material ingested and quantitative flow of material from leaves to invertebrate biomass has been less studied, but is fundamental to the understanding of food-web dynamics and ecosystem functioning. We measured leaf breakdown and secondary production of shredder invertebrates at six sites along a gradient of altitude (36 to 254 m a.s.l.), stream-size (10 to 566 L/s discharge) and shading (8 to 93% cover) in tropical coastal streams at Ilha Grande, Rio de Janeiro. We measured leaf processing from the loss of mass of packs of the most common leaves at each site. We also measured litter biomass and invertebrates in monthly samples and estimated secondary production of invertebrates associated with leaf processing. We estimated the amount of leaf material that would have had to have been ingested to produce the observed secondary productions by assuming 87% loss in assimilation and 50% loss to respiration. Leaf biomass (457 to 815 g AFDM/m^2) and secondary production of shredders (0.32 to 0.5 g AFDM m^2/month) varied surprisingly little along the gradient. Leaf breakdown varied substantially, which led to variation in leaf ingestion between 2.8 and 17% of observed mass loss of leaves (excluding one apparent high outlier), with no apparent relationship with the gradient. We conclude that a relatively small percentage of leaves is ingested by invertebrates and a larger percentage goes to microbes and physical processes including bioturbation.

RS21_O10_Night-time measurements highly relevant for assessing stream CO_2 fluxes: a Cross-European study

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Globally, streams represent major CO_2 emitters, accounting for approximately 70% of the total flux from inland waters. Hence, a proper understanding of carbon dioxide (CO_2) uptake and emissions from streams is crucial for accurately estimating aquatic global carbon emissions. However, diurnal dynamics of these fluxes are still not comprehensively quantified, contributing to a high uncertainty in regional and global carbon budgets. Within the EuroRun project, the 1st Collaborative European Freshwater Science Project for Young Researchers, we aimed to assess spatial and seasonal variability of day- and night-time CO_2 fluxes of 34 streams across 11 European countries. CO_2 fluxes were measured with drifting flux chambers once per season at midday and midnight. The median CO_2 fluxes during the day amounted to 1.4 µmol m^{-2} h^{-1} (IQR 0.5 to 3.1) and during the night to 2.1 µmol m^{-2} h^{-1} (IQR 0.95 to 3.75). The CO_2 fluxes during night exceeded those during day by up to eight times. Interestingly, these differences occurred throughout all seasons and showed no latitudinal patterns. Our results highlight the importance of night-time fluxes to accurately assess CO_2 fluxes from streams. As most studies are performed during the day, our survey indicates that global carbon budgets are currently underestimating the amount of CO_2 released by streams.

RS21_O11_Decomposition across the riparian-stream meta-ecosystem alters litter processing in streams

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Fluxes of leaf litter from the riparian zone are the main source of energy to low-order shaded streams. Lateral inputs contribute up to 23% to the total amount of litter entering streams but most decomposition studies assess only the fate of senescent leaves that fall directly from the canopy. To determine if decomposition, microbial and invertebrate colonization of lateral litter inputs are similar to those of vertical inputs, we assessed leaf decomposition of alder, poplar and a mixture of the two species in three scenarios across a gradient of terrestrial: aquatic exposures. Overall decomposition decreased with the increase in the period of terrestrial exposure. Invertebrate colonization tended to decrease with terrestrial exposure, but was more affected by litter type than by the exposure scenario, attaining higher values in the mixture than in the species alone. Contrarily to overall decomposition, the effect of terrestrial exposure on in-stream decomposition rates was species-specific. Alder decomposed faster and poplar and the mixture decomposed slower with the increase in the period of terrestrial exposure. The richness the aquatic hyphomycete community colonizing leaf litter after submergence and sporulation rates were strongly inhibited after a terrestrial exposure period. We show that the path taken by the litter has important effects on the functioning of the receiving ecosystem. Studies relying only on the fate of vertical inputs may not present a complete picture of the decomposition process in streams and may have been overestimating the overall richness and reproductive activity of the aquatic hyphomycetes colonizing leaf litter.

RS21_O12_Global patterns of organic-matter decomposition in riverine ecosystems demonstrated through peer sourcing

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Organic-matter decomposition is a central process in Earth's ecosystems, yet large-scale patterns and controls are poorly understood. We deployed a standardized assay in over 500 streams and their riparian zones, with sites located on each continent and in each major biome, spanning 140 degrees of latitude. We found global-scale patterns in decomposition rates, with stark differences among biomes, and negative relationships with latitude. Decay is very rapid in tropical forests (both wet and dry) and slow in tundra and boreal forests; these extremes bracket all other biomes. Variability in decay rates increases with proximity to the equator, suggesting strong temperature limitation at high latitudes and more scope for other environmental factors to influence decay at lower latitudes. The ratio of riparian to instream decomposition rates ranges widely among riparian-stream pairs and biomes, a finding with potential implications for ecosystem responses to climate change through landscape-scale portfolio effects. Activation energy is greater in streams than riparian zones, suggesting different factors other than temperature alone govern decomposition in these habitats. Moisture limitation on land is a prominent factor. The relationship between concentrations of dissolved nutrients and decomposition rates is unimodal, suggesting nutrient limitation at low concentrations and inhibition by nutrients or other pollutants at high concentrations. These data provide useful baselines for tracking effects of environmental change on organic-matter decomposition at large scale, and for moving toward a standardized process-based tool for global bioassessment programs.

RS21_O13_Role of aquatic macrophytes on steams waters chemistry

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Knowledge on phosphorus (P) and nitrogen (N) cycles is vital to resolve or prevent eutrophication problems in rivers, lakes and coasts. Aquatic macrophytes directly impact nutrient content in waters, acting as a sink via biomass growth and a source via biomass mineralization. Through photosynthetic activity, aquatic plants also modify water characteristics like O_2 and CO_2 contents. In vegetated streams, we hypothesize that O_2 and CO_2 variations imply water pH variations and finally impact the geochemical cycle of some redox elements like iron (Fe). As the coupling between Fe and P geochemistry is one of the main processes that control P availability in aquatic systems, the indirect role of plants on iron cycling could therefore influence the speciation of P. Such complex Fe-P interactions has been extensively studied in marine seagrasses rhizosphere and in soil science. To gain better insight into the links between macrophytes and Fe-P geochemistry in surface freshwaters, we have monitored the evolution of geochemical, physical, and vegetal parameters during the day-night cycle in streams colonized by different communities of plants. Streams were selected within the Leyre river catchment (SW France), characterized by two main land use (83% of pine forest and 14% of crop fields). Results show that freshwater aquatic macrophytes are hotspots of P sequestration as Fe-oxides bound P due to increasing kinetics of dissolved Fe oxidation during daylight photosynthetic activity. Intensity of this reaction varies seasonally and with the land use, showing that nutrient concentration and oxygen availability are the main drivers of the kinetic.

RS21_O14_Consequences of water diversion and its interaction with chemical pollution on river ecosystem functioning

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Water diversion related to hydropower generation is a common and growing human activity along streams and rivers. Discontinuities created by big dams in rivers have been widely studied, but the effects of small weirs are still poorly known. Furthermore, there is scarce information on how another relevant stressor, as chemical pollution, interacts with water diversion likely aggravating its impact. To assess the effects of water diversion and its interaction with chemical pollution on ecosystem functioning, we sampled four streams with a similar diversion scheme covering a gradient of pollution in the North Iberian Peninsula. We compared ecosystem-level processes between free flowing reaches located upstream and downstream from the diversion weir during a period of active diversion and a period of no diversion. Water diversion caused channel narrowing and streambed substrate coarsening downstream from weirs, but these geomorphic effects had weak consequences for ecosystem functioning. Among all measured processes, only the fragmentation rate of leaf litter in emerged parafluvial drybeds was affected by water diversion and pollution level. Contrary to our expectations, our results suggest that water diversion and its interactions with chemical pollution have limited effects on ecosystem functioning in the studied area, although the prevalence of water diversion will probably result in changes in biogeochemical functioning of river-canal networks.

RS21_O15_Litter quality modulates effects of dissolved nitrogen on leaf decomposition by stream microbial communities

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Rates of leaf litter decomposition in streams are strongly influenced both by inorganic nutrients dissolved in stream water and by litter properties such as lignin, nitrogen (N) and phosphorus (P) concentrations. As a result, decomposition rates of different leaf species can show contrasting responses to stream nutrient enrichment resulting from human activities. It is unclear, however, whether the root cause of such discrepancies in field observations results from interspecific variation in either litter nutrient or litter lignin concentrations. To address this question, we conducted a controlled laboratory experiment with a known fungal community to determine decomposition rates of 38 leaf species exhibiting contrasting litter traits (N, P and lignin concentrations), which were exposed to 8 levels of dissolved N concentrations representative of field conditions across European streams (0.07 to 8.96 mg N L^{-1}). The effect of N enrichment on decomposition rate was modelled using Monod kinetics to quantify N effects across litter species. Lignin concentration was the most important litter trait determining decomposition rates and their response to N enrichment. In particular, increasing dissolved N supply from 0.1 to 3.0 mg N L^{-1} accelerated the decomposition of lignin-poor litter (e.g. <10% of lignin, 2.9× increase ± 1.4 SD, n = 14) more strongly than that of litter rich in lignin (e.g. >15% of lignin, 1.4× increase ± 0.2 SD, n = 9). Litter nutrient concentrations were less important, with a slight positive effect of P on decomposition rates and no effect of litter N. These results indicate that shifts in riparian vegetation towards species characterized by high litter lignin concentrations could alleviate the stimulation of C turnover by stream nutrient enrichment.

RS21_O16_Cyprinid fish in stream ecosystems can reduce eutrophication effects

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The ecological role of different fish species in lakes and reservoirs is well understood and the knowledge is even used for monitoring or lake restoration. The ecological role of fish in streams and rivers is less clear. To analyse the trophic interactions between fish and benthic invertebrates, often salmonid fish in small streams are studied. However, larger streams and small rivers are often dominated by cyprinid fish species like common nase (*Chondrostoma nasus*) and European chub (*Squalius cephalus*) and fare less is known about the ecological role of these fish species. We assumed that both species would increase habitat quality of the uppermost horizon of the hyporheic zone. Nase is a grazer and can therefore be expected to reduce algal biomass, thereby reducing biological clogging and reducing the input of organic carbon into the hyporheic zone. Chub is omnivorous and its burrowing feeding behaviour might decrease clogging of the hyporheic zone due to bioturbation. To test our assumption, we performed a large scale field experiment in which we manipulated fish densities in a nutrient rich mountain stream. Our results show that high cyprinid densities increased the oxygen concentration in the uppermost horizon of the hyporheic zone, most probably by increasing vertical water flux and reducing algal biomass. We conclude from our findings that the existence of natural densities of cyprinid fish in larger streams and small rivers is important for their ecological quality. We postulate that an enhancing fish stocks might even be used to reduce eutrophication effects.

RS21_O17_Ecological role of beavers in the Swiss landscape

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Beaver (*Castor fiber*) have made a strong comeback in Europe, being visible in urban, agricultural and (near)natural landscapes. This study examined seasonality (hydrological cycle) in stream physico-chemistry and macroinvertebrate assemblages along two beaver-pond cascades (wetland, stream) in contrasting agricultural landscapes in Canton Zürich, Switzerland. Macroinvertebrates were assessed in terms of biodiversity and food web structure (stable isotope analysis). Physico-chemistry was affected strongly within the cascades across seasons, albeit greater in the wetland system with a longer water residence time. Beaver cascades reduced nitrogen downstream (upwards of 15%), increased carbon storage, and mostly increased DOC below cascades. Macroinvertebrate assemblages shifted along cascades with an increase in lentic species and large predatory (odonates, dytiscids) invertebrates in beaver ponds relative to stream sites, but also differed between the two beaver complexes and seasonally. Isotope analysis further revealed a contrast in diet between the two systems and along each complex. Allochthonous diets persisted in the stream complex, whereas shifts to autochthonous sources occurred along the wetland complex. The results highlight the important hydrological influence beaver can have in human-dominated landscapes, increasing spatio-temporal heterogeneity in hydrological properties and modifying macroinvertebrate assemblages in response to changes in the habitat template.

RS23 Urban freshwaters

RS23_O1_Stream biodiversity and habitat loss in two urban river systems over 40 years

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Globally urban streams and rivers are under increasing stress. A complex combination of factors in urban streams including altered hydrology and channel morphology, loss of habitat heterogeneity and increasing contaminants from stormwater and overland flow, all contribute to marked degradation of benthic communities. A study of benthic communities in two urbans river catchments in 1980 provided an opportunity to assess changes in surface river length, habitat, benthic invertebrate diversity and community composition along these rivers after 40 years. The Avon and Heathcote rivers are entirely contained within Christchurch City, New Zealand. Each river has about 20 named 1^{st}-2^{nd} order tributaries. In 1980 approximately 200 sites along these systems were sampled for basic water chemistry, substrate size and benthic invertebrates. In 2019, 50 sites were resampled with more intensive water chemistry, substrate size and an extensive composite kick-net of invertebrates. Over the 40 year period the upper reaches of springfed 1^{st} order tributaries in the north-west of the city have experienced marked drying. Approximately 10-15% of the length of these tributaries are now dry, with ephemeral flows during major storms. In 1980 two mayfly and three aquatic beetle species were collected in a number of sites in these two rivers. In 2019 no mayflies or aquatic beetles were collected in the two rivers. Community compositions have changed with more pollution tolerant species such as snails, amphipods and oligochaetes dominating. Although these results are not surprising they do provide empirical evidence of the temporal response of stream communities to urbanisation.

RS23_O2_Impacts of pollution and hydrological stress may cause homogenization in biological communities

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Wastewater inputs may account for most river discharge under hydrological stress situations, when low dilution accentuates the potential effects of chemical pollutants. We investigated the effects of urban wastewater discharges on the diatom and invertebrate communities in twelve streams of different size, water flow, and substratum type. Impact sites receiving high concentrations of ammonium, phosphorus, and pharmaceutically active compounds (antibiotics, analgesics, and anti-inflammatories) were compared to upstream, unpolluted, reaches. The largest differences in the diatom assemblage composition between the paired upstream and impact sites occurred under untreated sewage inputs, or in streams with lower dilution capacity. In these sites, the diatom assemblage was composed by a few pollution-tolerant species, leading to the regional homogenization of the diatom assemblages. Wastewater effluents also selected the most tolerant macroinvertebrate taxa, while long-living organisms and those with higher surface-body mass ratio showed higher sensitivity. Wastewater effluents caused a high dissimilarity between the invertebrate communities of the impact sites. The different response patterns to the joint pollution and hydrological stressors in macroinvertebrates and diatoms could be related to the intrinsic characteristics of the two communities, and particularly to their respective dispersal abilities. Our observations indicate that stressors'effects on diversity patterns differ according to the type and complexity of the considered biological community.

RS23_O3_Urbanization reduces trophic redundancy and alters resource flow through stream food webs

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The exact nature of the effects of catchment urbanisation on the structure and function of stream food webs is currently unknown. To characterize these patterns, we compared the consumer-resource integrations and resource flow through stream food webs in relation to the resource availability and abiotic characteristics at agricultural, woodland and urban sites in the Zagreb region of Croatia. Urbanised sites had lower trophic redundancy with fewer interactions between trophic levels, indicating a more fragile system. Increased loading and altered composition of nutrients, lower water discharge and higher light availability at urban sites likely promoted the contribution of aquatic macrophytes to diets of primary consumers. Macroinvertebrate predators relied more on detritivores and less on shredder prey at urban compared to woodland and agricultural sites. There was no effect of land use on isotopic variation of basal resources, primary consumers or macroinvertebrate predators, but all these trophic groups in urban and agricultural sites were enriched in nitrogen stable isotope ratios relative to their counterparts in woodland stream food webs. The physical and chemical ecosystem characteristics associated with intensive land use altered the resource availability, trophic redundancy and the flow of energy to upper trophic levels, with potentially negative consequences for community dynamics and ecosystem functioning. These empirical findings indicate that reducing nutrient pollution, agricultural runoffs and maintaining riparian vegetation can mitigate the impacts of land use on structure and function of stream ecosystems.

RS23_O4_Seasonal variability of phosphorus release from sediments of an urban lake

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In this study we present seasonal variability of the internal loading in a shallow, urban, eutrophic lake located in the Vistula valley in Warsaw. Due to low exposure to wind mixing the lake experiences long-term thermal and oxic stratification despite small depth (max 4,5 m). Stratification occurs from May till August in the deepest part of the lake, with anoxia and high temperatures (15-20°C) in the hypolimnion, which creates specific conditions promoting P release from the bottom sediments. Based on a seasonal field study, including throughout the day measurements, and incubation experiment together with thermodynamic modelling, we identified periods of high internal loading and its mechanism. In the area of the lake characterised by depth of more than 2 m, high internal loading occurs from June till August due to anoxic and warm meta-/hypolimnion. Under these conditions phosphate release is accompanied by sulphate reduction and production of ammonia and iron(II) ions which suggests that P comes from organic matter decomposition and reduction of iron(III)-P compounds. In shallower, warm and oxic parts of the lake, fast P release is induced by alkaline pH caused by massive algae blooms, which is however compensated by P precipitation with calcium compounds. If further decrease of water resources of the lake and it`s depth proceed due to large anthropogenic pressure, as was observed during last 50 years, intensification of the internal loading caused by increasing bottom layer temperatures is to be expected.

RS23_O5_Assessing the effects of a WWTP effluent on stream food webs through stable isotope analysis

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Point source pollution, including effluents from waste water treatment plants (WWTP), is one of the most relevant stressors in aquatic ecosystems. Effluents are complex mixtures of nutrients, organic matter and other pollutants that can alter stream communities and ecosystem functioning. We aimed at assessing the effects of WWTP effluents on the structure of stream food webs by analysing stable isotope ($\delta^{15}N$ and $\delta^{13}C$) ratios in basal resources (biofilm, bryophites, filamentous algae, fine benthic organic matter, aquatic and terrestrial coarse particulate organic matter) and consumers (macroinvertebrates and fish). To do so, we performed a BACI (Before-After, Control-Impact) experiment, in which we diverted part of a WWTP effluent into the lowermost 100 m of an unpolluted stream in Elgoibar (Gipuzkoa, N Iberian Peninsula), using an upstream reach as control. Significant temporal and spatial variation of the isotopic signatures were observed for many resources and consumers. Furthermore, the WWTP effluent also altered significantly the signature of biofilm and some primary and secondary consumers, with all the isotopic drifts occurring in the same direction. The results suggest that the food web downstream of the WWTP effluent is not stressed but slightly subsidized by the WWTP.

RS23_O6_Combined sewer overflows as a ruling force for the ecological status of small rivers?

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The ecological state of running waters is influenced by a variety of abiotic factors like flow- and discharge conditions, mass balances as well as provided substrates and habitats. Within the highly complex causal network of influencing factors, the hydro morphological conditions may play a crucial role in shaping the local invertebrate living communities. Aquatic species diversity is often positively linked to high dynamics of environmental factors. Therefore, disturbances in the system e.g. extreme flows are not necessarily negative. However, combined sewer overflows (CSO) may strongly increase extreme flow frequencies and amplitudes, leading to reduced biodiversity and retreat of specialized species. We investigated the influences of CSOs in the state of Baden-Württemberg, Germany, in order to identify rivers with “hydraulic overloading” and potential consequences for macro invertebrate communities. For 4,781 storm water treatment facilities the regionalized discharge was calculated. The receiving rivers were clustered in six groups of mean discharge from ≤ 50 l/s to ≥ 2000 l/s. Results show that more than 60% of the inflow points into the rivers, receive over 40 times per year discharge peaks of 1000 l/s and higher. For 40% of the rivers (discharge < 100 l/s) this means that the CSO discharge is the ruling hydrological force, defining the shape of the river and the composition of the riverbed. However, even though macro invertebrate analysis showed significant impairments in river quality, the results indicate that the impact of each CSO facility has to be regarded in the local environmental context to adequately plan measures.

RS23_O7_High-frequency monitoring of phytoplankton and cyanobacteria in a small urban lake

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Urban lakes are important spots of recreational activities. Excess nutrient input from their watershed associated with global warming increase the occurrence of toxic cyanobacteria blooms. In bathing areas, compliance with regulatory standards for cyanobacterial biomass and toxin concentrations requires a regular toxicity assessment to limit risks. Current methods for determining potentially toxic species are based on taxonomic microscope identification. They require very specialized skills and are time-consuming. Therefore, rapid, easy to implement methods must be developed. Field sensors of chlorophyll and/or cyanobacteria-specific pigments can achieve this goal. However, sensor data do not provide information on the species; their results can be very variable depending on the hardware characteristics and in some environmental conditions, they can be affected by high errors. In order to investigate the reliability of a monitoring system of cyanobacteria blooms, a survey was performed for three years (May 2016 to December 2018), in a small experimental lake (Lake Champs-sur-Marne, Great Paris, France). High-frequency measurements of physical-chemical variables, chlorophyll-*a* and phycocyanin fluorescence were collected at three points. In parallel, vertical profiles of the four main phytoplankton groups were measured at the same points, with a fluorimetric probe, during regular field campaigns (n=75). Lab analysis of chlorophyll-*a* and phycocyanin were performed. A regulatory monitoring of the bathing area supplied lab chlorophyll-*a* data and a semi-quantitative assessment of dominant species. This dataset is analysed in order to figure out how cyanobacteria sensor data are consistent with the other data. The sensor reliability conditions for assessing the cyanobacteria biomass are defined.

RS23_O8_Freshwater biodiversity conservation: the role of artificial ponds in the 21st century

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The number of artificial ponds is sharply increasing in most developed landscapes, and these new types of waterbodies are expected to dominate the pondscapes of the 21th century. They are created and managed for offering diverse ecosystem services, often in link with water management, aesthetic aspects or recreation, but they are rarely designed for providing habitats for the freshwater biodiversity. Despite this situation, artificial ponds can host many fauna or flora species. We illustrate here the benefit for biodiversity that four types of artificial ponds provide in Switzerland. We sampled plants, snails, beetles, dragonflies and amphibians, in 38 gravel pit ponds, 22 cattle watering ponds, 102 urban ponds, 8 alpine snowmaking reservoirs, and compared them with 80 "natural" ponds. The results evidenced that all types of artificial ponds host a lower biodiversity than natural ponds. Nevertheless, even if not species rich, their communities included some threatened species. For some taxonomic groups the richness was even high, depending the considered pond type. Beetles were well represented in snowmaking reservoirs, as dragonflies in cattle watering ponds, as plants in urban ponds and as amphibians in gravel-pit ponds. The artificial pond types outcome therefore to be complementary to each other's, and this justifies a pondscape approach with a management promoting a diversification of pond types. It outcomes also that the potential for biodiversity could easily be enhanced in artificial ponds through a pond design more appropriated, offering habitats to the biodiversity.

RS23_O9_Benefits of nature based solutions for urban streams

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Nowadays aquatic scientists and decision makers seek to explore the potential of nature-based solutions (NBS) to address contemporary water management challenges. They focus particularly on water for sustainable cities, disaster risk reduction and water quality. NBS use natural processes to enhance water availability, improve water quality and reduce risks associated with water-related disasters and climate change. The aim of presented paper is to find the most appropriate NBS to maximize benefits and system efficiency while minimizing costs and trade-offs. Although NBS are not a panacea, they will play an essential role in the functioning of urban aquatic ecosystems and in creating better living conditions in heavily modified urban cities. Humans are an integral part of nature, including river corridors, and therefore should live in harmony with it. It is expected that NBS help to improve water security for all kinds of ecological services.

SS1 Science and management of intermittent rivers and ephemeral streams: a European perspective

SS1_O1_Stream drying acceleration in Central Europe: Trends in aquatic and terrestrial communities

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Stream intermittency has expanded in the last 5 years over dominant part of the Czech Republic, where more than 50% streams at 1-4 Strahler order belongs to risk of frequent drying. Cumulative effect of supraseasonal drought can lead to a gradual change not only in aquatic communities but also triggers shifts in terrestrial assemblages which can use dry riverbed as a new type of habitat. Gravel bars can be rapidly colonised by vascular plants growing in surrounding riparian habitats/catchment and emerging from the sediment seedbank. For terrestrial invertebrate specialists can be the bare riverbed suitable refuges in the landscape lacking such habitats due to absence of natural disturbances. Similarly big terrestrial mammals can search for food in dry channels during flow cessation and later use them as preferable migratory corridors. Contrary to the expanding niche for terrestrial organisms, aquatic macroinvertebrates experience progressive reduction of habitats and time span to complete their life cycles. In response to this some taxa strongly reduced populations in previously perennial reaches. For very first time we observed new phenomena of delayed winter flow resumption (2-3 months latter then typically) associated with freezing of dry riverbed. All these new factors can lead due to its very fast onset to unpredictable changes in community structure and functioning (e.g. reduction of leaf packs decomposition by absence of aquatic macroinvertebrate autumn generations). Our research project (supported by grant LTC17017) explore some of these impacts using highly dynamic communities of rapidly changing streams in continental humid climate of Central Europe.

SS1_O2_Combined impact of stream drying and organic pollution on invertebrate seedbank: Experimental rehydration of dry riverbed sediment

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Due to the climate change, more and more streams become intermittent, even in temperate regions with humid climate as is the Czech Republic. Unfortunately, there is still a lack of information about co-influence of drying and other common anthropogenic stressors such as organic pollution on instream biota. Benthic invertebrates can reveal different responses (e.g., different resistance level to drying) to isolated or combined impacts of multiple stressors. We compared benthic invertebrates from dry riverbed sediment of 6 intermittent streams (3 with vs. 3 without organic pollution) using laboratory rehydration of the sediment. At each site we sampled 10 plots from 10 selected mesohabitats according to their proportional representation within the reach. Samples of benthic invertebrates were rehydrated for 2 months under controlled laboratory conditions to observe invertebrate seedbank hatching. Besides the duration of drying and organic pollution impacts, we also analyze substrate structure and moisture content of the mesohabitat samples as important factors affecting invertebrate resistance. Our results may help understand differences in invertebrate seedbank composition in organic-polluted and unpolluted intermittent streams, and differences in species resistance to both stressors.

SS1_O3_Large-scale distribution of aquatic invertebrates in permanent and intermittent streams

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Flow regime and its alterations deeply affect macroinvertebrate communities, especially considering the shift in conditions that is occurring in several rivers due to the combined effect of climate change and anthropogenic pressures. Aiming to understand the effect of flow intermittence on the large-scale distribution of aquatic invertebrates in permanent (P) versus intermittent (I) watercourses, we carried our work in the framework of the project NOACQUA (Prot. 201572HW8F) in 24 Apennine watercourses (11 I and 13 P) of the Po River Basin (N Italy) before the summer dry phase. We applied mixed effect modelling and spatial ordination techniques in order to evaluate the variation of metrics and community structure between I and P streams and variance partitioning for assessing the relevance of the different spatial scales in I versus P. Communities of I streams resulted with lower values of taxa richness and a greater variability than those found in P streams. These results suggested intermittency as a factor that decreases α-diversity and increases β-diversity. Moreover, we found that both in I and P streams, local environmental variables are the most powerful predictors of community structuring. However, the residual variance was much higher in P streams, suggesting the presence of more stable communities being more influenced by biotic dynamics than by habitat filtering. These findings represent valuable insight in the effects of flow alterations in the perspective of best-strategy planning to face the regime-shift phenomenon.

SS1_O4_Community response to 25 years of intermittent drying in temperate-climate streams with contrasting flow permanence regimes

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Most river networks include streams with different flow permanence regimes: perennial, those that dry only during unpredictable droughts (near-perennial) and those that dry seasonally (intermittent). The frequency, duration and regional extent of drying drive aquatic community composition, though studies combining all aspects of drying across streams with different flow permanence regimes remain rare. We combined invertebrate data from 46 temperate-climate river sites over a 25-year period including unpredictable drying events, to assess how spatiotemporal changes in drying affect α and β diversities among sites with different permanence regimes. We used daily discharge and monthly observational flow-state data to determine the hydrological conditions preceding each sample. Alpha diversity decreased with the duration of drying in the preceding summer and increased with the time since the preceding drying event. Diversity decreased more steeply and took more time to recover at near-perennial sites than at intermittent sites. Beta diversity increased with the spatial extent of drying, reflecting increases in environmental heterogeneity among sites. Regional diversity of flow permanence regimes promotes different community responses to drying, allowing species' regional persistence and post-drying recolonization. Climate change predictions of increases in drought duration and frequency may, however, threaten diversity if disturbance intensity exceeds community resistance and recovery capacities.

SS1_O5_Functional and taxonomic benthic macroinvertebrate diversity among multiple freshwater habitats in an intermittent river network

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Intermittent rivers (IRs) are characterised by flow cessation, and thus, are spatially and/or temporally dynamic ecosystems, shifting between lotic, lentic and dry habitats phases. These drying events lead IRs to be landscape mosaics of aquatic and terrestrial habitats. Aquatic macroinvertebrates present in IRs and ephemeral ponds often depend on refuges to survive streambed drying. Key refuges include instream ponds, permanent ponds, backwater channels and the hyporheic zone. Numerous studies have focussed on benthic macroinvertebrate taxonomic diversity in either instream or floodplain ponds. However, at a landscape-scale, research effort has often overlooked the connectivity, dispersal mechanisms, colonisation and refuges between a river and floodplain waterbodies in temperate IR networks. Moreover, biodiversity have been traditionally studied by using a taxonomic approach, but species functional characteristics also strongly influence their persistence in these ecosystems. In this study, we examine the effects of flow cessation on benthic macroinvertebrate diversity and community composition of multiple freshwater habitats, at the landscape-scale, in an IR network consisting of multiple perennial and intermittent sections by using a taxonomic and functional approach. We will determine whether instream ponds, floodplain ponds, perennial reaches and backwater channels provide a refuge during streambed / ephemeral ponds drying. In addition, we address metacommunity assembly mechanisms processes among instream sites, instream and floodplain ponds, and backwater channels. The identification of flow refuges and the examination of the local and regional environmental drivers of benthic macroinvertebrate communities over multiple freshwater habitats will be examined to provide landscape-scale conservation and management recommendations in intermittent river networks.

SS1_O6_The effects of riparian zones on carabid beetle assemblages and their functional traits of an intermittent karstic river

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Riparian zones are interfaces between aquatic and terrestrial ecosystems — complex ecosystems strongly influenced by the water flow. Such highly dynamic environment which changes both spatially and temporally is characterised by pronounced environmental gradients and habitat heterogeneity. Riparian zones differ from upland karstic habitats (shrublands and open pastures) in inundation frequency, vegetation composition and structure, soil properties and microclimate. The aim of this study was to determine changes in carabid beetle assemblages and their functional traits longitudinally along the intermittent Krčić River, Croatia; and laterally within adjacent karstic habitats. Within each habitat type carabid beetles were collected by pitfall traps at 36 sites. Carabid beetle species richness and diversity were significantly higher in the riparian habitats compared to the karst habitats. Similar significant pattern was observed for activity density which was over 3 times higher in riparian than in karstic habitats. Among examined functional traits body size and flight ability were related to the environmental parameters (e.g. vegetation structure and composition) associated with habitat types. Double constrained canonical correspondence analysis revealed that flight ability was significantly higher in riparian habitats, while larger body sizes were found in stable karstic habitats. Thus, lateral changes in community metrics were more pronounced than the longitudinal, since differences in community metrics (species richness, diversity and activity density) and functional traits were not significant. The riparian zone of the intermittent river in a dry karst environment represents a unique habitat supporting diverse carabid beetle communities.

SS1_O7_What does it mean to be ahead of the curve? Impacts of climate-change driven flow regime change on the life histories of stream invertebrates.

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Southwestern Australia has experienced climate-change driven climate drying for at least 50 years, decades ahead of other mediterranean-climate regions. Groundwater decline caused most perennial (gaining) streams to become intermittent (losing) streams. Bunn (1988) published detailed life histories for 13 species (amphipods, odonates, stoneflies, mayflies, caddisflies) in perennial streams in this region. We revisited these streams, most of which are now intermittent, to describe current life histories for these species. Four species (2 caddisflies, 2 mayflies) disappeared from now-intermittent streams. Two stoneflies switched from summer to winter breeding. The amphipod has survived in all streams. Two mayflies, a shredding caddisfly and a dragonfly still occur in now-intermittent streams, but these are likely to be population sinks. The transition from perennial to seasonal streams has had profound impacts on fauna that were formerly the most abundant species. When climatic drying alters flow regime, richness, abundance and identity of key species will change.

SS1_O8_Crustacean inflexibility on flow regimes in intermittent spring

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Intermittent springs are spatially "captive" systems that support aquatic invertebrates well adapted to the periodic disappearance of the flow. Consequences of no flow events in the karst spring Krčić more than 100 days per year were related to general community shift. This study was assessed population biology of the numerically dominant crustacean species *Synurella ambulans* and hydrological variables in determining the functional adaptation on periodic desiccation. The spring was seasonally researched during the average years and extremes with a period of zero flow in summer or even whole autumn, and in the year characterised by a continuous flowing phase. The aims were: (1) to find differences in population density and structure with flowing phases (before desiccation vs flow resumption) and to seasonal variation of flow regimes; (2) to confirm resilience traits to intermittency independent of flow regime; and (3) to determine life-cycle adaptation to intermittency. The species was well adapted to changing currents, seasonal drying of spring and seasonal changing of living substrates. We have confirmed resilience traits to intermittency independent of flow regime by a drastic drop of population density in summer during a continuous flowing phase. The records of only a few ovigerous females in samples point on the adaptation of life cycle to spring desiccation, and the females appear to lay eggs in the subsurface environment inside capillary interstices of karst. Further studies on the ecology of this highly adapted species and its relation to hydrological regime are essential for the understanding of intermittent spring functioning.

SS1_O9_The role of *Gammarus fossarum* populations as an indicator of previous stream drying

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Increasing stream flow intermittence is one of the long-term effects of climate change in the Czech Republic. Episodes of stream drying can strongly affect the whole aquatic invertebrate communities and even change the population structure of some species. One of the amphipods, *Gammarus fossarum*, an inhabitant of small, often drying streams, widespread across the whole Czech Republic, lacks any drought-resistant stages and is therefore strongly affected by dry episodes. We studied changes in its population structure across 12 pairs of intermittent and perennial streams in years 2012-2016 and discovered, that populations from intermittent streams have a higher proportion of larger males and a lower proportion of juveniles in comparison to populations of perennial streams. This finding supports the hypothesis that a higher male recolonisation ability is related to bigger body size and therefore higher overall mobility. Comparison of fecundity in natural residual pools and nearby streams in 2017 also indicated a lower proportion of breeding females in natural residual pools, probably caused by an increase in predation in overcrowded residual pools or overall stress in this highly unstable habitat. That could lead to possible egg loss and restricted population recovery after stream inundation. Our study confirms that population structure of *Gammarus fossarum* is one of the possible indicators of previous dry episodes on small streams across the Czech Republic.

SS1_O10_Role of the hyporheic zone in mountain streams progressively shifting from naturally perennial to intermittent systems

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Aim of this study is to explore the impact of intermittence in previously-perennial Alpine stream reaches, where the aquatic communities lack strategies and adaptations to survive the hydrological and physico-chemical changes caused by droughts. We investigated specifically the role of the hyporheic zone in increasing the resilience of these aquatic systems to drought. A first site was selected the headwaters of the Po River (NW Italy) with two stations (one perennial, one intermittent) with piezometers installed in the riverbed, instrumented with temperature and pressure dataloggers, where we monitored two supraseasonal droughts over a period of two years. A second site was chosen in the Po Plain (N Italy), where we monitored three tributaries with a gradient of intermittence at short-time intervals (3 days) during a drought event in summer 2018. We collected hyporheic fauna with a Bou-Rouch pump, used hyporheic meio- and macro-invertebrate composition, abundance, functional groups to assess the use of the hyporheic zone as a refuge from drought. The hyporheic and benthic communities responded quickly to the onset of the drought; as expected, where water is permanent, the hyporheic communities are abundant; conversely, increasingly harshness (i.e, reduction of the water table) affects hyporheic communities and increases the use of the hyporheic habitat as a refuge by benthic taxa. This research was conducted within the framework of the project PRIN NOACQUA "Risposte di comuNità e processi ecOsistemici in corsi d'ACQUA soggetti o intermittenza idrologico" – code 2O1572HW8F_003, funded by the Italian Ministry of Education, University and Research.

SS1_O11_Flow dynamics and connectivity drive changes in invertebrate composition and traits recovery after experimental floods in temporary streams

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Floods in intermittent and ephemeral streams influence invertebrate benthic communities by altering habitat and resources availability. Determining how functional traits influence species resistance and resilience connected to instream refuges and species re-colonisation along post-flood periods may help to elucidate mechanisms behind community recovery. To assess the influence of flooding events on invertebrate communities of temporary streams, we simulated late winter experimental floods in three karstic streams on the Mediterranean Island of Mallorca (E Spain). We used upstream control and downstream flooded stretches. Principal Response Curve analyses showed no differences in periphyton and benthic OM between control and flooded stretches, even though they showed weak recovery during the post-flood period (35 days). Meanwhile, PRC showed differences in benthic composition attributed to the experimental flood at only one of the three stream sites. These results suggest that the different disturbance levels depend on site specific hydromorphological characteristics. Around 50-60% of benthic invertebrates were present in the hyporheic zone, the latter tent to appear in the benthos following post-flood discharge reduction. Increase in richness after floods suggests the hyporheic zone being the main source of colonizers. Our results indicate that periods of high floods in winter-spring following flow resumption in temporary streams may constraint the ecological succession of biological communities before next drought, depending on floods influence in extending the water period. Moreover, our work underscores the importance of the hyporheic fauna as very important source of colonizers after floods, and stresses the importance of the connectivity to the groundwater aquifers.

SS1_O12_Multidimensional invertebrate community responses to drying in dynamic river ecosystems

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Drying represents the primary determinant of aquatic biodiversity in intermittent rivers and ephemeral streams (IRES). However, research focuses on benthic invertebrates in surface sediments, inadequately representing a connected community that extends into the subsurface. We explored invertebrate responses to longitudinal changes in water permanence in the vertical dimension. We compared benthic and hyporheic responses in terms of assemblage composition, alpha diversity and beta diversity. Contrasting with benthic reductions and despite compositional changes, hyporheic alpha diversity remained stable except at long drying durations, and the hyporheic occurrence of some taxa increased with drying. These results collectively suggest that the hyporheic zone can act as a drying refuge for benthic taxa. Beta diversity increased or remained stable for benthic communities, but remained stable or decreased for their hyporheic counterparts, likely reflecting contrasts in the influence of mass effects and environmental filtering on temporal variability in community composition. We found no evidence of decreasing dissimilarity between benthic and hyporheic communities with decreasing permanence, suggesting hyporheic assemblages maintain distinct biodiversity value despite temporary influxes of benthic organisms. As IRES increase in extent due to global change, we highlight that recognizing the vertical dimension can enable a holistic understanding of community responses to drying.

SS1_O13_Are all rivers equal? The role of education in attitudes towards temporary and perennial rivers

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Non-perennial rivers are prevalent yet often overlooked and underprotected. This may be because inadequate understanding of their ecosystem services leaves them undervalued by society; but evidence of negative attitudes towards them is scant. We investigated the strength and extent of negative attitudes by surveying undergraduate students from Australia, UK and USA on their agreement (positive attitude) or disagreement (negative attitude) with statements about the ecosystem services, moral consideration and protection of perennial and non-perennial rivers. Students were surveyed at the start and end of teaching units covering environmental topics. Disagreement with statements was uncommon (17% across all statements and surveys) and attitudes towards non-perennial rivers were mostly positive. However, attitudes towards perennial rivers were more positive, particularly in comparison with non-perennial ones when they were not flowing and in regards to their aesthetic value and recreational amenity. There were no significant differences in attitudes between river types in one teaching unit in Australia, and responses were more often more positive at the end of teaching units in the UK. Our study indicates education can change attitudes. The overall positive response to statements may reflect underlying environmental awareness and pre-existing interest of participants enrolled in environmental and biology degrees, but not necessarily specific knowledge of non-perennial rivers. General environmental education across the wider community could improve attitudes towards non-perennial rivers, particularly when they are not flowing or in regions where they are uncommon or inconspicuous, and could support positive protection measures and innovative, inclusive management.

SS1_O14_Stream drying duration affects the recovery of *Gammarus pulex* (Amphipoda: Gammaridae) from the subsurface sediments of an experimental flume study

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The occurrence of temporary streams in the UK may increase as a result of climate change and anthropogenic pressures on freshwater resources. Temporary streams cease to flow and often experience periods of surface and subsurface drying which reduces aquatic macroinvertebrate abundance and species richness. Previous experiments have demonstrated the ability of freshwater shrimp, *Gammarus pulex* (Amphipoda: Gammaridae), to move vertically through benthic and subsurface sediments during periods of water level reduction. However, the subsequent re-emergence of *G. pulex* from the subsurface sediments once surface flow returns has not been quantified. This experiment used flumes containing coarse (15-20 mm) transparent sediment in which water level was reduced to 20 cm below the sediment surface (providing a 5 cm fully saturated subsurface refuge) for a period of 24 hours, 1 week and 3 weeks. We examined the re-emergence of *G. pulex* from the sediment following rehydration and reinitiating flowing conditions. The results indicate that *G. pulex* were able to use the subsurface saturated sediment as a refuge and re-emerge into the surface flow. However, as drying duration increased, re-emergence from the subsurface was reduced. The results of the research are discussed in relation to the recolonization and recovery of temporary streams following drying events.

SS1_O15_Spatio-temporal dynamic of taxonomic and functional beta diversity of invertebrate communities in intermittent rivers

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Directionality of water, organism and solute fluxes within river networks (RNs) constrains the dispersal of organisms and generate predictable biodiversity patterns. In intermittent rivers, most studies have consisted in reporting snapshots of these biodiversity patterns, limiting our understanding of how biodiversity is organized in space and time. From a spatial perspective, the configuration of drying events within RNs could determine the spatial dynamic of aquatic communities: because headwater drying RNs are prone to slower recolonization than downstream drying RNs, they should exhibit higher spatial beta diversity. From a temporal perspective, the dynamic of drying events, characterized by their frequency and duration, could drive the temporal dynamic of aquatic communities. Because the frequency of drying events resets on-going ecological successions, beta diversity in time should increase with frequency. Because the duration of drying controls the responses of communities through resistance and resilience processes, beta diversity in time should decrease with drying duration. Last, these expected temporal patterns could differ according to the spatial drying pattern, as the slow recolonization of intermittent sites in upstream drying RNs could attenuate the temporal replacement of taxa compared to downstream dryings RNs, where the transition between terrestrial and lotic phases is faster. To explore these ideas, we analyzed a unique dataset spanning a two-year monthly sampling of 11 RNs in France. We computed taxonomic and functional beta diversity with their turnover and nestedness components in space and time. This study emphasizes the importance of taking into account spatio-temporal dynamics when considering biodiversity patterns in intermittent rivers.

SS1_O16_Structure of benthic macroinvertebrate metacommunities in IRES: comparison of DNA metabarcoding and morphological approaches

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The metacommunity framework has become a paradigm for understanding how biodiversity of IRES is structured in space and time. In such dynamic ecosystems, biodiversity is determined by local and regional processes, the latter supposedly playing a dominant role due to recurrent recolonization phases after drying. Macroinvertebrates represent a relevant biological model to explore IRES metacommunity dynamics due to their diversity of dispersal and functional traits. However, as they are taxonomically highly diverse, several limitations are associated with morphological identification, such as using coarse resolution for ubiquitous and abundant groups inhabiting IRES (e.g. dipterans, mites). In turn, this can bias our understanding of metacommunity dynamics. Using molecular identification, such as metabarcoding, could improve substantially this bias by allowing to assess betadiversity at a finer (species) resolution level. In this study, we tested this idea by assessing metacommunity structure of benthic macroinvertebrates in eight catchments of France prone to drying through both morphological and DNA metabarcoding identification. We predicted that a molecular approach would enhance our understanding of metacommunity structure in IRES compare to a morphological approach. To this end, we sampled macroinvertebrates in 20 to 30 sites in each catchment and processed one duplicate morphologically and the other with metabarcoding. We then compared metacommunity structure with the two approaches and discussed the contributions of molecular identification in metacommunity structure assessment.

SS1_O17_Testing metabarcoding for macroinvertebrate biomonitoring in intermittent rivers

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Understanding macroinvertebrate community dynamics in intermittent rivers is limited due to low taxonomic resolution. This holds especially true for groups with difficult taxonomy or for juvenile individuals for which the concept of taxonomic sufficiency, i.e. using taxonomic levels above species, is generally used. DNA metabarcoding is emerging as an affordable genetic tool to overcome identification problems since it allows inferring community composition from unknown bulk samples. Here, we applied DNA metabarcoding of the mitochondrial Cytochrome c Oxidase subunit 1 gene (COI) to study macroinvertebrate community dynamics in the Trebbia river, Northern Italy, as part of the NOACQUA project funded by MIUR (Prot. 201572HW8F). Macroinvertebrates were collected in December 2017 and July 2018 at six sites along the river course, with the last two sites being intermittent. A total of 129 and 69 taxa were identified with metabarcoding and morphological identification, respectively. Mean family richness recognized with metabarcoding was significantly lower when comparing per sample richness. Beta diversity patterns inferred by both methods were consistent across taxonomic levels ($r > 0.9$), although the use of operational taxonomic units (OTUs) provide a still significant correlation ($r \sim 0.8$) but a different ecological interpretation. Turnover component of beta diversity turns out to be more important than nestedness when shifting from higher (i.e. morphology-based) to lower (metabarcoding) taxonomic levels and OTUs. Metabarcoding proved to be a powerful method for studying macroinvertebrate community dynamics in intermittent rivers, despite both primer efficiency and reference database accuracy need to be improved to have more accurate diversity estimates.

SS1_O18_Flow intermittency, biodiversity and food web structure in an alpine fluvial network

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Alpine catchments can experience naturally high levels of flow intermittency (FI). However, little is known about the variability of FI and how it affects biodiversity and ecosystem functions in alpine streams. We used electrical resistance sensors to characterize FI at a high spatial and temporal resolution across 30 headwater streams within Val Roseg, Switzerland, a glacierized alpine catchment. We then compared macroinvertebrate biodiversity and stable isotope ($\delta^{13}C$ and $\delta^{15}N$) trophic indices with FI patterns. Streams exhibited high diversity in the extent of FI, with total time spent dry varying from 0 to 60 % of the year. The proportion of Ephemeroptera, Plecoptera, and Trichoptera taxa was lower in more highly intermittent streams. Primary consumers also assimilated proportionally more periphyton in more highly intermittent streams, interacting strongly with gradients in elevation and organic matter quality (C:N). These effects of FI on trophic structure were further validated through a paired stream experiment, where assimilation of periphyton by primary consumers increased as a response to an experimental increase in flow intermittency. These results thus show that increasing intermittency will shift alpine stream communities towards non-rheophilic taxa with an increased dependence on autochthonous production, fundamentally changing the structure of aquatic food webs.

SS1_O19_Incorporating intermittent rivers and ephemeral streams into global carbon cycle models

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Half the channel length of the world's river network comprises intermittent rivers and ephemeral streams (IRES). Compared to perennial rivers, IRES function as pulsed biogeochemical reactors, where accumulation, transport and processing of material are punctuated in space and time. During dry phases, large quantities of particulate organic matter (POM; e.g. leaves, algal biofilms, herbs) accumulate, and, when flow resumes, pulses of CO_2 emissions and dissolved organic matter (DOM) release accompany POM decomposition and transport. In addition to POM processing, it has also become evident that IRES sediments are biogeochemically active during both dry phases and upon rewetting, with significant fluxes of CO_2. However, global models of carbon cycling and estimates of CO_2 emissions from inland waters are limited to perennial rivers missing at least 84,000 km^2 of IRES channels. Are our understanding and estimates of carbon processing in river networks still accurate when IRES are not included? Supported by an international research network (http://1000_intermittent_rivers_project.irstea.fr/), we quantified the carbon content of sediments and the amount of POM accumulated on dry riverbeds from 211 IRES globally, to estimate carbon storage during dry phases, downstream DOM fluxes as well as CO2 emissions during rewetting events. We extrapolated these estimates at the global scale and showed that IRES substantially contribute to global carbon fluxes and that their inclusion into global carbon cycle models is critical.

SS1_O20_Transition to intermittency alters leaf litter breakdown processes in streams: How climate change is impacting stream ecosystem function

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Mediterranean climate regions of Australia are experiencing reduced precipitation and drying flow regimes, a patterns also occurring in other mediterranean-climate regions. In southwestern Australia, many formerly perennial streams have transitioned to intermittent flow regimes due to permanent declines in groundwater tables. In this project, breakdown of Eucalyptus leaves was measured over 320 days in formerly perennial streams, in leaf packs both accessible to (coarse mesh) and excluding (fine mesh) shredding macroinvertebrates. These results were compared to breakdown rates recorded from the same streams in the early 1980s, when flow regimes were still perennial, and to breakdown rates in the two remaining perennial stream reaches in the catchment in 2017-18. Leaf weight loss was significantly lower in now-intermittent streams compared to the perennial stream, where packs lost the most weight. Leaf packs in the stream with the lowest discharge lost the least weight. Fine and coarse mesh bags did not differ in weight in now-intermittent streams, but did differ in the perennial stream by the end of the experiment due to the arrival of shredding caddisflies there. Changes to the distributions and assemblages of shredding macroinvertebrates is likely a key driver of these differences, as formerly common species including shredding caddisflies are rare in now-intermittent streams. Flow regime drying altered physical and biological processes in stream leaf litter processing, impacts that may be expected in other med- regions as climate change progresses.

SS1_O21_Subsurface zone sustains microbial decomposition during the non-flow period of intermittent rivers

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Microbial decomposition is a key ecosystem process that transforms organic matter and fuels detrital-based food webs. Thus far, the efficiency of this process can be compromised during the dry phase of intermittent rivers (IRs). When water flow ceases, humid sediments represent the last aquatic habitat remaining and may have an important role in sustaining microbial decomposition. Furthermore, in a context of global change, flow intermittency will become more common and IRs appear as a perfect template to better understand the main drivers of organic matter processing in the surface and subsurface zones. To address this question, we selected 20 streams across Catalonia (NE Spain) along a gradient of flow intermittency, where we measured microbial decomposition placing wood sticks on both surface and subsurface zones (15 cm below streambed) over the course of one year. Our results showed that microbial decomposition was consistently greater in subsurface compared to surface zone when intermittency increased. Although the main driver of microbial decomposition was flow intermittency, phosphorous concentration and sediment C:N ratio and sediment grain size played also a relevant role, respectively, in surface and subsurface organic matter processing.

SS1_O22_Same metabolic resilience, different onset – metabolic implications of a rare drying in temperate river sediment

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Intermittence and drying is increasingly expanding to the banks and beds of perennial rivers, yet little is known about the metabolic consequences during drying and upon the return of surface flow. In summer 2018 we exposed sandy sediments of the Spree River, Germany in 56 outdoor mesocosms to an array of drying intensity: (no shade+no rain) > (no shade+rain) > (shade+rain), each for durations of 10, 30 and 90 days; half of each was enriched with fine particulate organic matter (FPOM). During drying, microbial activity was assessed as CO_2 emissions, and over four days of flow as O_2 consumption and ammonium (N) and phosphate (P) uptake/release in perfused and dark columns. After 21 days of drying, microbial respiration declined to a constant level of 1-6% compared to pre-drying; except for the shade+rain+FPOM treatment that remained constant at 8-13%. 24 hours after flow resumption all treatments reached comparable stable rates (on average -0.91μgO_2/g/h, -0.45μgN/g/h and-0.54μgP/g/h), suggesting metabolic resilience regardless of treatment. However, differences among treatments arose during the onset of microbial activity. Under lower drying intensity+FPOM, dormant cells rapidly activated resulting in a sudden increase in activity (respiration and uptake), while under higher drying intensity-FPOM the microbial community abundance was likely reduced resulting in slow increase in respiration and nutrient release. Our results highlight the significance of the drying conditions for the functioning and nutrient export of intermittent sections of perennial rivers and have implications for the management of these reaches.

SS1_O23_Non-flow drives the pigment structure of autotrophic biofilms in temporary streams

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Temporary streams naturally occur throughout the world, and predictions indicate that their frequency might increase because of the conversion of permanent watercourses during global change. The duration, frequency, predictability and seasonality of events define non-flow periods, these being exacerbated by the severity associated to the received solar radiation and the maximum temperature affecting the streambed. Overall, these exert selective effects on stream organisms, among which algae and cyanobacteria perform as primary producers. We assessed the effects of temporal components of non-flow periods, severity and seasonality on the pigment composition and abundance of autotrophic stream biofilms. Samples were collected in 33 streams scattered across 9 basins of the NE Iberian Peninsula, at two times (summer and autumn). For stream characterization, hydrology and severity were monitored daily for a total period of 250 days. Water chemistry and land uses were also characterized. Chlorophylls and carotenoids were extracted from biofilm samples and analyzed using high performance liquid chromatography (HPLC). Temporal components of the non-flow and its severity reduced active chlorophylls and primary carotenoids (directly related to photosynthesis) and increased some of those carotenoids with protective function (secondary carotenoids). The longer the duration of the non-flow period, and the stronger the severity, the higher the effects on the autotrophic pigments structure and composition. However, seasonality also has an important role on autotrophic pigments and can affect its composition and structure.

SS1_O24_Effects of drought on the self-purification capacity of temperate headwater streams

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Over the past decades, the frequency and duration of droughts has increased across Europe, causing perennial streams to shift to intermittency even in temperate regions. Our study aims to investigate the effects of drought on biogeochemical processes in temperate streams in Austria. In 2018, we studied 6 intermittent streams across a land use gradient. Water and sediments from intermittent and perennial reaches were sampled before and during the dry phase and analysed for nutrients, organic matter, and the biomass and activity of biofilms. In addition, we determined SRP and ammonium uptake via slug additions (wet phase) and lab incubations (dry phase). Preliminary results show no significant differences of bacterial abundances in intermittent streams between the wet and dry phase. Down to a water content of 10-15%, benthic biofilms of intermittent reaches did not differ in CO_2 production and enzymatic activities from perennial reaches. Only in sun-exposed gravel streams (water content 1-2%), benthic respiration was significantly reduced. Our study will be complemented in May/June 2019 by laboratory flume and perfusion core experiments to analyse the effects of desiccation on nutrient and DOM uptake by benthic and hyporheic biofilms under controlled conditions.

SS2 Aquatic metacommunities: research and applications

SS2_O1_Modelling community assembly along spatial and environmental gradients: A metacommunity approach

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Metacommunity ecology has emerged as a useful concept in recent decades because it can unlock new understanding of how local biodiversity patterns are influenced by processes operating at regional scales. As an analytical framework, it offers the opportunity to modify the prevailing paradigm of environmental filtering by including effects related to biogeographical history, connectivity and species' dispersal capacities. To what extent these species pool effects may interfere with niche-based selection in a broad range of taxonomic groups and environmental contexts remains an open question. This is partly due to the lack of models suitable for application to a broad range of taxonomic groups and types of trait data. Existing approaches are associated with severe biases in estimating shared spatial-environmental effects, are only suitable for individually measured trait data and/or include only a simplistic representation of species pool effects. We introduce a new meta-Community Assembly by Trait Selection (mCATS) model. The approach involves Monte Carlo sampling from regional species pools using probability weightings provided by site- and taxon- specific dispersal functions and trait-based estimations of species' abundances (constrained by observed community weighted means). mCATS reports standardised effect sizes for dispersal, trait-based and combined effects from the mean and variance of synthetic-observed community similarity compared with a null model in which dispersal functions and traits are randomised. The new approach can be applied at regional-global scales to a broad range of taxonomic groups and habitat types, using continuous, binary or fuzzy trait data.

SS2_O2_Historical legacies and contemporary constrains explain invertebrate and diatom metacommunity structure within a heterogeneous basin

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The relevance of biogeographic and evolutionary processes on community- and metacommunity- dynamics has been long debated; particularly when the study extent is below the continental scale. For instance, a growing body of evidence points to contemporary constrains (such as the structure of the dendritic network and species dispersal ability) as the major drivers of the fluvial metacommunities at the basin scale. However, under special circumstances, historical events could shape the assembly of regional species pools and affect the metacommunity dynamics in the present time. By systematically sampling diatoms and invertebrates in 28 pristine streams from the most representative ecoregions of the Orinoco basin, we show that historical events (e.g. Andean uplifts and the expansions and retreats of glaciers) have shaped distinct regional pools of taxa in both benthic communities. The extent of these pools greatly matches with the extent of the ecoregions, and can be seen as contemporary "footprints" of the historical events that have also shaped the stream forms and riparian ecosystems of each ecoregion. We found that the occurrence of distinct regional pools, shaped mainly by historical events, can override the possible effects of the spatial structure and the environmental heterogeneity within the basin. The statistical models elaborated on these communities suggest the influence of context-dependent factors on the structure and dynamics of each ecoregional metacommunity. Overall, in highly heterogeneous basins, as the Orinoco, the basin scale may not be the most appropriate for biodiversity conservation and stream management.

SS2_O3_Long-term changes in metacommunity assembly mechanisms in Mediterranean rivers

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Metacommunity studies aim at understanding assembly mechanisms in space, considering metacommunities as relatively temporally stable. However, recent studies have shown that metacommunity assembly mechanisms can vary considerably in time, especially in highly dynamic ecosystems (e.g. Mediterranean streams). So far, these studies have exclusively focused on seasonal changes, neglecting interannual variability. We analysed long-term changes in macroinvertebrate metacommunities collected in 15 Mediterranean streams sampled biseasonally in every year since 1996. We found that local environmental factors were more important during wet years because of enhanced stream network connectivity favouring species to reach suitable habitats, whereas dispersal limitation was more relevant during dry years due to a loss of flow connectivity leading to habitat isolation. However, these general patterns varied depending on the dispersal ability of the taxa considered. Our results can contribute to understand and mitigate the effects of water scarcity on Mediterranean freshwater biodiversity, which is especially relevant for future scenarios of increasing water demand and climate change.

SS2_O4_Niche packing and the mechanisms behind richness variation in stream communities: insights from a tropical-boreal comparison

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Biodiversity commonly increases from the poles towards the equator. A hypothesis is that tropical species are more specialized, with narrower niches than high latitude ones, supporting higher richness with low niche overlap. On the other hand, high species richness and niche packing (occurrence of species with high niche overlap) can be achieved independently of niche differences if coexisting species are equivalent competitors. So, comparing niche packing along richness gradients can shed light on mechanisms behind biodiversity variation. Here we used a dataset of stream communities in Brazil and Finland to compare the patterns of niche packing in two contrasting regions. We determined the species niche as the hypervolumes of their environmental preferences. At the regional scale, niche volumes were not different between regions, but boreal taxa presented smaller pairwise niche overlap and higher niche uniqueness, contrasting the idea of higher specialization in the tropics. At the local scale, niche packing increased with richness in both regions suggesting that biodiversity is not constrained by competition within niches. Niche packing in the tropics was negatively related to riparian forest cover, while it was not strongly related to any abiotic variable in the boreal region. Overall, we found evidence that tropical and boreal taxa behave as equivalent competitors at the local scale but with different drivers of niche packing at the regional scale. The higher niche packing in deforested tropical stream suggests a role for environmental filtering packing tolerant species, but surprisingly, no driver could be determined for variation in boreal niche packing.

SS2_O5_A metacommunity approach to improve biological assessments in highly dynamic systems

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Shifts in population and community composition in response to wide temporal and spatial variability can complicate the detection of anthropogenic impacts. Traditional biomonitoring and conservation programs may therefore face significant limitations if applied to highly dynamic ecosystems. Metacommunity ecology has a great potential to inform this situation because it incorporates dispersal processes in addition to local environmental filtering, i.e. the niche-based approach traditionally used in biomonitoring, and spatiotemporal variability in community composition. Here, we use intermittent rivers and ephemeral streams (IRES), which recurrently cease to flow and/or dry, as model system to translate these ideas into practical applications. IRES are globally frequent, support considerable biodiversity, but their dynamism, in terms of constant and severe changes in flow conditions, hampers their adequate management. Here, we propose a conceptual framework that illustrates how the reliability of biological indices and metrics in river biomonitoring may be affected by the interaction of dispersal limitation and flow intermittence. We establish a methodological framework that integrates physical- and organismal-based dispersal proxies, i.e. spatial and hydrological connectivity and organisms' dispersal abilities, into predictive modelling for developing dynamic ecological quality assessments. We provide an example of application using simulated macroinvertebrate IRES metacommunities. Such dynamic approaches based on metacommunities that incorporate niche-based and dispersal-based concepts are required to increase the capacity to monitor and protect ecosystems at risk under future environmental changes.

SS2_O6_Chironomid metacommunity dynamic along the temporal scale: can an appropriate sampling period diminish the influence of spatial processes

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Many studies have examined how local environmental factors and dispersal-based processes structure the metacommunities in freshwater ecosystems. Describing these patterns are especially important for macroinvertebrate biomonitoring methods which are constructed to be sensitive to the local environmental conditions while spatial processes can be a room of error for such models. Even though chironomids present one of the most diverse and dominant group of aquatic macroinvetrebrates, due to their difficult identification, this group has been excluded from many studies regarding metacommunity dynamic. Here we examined the metacommunity dynamic of chironomid communities and tested how the extent of dispersal-based processes vary along the temporal scale. Finally, we determined which taxa/taxa groups are associated with the spatial patterns. The Južna Morava river basin (Serbia) with 28 sampling stations, distributed on 10 rivers was used as a spatial model. The temporal scale was made of 7 sampling campaigns, including all seasons. Moran's eigenvector maps (MEM) obtained 7 models for different seasons defining multiple spatial variables for chironomid community modelling. Redundancy analysis (RDA) tested the community structure in relation to the suite of predictor variables including local environment and spatial variables, derived by MEM. The RDA models revealed that during autumn mounts, spatial variables were significant predictors ($p<0.05$) of variation in community structure. The Self-organizing map (SOM) showed that 18 chironomid taxa were highly correlated with MEM variables, as significant predictors in RDA models. Using spatial analysis in bioassessment can determine the appropriate sampling designs which can diminish the variability caused by dispersal-based processes.

SS2_O7_Assessing the importance of metacommunity network structure for the uniqueness and stability of lake communities

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From a metacommunity point of view the connectivity among local communities is crucial for biodiversity, but the patterns of species richness and turnover resulting from colonization likely depend on the characteristics of isolation gradients. We hypothesized that: 1) sites in the center of a metacommunity have higher richness and turnover, and 2) central sites show lower contribution to beta diversity but a higher stability, mainly due to the “species source” role and the “buffer” capacity of the surrounding sites. To test this, we use a graph theory approach to obtain centrality metrics and relate them to temporal species turnover, community uniqueness and stability of organisms with different dispersal abilities (from phytoplankton to flying invertebrates). Taking advantage of a long term monitoring carried out in Swedish lakes from 1995 to 2015, we have calculated the temporal turnover, uniqueness and stability of the communities from different lake subsets across Sweden. We have then combined this information with the centrality metrics obtained for each monitored lake from a 5360 lake network. Our preliminary results showed that the uniqueness of the lakes was mainly caused by the replacement of species rather than variations in species richness, and that was higher across time than across space. In relation to the centrality, we detected a negative relationship with species temporal turnover. This relationship could be explained because central lakes might have higher species flux that would allow for a higher stability of species composition, which eventually could translate into the observed lower mean temporal turnover.

SS2_O8_Understanding the role of pond network properties and pond characteristics on beta diversity patterns

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One of the major goals of community ecology is to understand the mechanisms underlying beta diversity. Recently, the classical calculation of beta diversity has been extended to the calculation of its decomposition into several components: replacement and richness, the local contribution to beta diversity (LCBD), and the species contribution to beta diversity (SCBD). On the other hand, the newly arisen theoretical approach of metacommunities, allows a deeper knowledge of the regional biodiversity and thus, of the beta diversity. The structure and role of the pond network can be analyzed from a community level perspective (with 'degree', 'closeness' and 'betweenness'centrality metrics) and from a metacommunity level perspective ('linkage density', 'connectance' and 'diameter'network metrics). In this study, we try to link the patterns derived from the beta diversity related metrics with the pond network properties. We have studied the macroinvertebrate metacommunities from five networks of Mediterranean temporary ponds and characteristics of the ponds such as habitat condition (ECELS index), environmental variability and pond size. We analyzed the relationship between metacommunity characteristics (including several beta diversity metrics and species richness) as the response variables, and pond characteristics (i.e., habitat variability and size) and the centrality metrics as the explanatory ones. We found that the different beta diversity metrics were mostly explained by centrality metrics and in some cases by pond characteristics. Pond size does not seem to have a major role on the beta diversity of these metacommunities.

SS2_O9_Aquatic mollusc metacommunity structuring in lentic habitats of two regions differing in trophy level

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The highest freshwater mollusc diversity was repeatedly found in lowland standing waters. Despite the increasing negative anthropogenic impact of these habitats, still only little is known about the main drivers of mollusc diversity among individual stagnant water bodies at regional scale. It is assumed that different processes control mollusc assemblages in oligotrophic and eutrophic sites because many mollusc species are associated with a high macrophyte cover. Besides environmental filters, freshwater mollusc distribution reflects interconnection among individual sites via active vectors due to passive dispersion mode of molluscs. Further, the distances between sites govern the success of mollusc migration to new habitats, being also link with their long-term survival in a dynamic environment. In this study, we quantitatively sampled mollusc assemblages in two regions differ mainly in productivity and trophy level. In the Dyje River floodplain (south-east Czechia, 56 sites sampled), 33 species were found, while in lakes of Dumre (middle Albania, 22 sites), only 9 mollusc species were recorded. While Albanian sites are isolated, oligotrophic (of low phosphorus and calcium concentration), the Czech sites are highly interconnected and eutrophicated. We hypothesized that 1) the habitat heterogeneity, productivity and interconnection significantly influence mollusc species richness and distribution in both regions; 2) species sorting is a dominant process structuring the mollusc metacommunity at small spatial scales; and 3) anthropogenic changes lead to the homogenization of environmental characteristic of sites, and thus to a homogenization and decrease of mollusc regional diversity.

SS2_O10_Assessing the assembly drivers of seasonal succession and wildfire effect on a temporary pond metacommunity through traits selection

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The comprehension of community assembly mechanisms is a prevalent aim in ecology. However, assessing assembly mechanisms in metacommunities has not been straightforward so far. The theory of community assembly via traits selection (CATS) proposed a framework for identifying traits selection and its effect on community assembly. We used this framework aiming to better comprehend wildfire impacts and community assembly mechanisms on temporary pond macroinvertebrates. We took advantage of a wildfire that partially burned a temporary pond system and surveyed it along the whole post-fire hydroperiod. Then, we used the CATS-regression to estimate the interaction among trait selection and environmental factors, including the wildfire effect. We analysed trait-environment and trait-site interaction throughout time considering faunal traits such as body size, dispersal ability, life history and feeding habits. We found that the strength of selection coefficients and their dependence on environmental conditions varied throughout time. At the beginning of post-fire hydroperiod, a strong linkage between environment and traits selection was observed, which diminished towards the middle of hydroperiod. Wildfire appeared as a determining selective force, which, combined with the change in selected traits among other environmental gradients, drove assembly mechanisms that differentiate the structure of local communities. Further, the general attenuation of the role of traits in community assembly through time supported the view of a balance among assembly drivers in a niche-neutral gradient. In temporary ponds, such fluctuation would coincide with their successional model, which describes stronger abiotic control at the beginning of the hydroperiod (allogenic succession) and weakens towards the middle (autogenic succession).

SS2_O11_CONNECTing high frequency *in situ* measurements with remote sensing to monitor phytoplankton dynamics along river-connected lake chains

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Increasing frequencies of extreme weather events challenge river-lake systems. Specifically, heavy rain events with nutrient run-off from the catchment increase eutrophication and, thus, the likelihood of harmful algal blooms and potentially elevated greenhouse gas emissions. Still phytoplankton dynamics and algal bloom development along river-connected lake chains are poorly understood. This is of special concern, since the water quality of river-connected German lowland lakes is in poor or bad ecological status (European Water Frame Directive). Furthermore, monitoring of freshwater ecosystems is often limited in space and/or time. Therefore, the interdisciplinary project CONNECT aims at getting comprehensive insights on lake-chain ecology by using a unique combination of high frequency in-situ measurements (multiparameter probes), high-throughput lab approaches by picture-based flow cytometry (FlowCam), pigment analyses (HPLC) and various remote sensing tools. This enables lake monitoring on high spatial and temporal scales. We hypothesize amongst others that lake connectivity is of major importance for spreading eutrophication events and subsequent algal blooms, thus increasing the coherence between lake ecosystems along a river-lake chain. To test our hypotheses of lake-to-lake connectivity we will conduct a field campaign in the Havel river-lake system (NE-Germany) and a large-scale enclosure experiment, in which we will manipulate retention times. CONNECT further aims to i) built a collaborative research network between aquatic ecologists and remote sensing experts, ii) analyze effects of lake-to-lake connectivity on phytoplankton bloom development and gas emissions iii) improve ground truthing of remote sensing data in freshwater systems, and, iv) provide advances in freshwater monitoring and management.

SS3 Hydrology, biogeochemistry and ecology of mountain freshwaters

SS3_O1_Physical habitat alterations in Alpine running waters: study cases from NW Italy and a new initiative

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Alpine streams are precious, vulnerable and unique environments, but now face enormous pressures acting at global (i.e climate change) and local (i.e. physical habitat alteration) scales. Thus, their conservation is more and more crucial. In this communication, we present the new Centre for the Study of Alpine Stream (ALPSTREAM), a project recently funded by the INTERREG Alcotra Terres Monviso combining a protected area (Parco del Monviso) and the efforts of three Italian universities (University of Piemonte Orientale, University of Turin, Polytechnic of Turin), with the aim of increasing knowledge and protection of Alpine rivers. Besides describing our research facilities, planned research, and teaching activities, we report the results of some studies already carried out in the Western Italian Alps. In particular, we analysed how hydro-morphological alterations can dramatically alter alpine river ecosystems, especially focusing on two types of impact: i) alteration of the hydrological regime, namely the increase of droughts in the Alpine area and the consequent intensification of hydrological intermittence and ii) alteration of the substratum, as a consequence of the widespread and unnatural erosion of fine sediments. Our results show how both these impacts combine to produce a depletion of benthic macroinvertebrate biodiversity, with consequent alterations of their functional structure and population densities. The cascading effects on stream energy pathways and trophic organisation are still unclear but can be dramatic, thus their evaluation will represent a pivotal field of research in our project. These studies have been funded by PRIN Project NOACQUA prot. HW8F.

SS3_O2_Ecological and sedimentological effects of an experimental flood

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Globally, there is growing recognition of the importance of natural flow regimes in maintaining river integrity downstream of large dams. Increasingly, experimental floods are being implemented within regulated rivers to enhance their ecological integrity. Despite this, little is known about the importance of refuge provision in the resistance and recovery of ecological systems to such experimentally high flows. We examined the response of benthic and hyporheic macroinvertebrate communities to an experimental flood in the Swiss National Park at a number of sites characterised by differing habitat provision and sediment characteristics. Macroinvertebrate communities were sampled at four sites before, 1 day after (resistance) and 7 days after (resilience) the experimental flood. At each site benthic and hyporheic (0.25 m and 0.50 m depths) macroinvertebrate samples were taken in association with sediment characteristics (substrate composition and permeability, fine sediment content and strength of vertical hydrological exchange) to understand the importance of refuge provision in the context of flow maintenance programmes. Results from this study provide evidence of the mechanisms promoting ecological change in riverine systems subjected to experimental flood events.

SS3_O3_Ebb and flow: macroinvertebrate resilience to varying hydropeak frequency

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As the need for renewable energy increases, the prevalence of small hydropower production is increasing worldwide. With this growth, operators would like to assess the potential of small run-of-the-river schemes for flexible power production using existing infrastructure. Many of these dams are built on small rivers in sensitive alpine regions where their impact on native flora and fauna remains poorly understood. The cumulative effect of repeat hydropeaking is known to be detrimental to downstream aquatic ecosystems, but quantifying this impact is a complex function of magnitude and frequency of hydropeaking events. To better understand the rate of recovery of benthic macroinvertebrates as a function of time between peaks, an experiment was conducted on the upper Rhone River in the Swiss Alps at a newly opened small hydropower scheme. Cumulative impacts were assessed over several weeks by measuring invertebrate drift response (rate and taxonomic and trait diversity) and habitat recovery (riffle vs pool) to 15-minute hydropeak events. Delays between peaks were varied from 24 hours to 7 days in early winter. This research addresses a critical data gap regarding the cumulative impacts of hydropeaking and the optimal hydropeaking timescales for invertebrate (and ecosystem) recovery. Through an improved understanding of the relative ecological impact of different hydropeaking regimes, hydropower operators will be better equipped to balance economically reasonable delays with both societal demands and ecosystem health in increasingly sensitive alpine regions.

SS3_O4_Temporal shifts in floodplain macroinvertebrate metacommunity structure

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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. Metacommunity organization can change in time, reflecting changes in habitat connectivity, dispersal and local environmental conditions, but no studies have investigated the effect of flood disturbance on metacommunity structure in floodplain systems. Here, we examined patterns of spatial and temporal beta diversity in 24 parafluvial habitats of the Maggia river floodplain, Switzerland. We also characterized temporal changes in metacommunity organization for groups of macroinvertebrates with differing dispersal abilities. We found that flooding homogenized environmental conditions within sub-sections of the floodplain. We also found that flooding increased beta diversity by redistributing taxa in a stochastic manner within the floodplain, thus disrupting environmenttraits linkages. Most importantly, we found that metacommunity organization varied in time, with greater Species Sorting at later stages of assembly for both aerial and aquatic dispersers. Immediately after the flood, Mass Effects dominated for aerial dispersers whereas aquatic dispersers were distributed randomly, this highlighted the fact that dispersal mode had a great effect on temporal changes in metacommunity organization. Our study shows that the balance between the processes structuring metacommunities in highly dynamic ecosystems does vary with environmental conditions, connectivity and the dispersal ability of species, but also importantly with the stage of assembly following a disturbance.

SS3_O5_Characterization of alpine habitats from threatened Dragonflies to promote a management adapted to climate warming

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Current climate change has a strong impact on species distribution. In mountain, climate change push species in altitude where they might be trapped. To study these ongoing changes and their impact on aquatic species of alpine habitats, we measured several abiotic and biotic environmental variable for characterizing the habitats of boreal-alpine dragonfly species (Odonata). Our study took place in the Western Alps, in the region of Chamonix. We visited, 84 wetlands on a 19300 hectares area situated above 1900 meters above sea level in 2017 and 2018. At each site, we characterized wetlands by measuring temperature, altitude, trophic state, physical, chemical and connectivity parameters. We assessed the presence of Odonata species by combining several detection methods (larvae, exuviae, adults, environmental DNA). Our data analysis demonstrated that temperature, strongly correlated to altitude, was the most important factor in explaining the presence of dragonflies. Other factors such as the presence of aquatic vegetation, and in particular the presence of a vegetation belt also favor the presence of dragonflies. We developed species distribution models to predict the occurrence probability of the dragonflies species depending on these characteristics. These models are crucial to predict future distributions of Odonata species in the Western Alps and to develop relevant management of waterbodies to mitigate the impact of climate change.

SS3_O6_A global synthesis of aquatic biodiversity responses to glacier retreat

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Glaciers cover about 10% of land area on Earth yet they are rapidly retreating and many will disappear within the next decades. Glacier retreat is a worldwide phenomenon leading to an increased threat to water resources, biodiversity and associated ecosystem services for hundreds of millions of people. Our understanding of the ecological consequences of glacier retreat has improved significantly in the past decade, however, we still lack a comprehensive framework that can predict biodiversity responses to glacier retreat globally, across diverse habitats and taxa. Here, using a global database of 80 published studies and > 700 biodiversity surveys covering most regions worldwide, we show that on average taxa density and richness increase at sites with lower glacial influence. However, there was a significant response heterogeneity among organisms, in particular across taxonomic groups. Our global analyses further identify key geographical variables (regional glacier cover, isolation and melting rates but not latitude nor altitude) and species traits (size and trophic position) that would modulate biodiversity sensitivity to glacial retreat. We finally propose a conceptual mechanistic framework, that equip environmental scientists and managers with predictions and processes related to biodiversity change as a result of glacier retreat.

SS3_O7_Metabolic regimes of Alpine streams

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Temporal dynamics of snowmelt and glacier ice melt determine the metabolic regimes of Alpine streams by regulating resource supply and physical disturbance. Despite evidence of the impact of global warming on the hydrology of snowmelt-driven and glacier-fed streams, little is known on the consequence for the whole-stream ecosystem metabolism dynamics. In this study, we estimated gross primary production (GPP) and ecosystem respiration (ER) with the open-channel oxygen method from 1 October 2016 to 30 September 2017 in 3 streams (glacier coverage ranging from 1.8 to 27.7 %) and 3 streams with no influence from glaciers (Switzerland). We applied hydrodynamic modelling on high-resolution digital elevation models to characterize streambed stability and critical shear stress. We anticipated that the hydrological regime and derived physical disturbance shape the metabolic regime of the stream ecosystems. We postulate that streambed instability induced by storm events are fundamental to describe the temporal variability in stream metabolic dynamics. Preliminary estimates of GPP and ER rates across streams ranged from 0.2 to 15 g O_2 m^{-2} d^{-1} and from -20 to -3.3 g O_2 m^{-2} d^{-1} respectively and were constrained to metabolic active periods with favourable light and stable streambed conditions. Our results help understand and predict potential changes in the extent and magnitude of metabolic rates and carbon processing capacity of Alpine streams as a response of climate change.

SS3_O8_Evasion fluxes of carbon dioxide from turbulent headwater streams draining the world's mountains

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Despite large mountain surface area, the role of mountain streams in the global carbon cycle is poorly constrained. We combine a novel scaling relationship of streamwater CO_2 with a recently published gas transfer velocity model for turbulent water surfaces. Together with highly resolved spatial geodata, we estimate CO_2 evasion fluxes from small Swiss mountain streams. Our analyses show that although mountain streams have relatively low pCO_2 compared to e.g. boreal streams, high gas transfer velocities cause surprisingly large CO_2 evasion fluxes. We estimate that small Swiss mountain streams evade approximately 0.34 Tg C yr^{-1} into the atmosphere. Additionally, we analyzed carbon stable isotopes, monthly sampled over two years, in order to assess sources of CO_2 in 12 Swiss mountain streams. The carbon stable isotope analysis reveals the central role of groundwater; bedrock weathering and soil respiration as the dominant sources of CO_2 in Swiss mountain streams. Based on a mass balance approach, we show that groundwater deliveries of CO_2 are sufficient to sustain the high CO_2 evasion fluxes from Swiss mountain streams. We also use new data of the global stream network and geodata to estimate CO_2 evasion fluxes from mountain streams worldwide. Our analyses show that in Europe, mountain streams evade 8.4 Tg C yr^{-1}, which is about half of the previous estimates for all European streams and rivers. We estimated that globally mountain streams evade 194.0 Tg C yr^{-1}. This is unexpectedly high, as previously mountain streams have been considered to play a minor role in the global carbon cycle.

SS3_O9_Whole-lake metabolism along an alpine dissolved organic carbon gradient

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Alpine lakes are vulnerable to global change including warming and changes in lateral transport of dissolved organic carbon (DOC) from the land. We compared patterns in whole-lake metabolism among 28 Swedish alpine lakes with DOC concentrations between 1 and 8 mg/L and total nitrogen concentrations between 30 and 190 µg/L. Volumetric gross primary production (GPP) and ecosystem respiration (ER) were estimated based on time series analysis of free-water oxygen concentrations, measured at 10 min intervals throughout the open-water season near the lake surface and lake bottom, and integrated over the whole lake. Along the DOC gradient, whole-lake gross primary production (GPP) and ecosystem respiration (ER) increased from 0.15 to 0.29 mg O_2 /L/d and -0.13 to -0.31 mg O_2 /L/d, respectively. This pattern was pronounced during the stratified period, but absent during the overturn period. Both across and within lakes, GPP and ER were strongly coupled and showed high epilimnetic rates when mixing depth was shallow and light availability was high. We evaluate the observed patterns in the context of classical hypotheses on nutrient and light limitation developed to explain pelagic GPP, and anticipate new insights from our whole-lake estimates.

SS3_O10_Reduced glacial influence mediates periphyton composition and quality in alpine streams

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Glacier retreat alters both physical and chemical characteristics of glacially influenced streams, with consequences on the biological communities colonizing these headwaters. While reduced glacial influence is known to alter the structure of alpine stream invertebrate communities, effects on other biotic groups such as primary producers remain poorly quantified. In 68 study sites along a gradient of glacial influence, we characterized both periphyton community structure [biomass and the relative abundance of diatoms (+ chrysophytes), green algae, and cyanobacteria] and functioning (photosynthetic and enzymatic activities), and measured algal growth rate. Using comprehensive data sets from glacier-fed streams in the Eastern and the Western Alps we linked these periphyton features to climate-change associated environmental modifications. In addition to known effects of declining glaciers on algal diversity, we here provide quantitative estimations of periphyton quality and the relative coverage of algal and bacterial groups on streambed surfaces in response to environmental changes. We found, for example, that harsh environmental conditions (e.g., cold water temperatures and high turbidity) favor the dominance of diatoms and chrysophytes within the periphyton, which groups are considered to be of higher nutritional quality for grazing invertebrates when compared to cyanobacteria. These results will thus help to anticipate changes in food resources, and thereby food webs in alpine catchments as response to declining glaciers.

SS3_O11_Glacier meltwater inputs affect feeding habits of alpine stream macroinvertebrates

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Shifts in glacier meltwater inputs and vegetation gradients substantially change energy supply and trophic interactions within alpine stream food webs. Our goal was to enhance understanding of food resource changes and dietary niches of macroinvertebrates inhabiting alpine stream types contrasting in glacier meltwater inputs. We measured a range of physico-chemical stream attributes and carbon and nitrogen isotope ratios ($\delta^{13}C$, $\delta^{15}N$) of stream macroinvertebrates and their potential food sources at seven sites accessible throughout a year (2013/2014) within a Swiss Alpine glacial floodplain (Val Roseg) undergoing rapid glacier retreat. The range in macroinvertebrate $\delta^{13}C$ (-33.5 to -18.4 ‰) and $\delta^{15}N$ (-6.9 to 6.7 ‰) values corresponded to values measured in a previous (1997/1998) study within the same alpine catchment, suggesting that macroinvertebrates inhabiting Val Roseg stream network generally have not changed feeding behavior during the period of rapid glacier retreat. Feeding niche differences across differing stream types and alpine stream taxa were not significant, indicating that most alpine stream macroinvertebrates are plastic in their feeding behavior, relying on food resources available in a particular stream. Macroinvertebrate $\delta^{13}C$ seasonal trends followed the respective periphyton patterns, suggesting that autochthonous resources are the main energy source within this alpine catchment. A significant correlation among physico-chemical proxies of glacier meltwater inputs (P-PO_4^{3-}, TIC, conductivity and turbidity), $\delta^{13}C$ and $\delta^{15}N$ values, and isotope niche parameter SEAc (a proxy for feeding niche width) indicated that glacier meltwater plays an important role in shaping the energy base within alpine stream ecosystems.

SS3_O12_Decreasing glacier cover drives predictable successional changes in the structure and allometry of river food webs

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Glacier retreat threatens the biodiversity of mountain river ecosystems globally, but the implications for whole aquatic food webs remain unknown. We present nine new river food webs derived from gut contents analysis along a chronosequence of 0 to 64 % catchment glacier cover in the Austrian Alps. Declining glacier cover was a strong driver of food web assembly, with a threshold in connectance and trophic web descriptors identified at approximately 26 % glacier cover, below which an increase in basal taxa abundance and biomass drove dominance of donor-controlled network assembly. The rate of increase in basal taxa abundance was not matched by that of river invertebrates following deglaciation, potentially due to dispersal limitation within fragmented headwater habitats. Food webs rapidly reorganised as glacier cover was lost, due to low directed connectance and the shortest food chain lengths yet reported for rivers. Despite this, no taxa were extirpated with deglaciation. A proglacial lake aligned food web structure towards that of rivers lacking glacier cover, indicating that the prolific lake formation which often accompanies glacier retreat may modify mountain freshwater ecosystems significantly. Scaling coefficients representing individual and species-averaged mass-abundance regressions were higher than predicted by metabolic theory and increased with ice loss, suggesting that consumers may capitalise upon legacy effects of seasonal biofilm abundance cycles or host increased energy transfer efficiencies at high glacier cover. This research presents first descriptions of significant river food web rewiring along the natural successional gradient imposed by glacier retreat.

SS3_O13_Characterisation of a rock glacial stream under a multitrophic approach

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In the Alps, the glacier imprint on stream hydroecology is fading due to progressive retreat, and permafrost is increasing its influence due to the slower response to air warming. Streams fed by rock glaciers have been recently addressed as distinct ecosystems where the thawing ice exerts a key role in shaping the physical and chemical conditions of the habitat. This contribution presents the preliminary findings of a study conducted in the European Alps (Solda valley), where the outflow of an active rock glacier was characterised in terms of habitat conditions, dwelling communities, food web and ecosystem functions under a multitrophic approach. Despite the harsh habitat setting in terms of permanent low water temperature (< 1.4°C), high water transparency enhancing UV penetration and high concentrations of trace elements, the stream supported rich and diverse microbial, diatomic and invertebrate communities. Extensive bryophyte mats favoured the retention of abundant organic detritus, and primary production (Chl-*a*) and epilithic biomass exhibited values comparable to non-glacial streams. This abundance of autochthonous resources supported a complex food web, that includes three trophic levels represented by primary producers, primary consumers and predators. The functionality of the community was reflected in the breakdown rates of organic matter, which was unexpectedly high and comparable to that of non-glacial streams. The study supports previous findings on the distinctiveness of rock glacier outflows in terms of habitat setting, and provides a first synthesis on the role of such streams in shaping biodiversity and ecosystem functions in catchments experiencing drastic glacier retreat.

SS3_O14_Replacement of native forest by exotic forest plantations in Chile: Impacts on the functioning and structure of mountain river ecosystems

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Land-use changes have ecological implications not only for the health of terrestrial but also for aquatic ecosystems, especially for pristine mountain rivers. Over the last decades, mountain catchments of south-central Chile have suffered a drastic expansion of exotic forest plantations. Consequently, it represents a first order issue for water management. In this study, we assess the influence of replacement of native forest by plantations on the structure and functioning of river ecosystems. We present results from eighteen mountain rivers of the area most strongly affected by exotic forest plantations in Chile. Sites were selected according to a control-impact design using a geospatial database of the river network. Impacted sites presented total cover of more than 60% of forest plantations upstream of each of the sampling site. These were paired with control sites where native forest cover exceeds 70% of the catchment. We analysed changes on macroinvertebrate and fish assemblages, sediment, water quality, nutrients, periphyton, and the effects on ecosystem metabolism based on dissolved oxygen concentration. Comparison of flow regimes revealed a reduction of flow during low flow periods in modified catchments. Furthermore, results revealed an effect of the land-use change on most of the functional and structural indicators used in this study.

SS3_O15_Loss of Alpine grasslands and pastures threatens taxonomic and functional diversity of stream benthic macroinvertebrates

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The European Alps are currently facing an on-going land use change: scrub and forest areas are expanding at the expense of low-intensity agricultural areas, which are increasingly abandoned. Whereas this process has been researched extensively in relation to terrestrial ecological issues, such as decline in floral diversity, no study has investigated the implications of land use changes for the fauna of Alpine streams. Here, we show that four types of land cover measured at the catchment and reach levels (rocks, grasslands above the treeline, coniferous forests, bottom-valley pastures) greatly influence the benthic macroinvertebrate communities of Alpine streams in terms of taxonomic and functional composition. We found a striking structural similarity between the macroinvertebrate communities of streams draining grasslands and those of pasture areas, thus revealing a smaller-than-expected effect of elevation in comparison to external land-use influence: the two aforementioned communities exhibited not only the highest taxonomic richness, but also high functional richness and divergence. These results suggest that the environmental benefits of Alpine low-intensity agricultural areas (grasslands and pastures) extend beyond the terrestrial habitats. Accordingly, more research efforts are needed to understand the dynamics influencing Alpine riverine habitats at the landscape level.

SS4 10th UAMRICH (Use of algae for monitoring rivers and comparable habitats)

SS4_O1_A comparison of benthic-algae-based environmental assessments in the European Union and the United States

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Freshwaters face multiple environmental problems including eutrophication, acidification, salinization, and climate-change, all of which can lead to impairment of ecosystem structure and function. Furthermore, these stresses act in combination. Benthic algal-based assessments to quantify impairment are used in both the EU and USA. Using case studies, experience, and the literature, we compare concepts, approaches, and methods between the EU and USA to offer an updated picture of benthic algal-based assessments internationally. Both the USA and EU are federal entities within which member States have a reasonable amount of flexibility to adopt individualized methods. We attempt a synthesis of the following key topics: Water-Framework Directive (WFD) – Ecological Quality Ratios (EQR) vs. Biological Condition Gradient (BCG): how similar/different are they; what is the extent of divergence in assessment approaches across States/Countries within USA/EU, does it prevent comprehensive assessments, and how does it affect approaches to remediation; relationships between State/Country level monitoring programs and US/EU level programs; which metrics are used (and which algal groups are included); which pressures are assessed and are pressure-response relationships demonstrated; sampling design and methods; taxonomic resolution and harmonization; intercalibration and ring tests vs. quality assessment/quality control (QA/QC); setting of targets; decoupling of biodiversity inventories from environmental assessments; harmonic and strategic integration of the emerging molecular tools/metagenomic approaches in the existing knowledge-framework of environmental phycology.

SS4_O2_The search for the perfect river

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There is little doubt that rivers in Europe currently have nutrient concentrations substantially above those that might be considered natural. Over the last two decades, nutrient concentrations have declined, particularly for phosphorus, but consequent changes in river ecology have been less easy to demonstrate. For rivers it has proved particularly challenging to develop statistical models capable of confidently predicting nutrient concentrations that support good ecological status. Much of our thinking about the way nutrients influence river biota has come from work on lakes. Naively perhaps, we have assumed rivers exhibit similar responses without considering the more dynamic nature of the river environment. We replace phytoplankton, with a less well-defined concept of the phytobenthos, typically the diatom assemblage, and we look for changes in this community and that of macrophytes assuming their status will be primarily determined by nutrients. As we approach the 3rd cycle of the WFD we now have the data needed to review these expectations and, in this paper, we will present findings from an analysis of a large UK data set. We consider which of our metrics show the strongest relationships with nutrients, how important other environmental factors are and how well we have been able to estimate the reference metric values that are crucial for the determination of the Ecological Quality Ratio used for Water Framework Directive classification. In our conclusions we will attempt to establish whether as ecologists we are heading in the most appropriate direction in our search for the perfect river.

SS4_O3_European river ecological assessment: What next?

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One hundred and forty river assessment methods have been intercalibrated and included in the European countries` monitoring tool-kits. Half of these methods are based on primary producers: macrophytes (29 methods), phytobenthos (28), and phytoplankton (13). Biological assessment methods based on primary producers usually target nutrient enrichment, so should be able to used to set nutrient criteria. However, only 38 methods out of 70 based on primary producers (54%) demonstrate significant relationships between nutrients and biological response. As a result, river nutrient boundary values are more variable than those reported for lakes. Some variation is expected due to the range of water body types; however, large variations occur also within common types. Some countries have set "good" status criteria above 500 µg/l TP and above 10 mg/l TN; these are unlikely to support "good" ecological status. Such nutrient criteria create problems for reaching good ecological status and for managing transboundary river basins. A causal relationship between nutrient(s) and a biological variable can be expressed in a statistically meaningful manner which can inform decisions for managing water bodies. In this study, we use regressions between nutrients and phytobenthos metrics to derive nutrient targets for several river types. These targets are compared to the nutrient targets set by member states. We demonstrate that the majority of national boundary values fall within the range of predicted values if uncertainty is taken into consideration; however, several boundary values exceed this range significantly.

SS4_O4_Optimization of reference taxonomy, OTU grouping, and amplicon choice in algal bioassessments using DNA metabarcoding

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DNA-based methods to characterize community structure are promising time- and cost-effective alternatives to traditional morphologic methods for algal-based assessments. However, in order to implement DNA metabarcoding techniques on regional and national scales, additional work is needed to examine the sensitivity of site assessment to the constraining of sequences to morphology-derived taxonomic names, operational taxonomic unit (OTU) classification, and amplicon performance across a series of target algal groups (e.g., all algae, chlorophytes, cyanobacteria, and diatoms). We characterize the effects of multiple decision points along the DNA metabarcoding workflow on predictive models. Our models are constructed from OTU presence/absence data and nutrient, major ion, and pesticide concentrations, as well as hydrologic and landscape measures from 92 streams in California, USA collected along urban and agricultural gradients. Our results show strong similarities in diversity metrics and predictive models among reference-based, taxonomy-free, and morphology-based datasets. We also find strong similarities across a range of OTU classification criteria and different amplicons targeting the same algal group. Furthermore, our results indicate different algal groups respond differently to environmental factors. For example, diatoms show a strong response to agricultural influences while cyanobacteria are more affected by urbanization. Our results suggest DNA-based techniques are sensitive to multiple algal groups within a bioassessment framework, so for each major algal group we identify a DNA metabarcoding workflow that yields optimal sensitivity for algae community structure and environmental assessment.

SS4_O5_Comparison of ecological status classification systems based on diatoms in north western Spanish siliceous basins

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Samples of water and epilithic diatoms were taken in 55 locations in Galicia (NW Spain) in summer 2002-2003 and spring 2004 (n=156). The objective was to compare the assessment of two different classifications systems for the ecological status of the streams and to explore the appropriateness of the systems in evaluating the ecological status. We compared the performance of the Galician (NW Spain) official methods (MDIAT and IPS) used to assess the ecological status with diatoms. DISTLM and dbRDA analysis were used to test how the environmental variables explained diatom assemblages (PRIMER v.7). Secondly, we analysed the response of diatom taxa and of the community to the identified disturbance gradients. DISTLM 10 best models had a similar AICc value and included between 7 and 10 variables explaining 36-37% of total variance. The first axis of RDA separated streams influenced by agriculture use, and the second axis was associated with streams having higher values of electrical conductivity and phosphates. TITAN analyses identified the sensitive and tolerant species along the tested disturbance gradients. The most sensitive species to all disturbance gradients were different species of the genus *Eunotia*. While the tolerant species to the disturbance gradients were *Planothidium frequentissimum*, *Nitzschia palea*, *Reimeria sinuata* and *Fragilaria* sp. This study aims to unravel the importance of taxa specific sensitivity in the assessment provided by ecological status classification, in order to understand the differences found in practice when in the same region water authorities apply different classifications systems.

SS4_O6_Water scarcity in Alpine streams: how diatoms respond to lentification and rewetting phases

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We present here the results of the project NOACQUA concerning the effects of water scarcity on benthic diatom community in streams of SW-Italian Alps. Hydrological alterations in Alpine rivers have been widespread due to the combined effects of global climate change and local impacts. As supra-seasonal droughts are becoming more and more frequent in this river type, we focused on two key-phases that characterize hydrological alterations: i) the lentification that precedes the flow interruption and ii) the subsequent rewetting phase. As endpoints, we considered taxonomic, functional and structural changes in the diatom community. Our results highlighted how lentification created heterogeneous microhabitats that favoured turnover of assemblages. Functional groups varied along temporal and spatial gradients driven by the lentification process. In particular, motile and medium-sized low profile species increased during summer, as well as adnate and stalked diatoms. During the rewetting phase, we observed a rapid recovery in accordance with the classical pattern of diatom colonization. When considering ecological guilds, we showed a significant response of high profile and colonial taxa. Their proportions increased over the time in the intermittent section and exceeded that of the perennial section after 40 days after the water returned. We discuss our results in the light of the application of diatom biomonitoring to Alpine streams facing newly intermittent conditions. This research has been funded by the PRIN project NOACQUA prot. 2012572HW8F.

SS4_O7_Looking for ecological indicators in springs in the Alps and Dinarides with special attention to the ophiolitic substratum

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Since establishing the European Water Framework Directive, benthic algae are used as one of the mandatory biological quality elements in evaluations of ecological status in rivers and lakes. However, spring ecosystems are insufficiently covered by protective legislation despite their important role to preserve biodiversity of rare taxa, and to be appropriate and useful for long-term ecological research. Springs are characterized by high biological integrity, heterogeneity, and extreme sensitivity to direct and indirect disturbances. Algae can reflect very well the effects of geology, physical and chemical characteristics of the groundwater quality, but the development of biotic indices to assess ecological status of springs is still in an initial phase. The goal of this study is to define ecological indicators in the spring biota, with special attention to the ophiolitic substratum, which has been rarely studied so far. We compared two pairs of datasets: benthic algae in springs on limestone and ophiolitic substratum in the Alps and Apennines in northern Italy, and springs in the Dinarides in Bosnia and Herzegovina well comparable to the previous ones as regards the lithological substratum, and all the main morphological, physical, and chemical parameters. Trophic and diversity indices, together with multivariate approaches, were used to assess differences between the diatom assemblages and environmental determinants in the two pairs of datasets. Sets of algal taxa typical for springs on ophiolitic substrata are proposed. Relatively high values of established trophic indices, especially in springs in the Dinarides, emphasized the importance of developing spring-habitat specific benthic-algae based bioassessment methods.

SS4_O8_Unveiling the hidden and understudied biodiversity of benthic algae in Egyptian desert springs and other inland habitats using a polyphasic approach (PhyBiO Project)

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Recently, we in-depth investigated and characterized algal and cyanobacterial taxa from Egyptian desert habitats; these included: species (and genera) new to science (e.g., the desert-crust green alga *Pharao desertorum*, the desmid *Euastrum elfarafraense*), taxa of special interest for their distribution patterns (e.g., the filamentous green alga *Rhizoclonium* sp. 10.6 µm from a desert, hypothermal spring), and rarely-observed species (e.g., the true-branched heterocytous cyanobacterium *Westiellopsis prolifica*). To continue unearthing the hidden algal and cyanobacterial biodiversity in these remote and poorly-studied ecosystems, the PhyBiO project ('The Phycological Biodiversity in Egyptian Oases and Other Comparable Habitats, with special attention to the Challenges of its Use in Bioassessment of Water Resources') was funded in 2018 by the Italian Ministry of Foreign Affairs and International Cooperation (MAECI). Using observations on the life-cycle stages, modern morphotaxonomy, ultrastructure, ecology, and molecular phylogenetic characterization of taxa collected for the PhyBio project from springs and lakes in the Western Desert of Egypt and from bare-rocks of inselbergs of two wadis in the Egyptian Eastern Desert, we could so far identify new and rare species including: the diatoms *Halamphora shaabanii* sp. nov., *Achnanthidium fonti-salinae* sp. nov., and the heterovalvar pinnate araphid *Licmophora normaniana* (typically cosmopolitan in marine coasts but apparently not yet observed in inland mineral desert springs); *Stigeoclonium*-like species (probably close to the poorly-known filamentous green-algal genus *Cloniophora*); the rare charophyte *Chara globata* found in a thermal mineral spring; the novel desmid *Cosmarium yassinii* sp. nov., and finally the worldwide rarely-recorded zygnematalean species *Hallasia* cf. *reticulata*.

SS4_O9_Algae beads as a tool for the comparison and intercalibration of chlorophyll *a* measurements

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In vivo fluorometry for algae monitoring in lakes and rivers is a widely used technique. Fluorometric chlorophyll *a* determination of microalgae and cyanobacteria is sensitive and the parameter is easily accessible. However, different fluorometers are difficult to compare due to different optical designs. A good congruence is needed for accurate long termed measurements in different areas. Fluorescent dyes are used as standards, but cannot cover the range of excitation and emission compared to membrane associated photosystems of algae and cyanobacteria. Real algae from a culture are subjected to continuous change during growth and decay. The immobilization of the cultured algae in beads keeps the cells in a frozen status and enables their use as a standard for comparisons and intercalibration. Sodium alginate beads with the unicellular *Chlorella vulgaris* are easily prepared and dissolved again afterwards. The beads are homogeneous and stable for more than two months. Chlorophyll *a* content as well as maximum quantum yield remains constant over the time. The distribution of these algae beads will help to compare better and improve fluorometric measurements of the chlorophyll *a* contents in the field and in the laboratory.

SS5 Understanding cross-habitat linkages between stream and riparian zones to optimize management of biodiversity and ecosystem services

SS5_O1_Riparian buffer properties, cross-habitat connectivity, and biodiversity and ecosystem functioning in stream-riparian networks: Introducing CROSSLINK

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Stream-riparian networks are key components of green and blue infrastructure that underpin landscape integrity, support biodiversity, and sustain human societies. However, these networks are subject to multiple anthropogenic pressures, e.g. from water extraction, agriculture, and urbanization, which affect ecological connectivity, drive habitat and diversity losses, and threaten ecosystem services. The rehabilitation of woody riparian buffers along stream channels is frequently proposed as a management measure capable of addressing multiple goals, including enhancement of cross-habitat connectivity and ecosystem functioning, and protection of biodiversity in both terrestrial and freshwater habitats. However, the understanding of how different buffer strip properties (size, composition, placement in the catchment) affect these ecological properties is presently limited. The BiodivERsA funded project “Understanding cross-habitat linkages between blue and green infrastructure to optimize management of biodiversity, ecosystem services and multiple human uses (CROSSLINK)” is currently developing a framework for optimization of riparian buffer design. The framework is underpinned with data collected from spatially-explicit field sampling campaigns conducted in four European case study catchments in Sweden, Romania, Norway and Belgium. Initial analyses reveal marked shifts between sites without and with riparian buffers in multiple properties, including environmental variables (e.g. temperature, fine particulate organic matter), biodiversity, and ecosystem processes rates (e.g. leaf decomposition). In most cases these changes are indicative of improved environmental conditions. However, differences in responses of variables to specific buffer strip properties highlight the potential tradeoffs that need to be considered when planning the placement, size and species composition of riparian buffers at a landscape scale.

SS5_O2_Novel biomarkers reveal landscape influences on linkages between aquatic and terrestrial food webs

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Stream and riparian habitats are meta-ecosystems that can be strongly connected via the emergence of aquatic insects, which form an important prey subsidy for a wide range of terrestrial consumers. However, human perturbations that impact these habitats may propagate across traditional ecosystem boundaries, thus disrupting aquatic-terrestrial food-web linkages. Consequently, there is an increasing appreciation for measuring cross-ecosystem connectivity as an indicator of anthropogenic disturbance, but it remains poorly understood how this system property responds to mitigation and restoration efforts involving riparian buffers. Here we investigate how buffer extent, composition, and network location influences cross-ecosystem connectivity at stream locations in temperate European mixed-use landscapes. We used polyunsaturated fatty acid (PUFA) biomarkers to measure putative aquatic linkages to terrestrial predators (spiders, beetles). Preliminary variation partitioning analysis indicates that buffer extent and composition explains a small, but significant proportion of the variability in the terrestrial fatty acid profile after accounting for predator identity and network position. Using structural equation modelling, we attempt to show a linkage between aquatic insect communities and the PUFA content of terrestrial predators as mediated by buffer extent and composition. Responses may reflect terrestrial predator identity, which can differ considerably with buffer presence. Our preliminary findings suggest that riparian buffers potentially alter aquatic-terrestrial food-web linkages by increasing subsidy quality whilst reducing overall system productivity. Using PUFAs in conjunction with other tools to describe cross-ecosystem connectivity will provide a more comprehensive means to assess environmental change and the efficacy of nature-based solutions (i.e., riparian buffers) intended to offset human impacts.

SS5_O3_Tracking aquatic subsidies in terrestrial food webs

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Riparian habitats are key interfaces that regulate flows of resource subsidies between aquatic and terrestrial food webs, whilst supporting high biodiversity and providing ecosystem services. However, frequently these habitats are highly degraded, especially in agricultural landscapes. In this study, the effect of riparian buffer properties on the diversity of terrestrial invertebrate communities along stream channels was investigated in an agricultural catchment in Uppland, Sweden. Additionally, ecological connectivity was investigated by analyzing the polyunsaturated fatty-acid (PUFA) content of riparian invertebrate consumers. PUFAs are physiologically essential for animals, and are almost exclusively produced by algae in aquatic environments. PUFAs can therefore be used as biomarkers to track the uptake of aquatic subsidies into terrestrial food webs. Spiders and ground beetles were collected and identified for 10 paired sites in an agricultural landscape (with and without a forest buffer), and 5 reference forest sites. We found that the abundances, community composition and biomass of the riparian invertebrates differed between buffer types. These differences can partly be explained by trait-mediated habitat preferences and local habitat availability. Preliminary analyses of the PUFA content indicate that riparian characteristics may play a role in the strength of aquatic-terrestrial linkages, with the highest PUFA concentrations recorded at forested reference sites. Furthermore, there may be a trade-off in subsidy quality versus quantity as invertebrate biomass and PUFA content seem to show contrasting patterns. Understanding the factors that affect connectivity and the flow of resource subsidies is vital for the development of effective management and restoration of stream-riparian networks.

SS5_O4_Study of aquatic-terrestrial predator-prey relationships: How does agriculture alter the quantity and quality of stream exports?

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Freshwater ecosystems and their adjacent terrestrial ecosystems are strongly linked via the flux of organic and inorganic material as well as organisms. Aquatic emergent insects serve as prey for riparian predators like bats, lizards and spiders. The quantity (biomass) and quality (poly unsaturated fatty acids: PUFA) of aquatic emergent insects can be important for riparian communities. Many anthropogenic stressors can alter stream ecosystems. Often these stressors are related to agriculture. Contaminants or habitat destructions can lead to changes in stream ecosystems, which can propagate along the food web to the riparian ecosystem. The aim of our study was to identify possible effects of agriculture on the quality (PUFA) and quantity (biomass) of aquatic emergent insects as well as on terrestrial predators. Both are important to understand the energy and nutrient exchange between ecosystems and to predict effects on food webs of adjacent ecosystems. For this purpose we conducted a field study in ten streams in Rhineland-Palatinate, Germany. In every stream, one site was located in the forest without agricultural influence and another site downstream in the agricultural zone. Aquatic emergent insects were sampled continuously from March to September 2018. Additionally spiders (*Tetragnatha* sp.) were collected three times as terrestrial predators. The hydromorphological structures, nutrient and pesticide concentrations were monitored to analyse how these factors can influence the quality and quantity of aquatic emergent insects and how this in turn may affect spiders. The identified response patterns towards these stressors will be discussed in the presentation.

SS5_O5_Diving into murky waters: effects of brownification on boreal stream ecosystems

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The colour of surface waters has darkened throughout the northern hemisphere due to a steady increase in the quantity and quality of terrestrially produced dissolved organic carbon (t-DOC). Forestry activities intensify brownification by modifying riparian soils and enhancing light availability via removal of riparian canopy. We used stream mesocosms to examine whether brownification and canopy removal affect stream communities and ecosystem functioning, with a focus on benthic biofilms. Our results indicate a strong shift towards heterotrophy in biofilm metabolism as a response to increased DOC. Elevated DOC resulted in higher bacterial production, likely fueled by excess C, as we detected a simultaneous increase in biofilm respiration. Algal biomass and quantities of nutritionally essential fatty acids (EPA and DHA) decreased drastically and terrestrially produced low-quality fatty acids (LSAFA) increased with brownification. Canopy removal tended to moderate the effects of elevated DOC as algae benefited from less limited light conditions. Changes in stream biofilm may propagate up in stream food webs and understanding the consequences of brownification is therefore critical for effective water quality management.

SS5_O6_Modelling the effect of woody riparian vegetation on the diversity and composition of stream macroinvertebrates and spiders in the Zwalm River basin (Belgium)

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Within several river basins, unsustainable agricultural practices and urbanization have been contributing to poor water and stream quality affecting stream fauna composition and diversity. To alleviate stream deterioration, numerous measures such as the implementation of vegetative riparian buffers are considered and applied. Specifically, it is hypothesized that woody riparian vegetation may play a crucial role in stream ecosystems and its occurrence may significantly affect ecosystem processes, stream fauna composition and diversity. We aim to determine the effect of woody riparian vegetation on the diversity and composition of stream and riparian fauna (i.e. macroinvertebrates and spiders). A case study in the Zwalm River basin, Belgium, is presented. The basin is mainly used for agriculture. On top of that, various efforts have been done to restore the stream quality. Yet, the impact of woody riparian buffers is not well-studied. Thus, woody riparian vegetation was characterized in 34 sites within the Zwalm basin. The sites were composed of 5 reference sites, pairs of unshaded and shaded sites and downstream sites. At each site, 6 quadrants of 10 x 5 m were examined. In each site, stream invertebrates were collected and water chemistry was measured. Additionally, spiders were collected within each quadrant. Moreover, varying spatial riparian vegetative and land use properties were calculated and determined using the GIS land use map available at geopunt.be. Subsequently, models (i.e. decision trees and regression models) were developed to relate the riparian properties (i.e. GIS & field data) with chemical water properties and the diversity and composition of stream invertebrates and spiders. The model outcome provided knowledge on the effect of different riparian properties on the diversity and composition of stream and riparian fauna. Furthermore, the results provided insights into whether woody riparian vegetation can be used as an additional measure to improve stream quality and the needed quantity of woody riparian vegetation to alleviate fauna diversity within the basin.

SS5_O7_Effects of contaminants across ecosystem boundaries: Concept and experimental design

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It is common knowledge that freshwater ecosystems are under substantial anthropogenic pressure. Contamination by organic and inorganic substances of anthropogenic origin via point and non-point sources is one of the most important factors worldwide. This fact has attracted substantial attention by researchers that are interested in the impact chemicals at different levels of biological organization – from biomarkers to population and even ecosystems. However, relatively little information is available on how the chemical contamination of aquatic ecosystems impacts their subsidy of adjacent terrestrial (riparian) food webs, which might either be bottom-up or top-down directed. The scarcity of data might mainly be driven by the complexity of experimental designs required to test for related hypotheses. This presentation will discuss experimental designs that support the development of this emerging field of research. We argue that experimental systems that are specifically designed (i.e., contain both an aquatic and a terrestrial model ecosystem) to assess for the aquatic subsidy of terrestrial systems will be fundamental to advance knowledge. In addition, expanding the perspective by focusing besides on the quantitative impact of contamination on the subsidy also qualitative measures need to be involved. In this context, stable isotope analyses and methods describing the energetic and nutritious conditions of both the prey from aquatic resources and the predator in riparian systems are imperative. The complexity of aspects associated with the stress-induced implication on the subsidy of terrestrial systems by aquatic resources opens doors for interdisciplinary collaborations of ecology and ecotoxicology.

SS5_O8_Stressors across boundaries – The propagation of aquatic stressors to terrestrial ecosystems

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Emerging aquatic insects from freshwater ecosystems are an important prey for predators in the riparian area. They may alter the riparian food web and ecosystem functions. The abundance and composition of aquatic insect communities is influenced by a variety of anthropogenic stressors including habitat degradation and agrochemicals. We conducted several field and semi-field studies on the influence of stressors on the emergence of insects and related responses of recipient food webs in terms of diversity and abundance of riparian spiders as well as their dietary composition. We show that agrochemicals and habitat degradation lead to shifts in the emergence of aquatic insects, which in turn is associated with a shift in the composition of riparian spiders and a reduction of spider richness. Stable isotope analyses revealed that these changes are reflected in altered dietary composition of spiders that utilize aquatic prey. Finally, we demonstrate that reductions in aquatic prey influence riparian communities with cascading effects down to terrestrial plants and their primary production. We discuss consequences for ecosystem management and avenues for further research.

SS5_O9_Microplastics in benthic macroinvertebrates

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Microplastics in the environment is an increasing concern and a growing body of studies suggest that plastics are found almost everywhere. This calls for more research into sources, sinks and interaction with biota of microplastics to quantify its potential impact as an ecosystem stressor. In freshwaters, microplastics in surface water and sediment, together with the interaction with biota, have only to a limited extent been investigated. However, studies thus far have pointed towards the importance of streams and rivers as vectors for plastic to the marine environment and that microplastic is present at high concentrations in freshwater potentially posing an environmental risk.We investigated 12 sites in an urban area (part of the Norwegian CROSSLINK station net) covering a gradient of contamination and catchment dynamics. Our focus was the ingestion of microplastics by benthic freshwater macroinvertebrates. Selected macroinvertebrates, grouped according to feeding traits, was analyzed for microplastic content by digesting them with chitinase. By determining shape, type and chemical characteristics of each polymer, we identified overall sources for microplastics. This enabled us to elucidate differences in microplastic occurrence among a range of feeding traits. In addition, sedimented material from the same sites has been tested for the presence of microplastic that allowed us to assess macroinvertebrates suitability as indicators in microplastic assessments by correlating the microplastic ingestion with microplastic in sediment and other environmental parameters.

SS5_O10_The ecological impacts of warming and urbanisation on freshwater microbial communities

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Urbanisation is introducing multiple chemical stressors into aquatic ecosystems. Alongside climatic changes, these stressors have the potential to significantly alter freshwater biodiversity, but the combined and likely interactive effects are poorly understood. Freshwater microbes are likely to be particularly affected due to their position at the base of freshwater food webs, and thus any impacts may have profound influences on the biogeochemical and nutrient cycles they regulate. To address this, we sampled sediment from eight CROSSLINK streams in Oslo (Norway) that covered a gradient of urbanisation contexts, ranging from relatively pristine to highly impacted. Sediment from each stream was experimentally manipulated in lotic mesocosms (NIVA), and either maintained at ambient (13°C), or elevated (17°C) temperatures to reflect likely climate warming scenarios. After one week, a third of the sediment was reciprocally transplanted between ambient and elevated temperature conditions, before all mesocosms were exposed to a 24-hour extreme temperature event (ambient increased to 17°C; elevated increased to 19°C), and then reverted to original temperatures. Sediment was sampled systematically across the three-week experiment for DNA-based analysis of microbial taxonomic and functional diversity using Next Generation Sequencing and quantitative (q)PCR. We present results examining the impacts of warming on urban freshwater microbial communities, and explore patterns of resistance and resilience in these communities in response to episodic warming events. By considering these responses across both functional and taxonomic groups, results from this work has the potential to help inform management solutions that maintain appropriate ecosystem functioning in urban environments.

SS5_O11_Impacts of agricultural land use on stream macroinvertebrates and ecosystem processes in three contrasting European catchments

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Stream-riparian networks comprise strongly-linked ecosystems that underpin landscape integrity. However, they are subject to multiple human uses and pressures that cause biodiversity losses with effects on ecosystem services. The assessment of links between human modifications and the structure and functioning of aquatic ecosystems has become a major issue in stream research and management. This paper reveals the main patterns that characterise the structure and abundances of benthic invertebrates and ecosystem process in relation to the structure and spatial configuration of stream-riparian networks in three contrasting European catchments dominated by agriculture. They are located in Romania (the Argeș River catchment), Belgium (the Zwalm basin) and Sweden (the Lake Mälaren basin). In each catchment, macroinvertebrates responses and ecosystem processes were experimentally assessed in 30 stream sections, located along low order streams. The main stressors identified at different spatial scales that have significant effects in shaping the structural and functional patterns are discussed. Limited lateral connectivity between streams and terrestrial landscape restrict the abundance of Ephemeroptera, Plecoptera, Trichoptera taxa and accelerate the leaf litter decomposition process. Causal links between the variables returned by the backward selection method in redundancy analysis and benthic macroinvertebrates, as well as the processes that underpin them are also discussed. Our results clearly reveal that the structure and spatial configuration of stream-riparian networks affect the structure and functioning of stream systems in landscapes dominated by agriculture being critical for mitigating effects of global environmental change.

SS5_O12_Using an easy standardized material as functional indicator of environmental stress in stream ecosystems

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For more than a decade there has been an increased focus in freshwater ecology on functional indicators of ecosystem health. Leaf litter decomposition has been the predominantly used functional proxy and studies have shown a relationship between environmental impact and rates of decomposition. In many ways, this type of functional measure is now ready to be incorporated into standardized environmental assessment and the context of the Water Framework Directive (WFD). In this study, we tested the decomposition rates of the commercial product Wettex© along gradients of environmental impact in stream ecosystems and benchmarked it to the decomposition of natural leaf litter (Alder; *Alnus glutinosa*) and cotton strips. Wettex© has properties similar to natural leaves with a 75% cellulose – 25% cotton content and is easy to use in a standardized manner at low costs. A sub-set of CROSSLINK sites were investigated along gradients of different environmental impact in Norway (urban), Sweden (agriculture) and Belgium (agriculture/urban) using both coarse and fine mesh bags for Wettex© together with natural litter and strips of cotton. Wettex© decomposition rates reflected environmental stress in all three systems comparable to what has previously been found for leaf litter with increasing rates until a certain threshold in impact after which it declined. The benchmarking showed that Wettex © performed more similar to natural leaves than cotton strips. Our study shows promise in using an easy standardized product such as Wettex © in routine monitoring and could facilitate uptake of functional indicators among river managers.

SS5_O13_Ecosystem services in riparian areas: current structure and knowledge needs for better decision making

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Riparian habitats bordering freshwater habitats represent an important landscape element that sustains a rich biodiversity and provides useful ecosystem services to humans (e.g. food regulation, water purification, recreation). Current work is aimed at providing an overview about the distribution of ecosystem types belonging to Romania's major rivers riparian areas (up to order three following Hack's ordering). The current status is assessed against their potential role to provide a wide range of ecosystem services. High resolution data provided by EU program Copernicus were mapped and analyzed using GIS environment. The total coverage of riparian areas represent 13.5% of Romanian territory. Among the 73 types of ecosystems identified within the riparian areas (according MAES level 4 classification), the most dominant one is represented by "Non-irrigated arable land". The weights of natural and semi-natural systems are: 35.9% and 0.1%, whereas human-dominated, and human-created systems represent 47.1%, and 16.9%, respectively. These values indicating a high degree of naturalness but also a very high pressures from socio-economic systems. The identified ecosystems where associated to their potential rank to provide various services, then the general categories of ecosystem services were mapped. Conflicts between policy and current state of the riparian areas were identified and knowledge needs are discussed. This approach is considered useful for setting-up the baseline for current state of riparian areas in Romania and creating the ground for scientific sound decision making, and for communicating the importance of riparian ecosystems for human wellbeing.

SS5_O14_Smarter riparian buffer zones to reduce greenhouse gas emissions from stream ecosystems after forest harvesting: hypotheses, data and research needs

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Riparian buffer zones (RBZ) are left along streams after forest harvesting to mitigate adverse impacts on stream ecosystems. To what extent RBZs mitigate emissions of greenhouse gases (GHGs) that originate from forest clear-cut soils and leach to streams is unclear, but highly relevant for the overall climate change mitigation potential of forest management. Here, I discuss hypotheses, data and research needs on the fates and pathways of GHGs on their way from forest clear-cut soils to streams and how RBZs should be designed to mitigate overall GHG emissions to the atmosphere. I summarize recent evidence from Swedish clear-cut experiments and large-scale surveys suggesting that forest clear-cutting increases GHG concentrations in groundwater, but does not enhance GHG emissions from open waters. Based on these findings, I hypothesize that GHGs leaking from clear-cut areas are retained, transformed or emitted in RBZs. I provide a conceptual framework on potential sources and sinks of GHGs in RBZs and discuss experimental designs to evaluate different RBZ layouts regarding their potential to minimize GHG emissions from the stream-riparian zone continuum following forest clear-cutting. This work is expected to contribute to a more holistic, cross-ecosystem approach towards more sustainable forest management practices that help to mitigate anthropogenic climate change.

SS5_O15_Can riparian buffers mitigate effects of environmental stress on fish communities in urban streams?

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We investigated fish communities in 35 stream sites in an urban setting (Oslo, Norway) and specifically addressed the effects of riparian buffers as part of the Biodiversa CROSSLINK project. Twenty of the sites were paired with and without forested riparian buffers at the scale of the sampling reach. Paired reaches were always relatively close together (25 – 300 m) with the upstream reach not having a riparian buffer. The additional sites were situated along the river continuum in the same systems, from headwaters to they entered the sea. A 30 m reach was electrofished and a total of 5 fish species were caught with brown trout (*Salmo trutta*) being dominant. Presence of a vegetated riparian buffer had a significant ($p<0.05$) and positive effect on fish densities at low to moderate levels of environment stress, while the highly polluted streams had no fish present in either of the two types of reaches ($n=6$). Likewise, stream size had little influence on fish community composition as it is predominantly influenced by the level of environmental stress. Our results suggest that riparian buffers have the potential to mitigate the effects of land-use, in this case urbanization, on fish communities to a certain degree of environmental impact, after which the positive influence is de-coupled when habitat conditions become too degraded, both in terms of water chemistry and physical conditions.

SS5_O16_Effects of woody riparian buffers on the diversity and functional trait composition of macroinvertebrates in an agricultural catchment

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The rehabilitation of woody riparian buffers is frequently proposed as an effective management measure for reducing the impacts of agricultural land use on freshwater habitats, by reducing erosion, increasing microhabitat stability, restoring allochthonous detrital inputs into stream foodwebs, reducing insolation, dampening thermal fluctuations, and possibly enhancing nutrient retention and reducing pesticide runoff. Together, these changes should have positive effects on macroinvertebrate communities. We investigated the effects of land use and riparian buffer properties on the taxonomic and functional trait diversity and composition of macroinvertebrate communities in 30 stream sites in an agricultural catchment in Sweden. Twenty sites were paired on 10 independent stream reaches, with each pair comprising an upstream site unbuffered by woody riparian vegetation (UNB), and a downstream forest buffered (FBF) site. The remaining sites consisted of 5 downstream sites in the agricultural landscape matrix (AMT), and 5 upstream forested sites (FOR). Species richness increased from upstream to downstream and NMDS analysis showed shift in taxa composition on a land use gradient (agriculture – forest). FBF sites were generally more diverse than UNB with higher number of ETP taxa, but had lower macroinvertebrate abundance than UNB sites. FBF sites had higher portion of grazers/scrapers compared to UNB, but other feeding groups were relatively well preserved and showed fewer marked differences. These results are discussed in relation to analyses of trophic structure using stable isotopes (C, N). Overall, our results highlight the potential for riparian buffers to alter macroinvertebrate communities even within stream reaches over relatively small spatial scales.

SS5_O17_A landscape-scale field experiment in six rivers shows how in-channel retention boosts detrital resources and invertebrate species diversity

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Poor species diversity in rivers is often assumed to be due to harsh environmental conditions, particularly when the latter are caused by human impacts, such as removal of riparian vegetation that causes bank erosion and sedimentation of the bed. However, species may fail to colonise these locations because resources of food and living space are lacking rather than because the physical environment is unsuitable. We tested this hypothesis with an experiment, carried out in six rivers, in which resources of terrestrial plant detritus were boosted at manipulation sites by increasing channel retention using pairs of wooden stakes. Other sites acted as controls. All rivers had intact terrestrial vegetation upstream of experimental sites but only sparse riparian vegetation otherwise. Benthic invertebrates, standing stocks of detritus and retentiveness were quantified prior to manipulation and re-sampled 9 months later. Detrital standing stocks and taxon richness increased strongly at manipulation sites in three rivers with weaker effects in the other three rivers. The strongest effect sizes occurred in rivers that had the poorest, pre-existing capacity to retain drifting detritus. Furthermore, faunal composition at manipulation sites changed significantly in all six rivers. Our results demonstrate that species can disperse into and colonise seemingly degraded environments if scarce resources are boosted, and these findings have significant implications for river restoration.

SS5_O18_Spatial scale and the responses of riparian and instream invertebrate assemblages to forest cover and agricultural land use

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Loss or alteration of riparian vegetation from land use often results in biodiversity loss and impairment of valued ecosystem services. Here we compare the response of ground-dwelling terrestrial and instream benthic invertebrate assemblages in eight lowland boreal streams and their adjacent riparian habitats, four flowing through forest and four through agricultural fields. The forested streams flowed through predominantly coniferous forest (73 – 98 %), whilst land use in the agricultural streams was more varied (8 – 43 % agriculture). Characterisation of reach-scale riparian habitats showed marked differences between forested and agricultural streams: forested streams had riparian habitats classified as 93 – 98 % forest, whilst the agricultural streams had 40 – 95 % classified as agriculture. Species richness and abundance of carabid beetles ($r = 0.59$ and 0.43, respectively) and instream assemblages ($r = 0.27$ and $r = 0.75$, respectively) were positively correlated, whilst staphylinid beetles ($r = -0.52$ and -0.59) and ground-hunting spiders ($r = -0.28$ and -0.23) were negatively correlated with agricultural land use. Constrained ordination (RDA) showed that the best predictors of riparian and stream assemblages were: temperature for carabids (29.2%, $n = 64$ species), soil organic content for staphylinids (26.8%, $n = 85$ species), % riparian coniferous (29.6%) and % riparian deciduous (23.7%) for ground-hunting spiders (146 species) and % riparian coniferous stream benthic invertebrates (21.6%, $n = 91$ taxa). The importance of spatial scale in predicting community changes will be discussed.

SS5_O19_Towards an optimal allocation of riparian forest at catchment scale?

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Stream-riparian networks provide connectivity in a landscape and are essential for sustaining biodiversity and key ecosystem services. Although the benefits of riparian forests may be high, they are subject to multiple human pressures that affect their functionality and causing stakeholder conflicts. There is thus an urgent need to improve our understanding on the multifunctionality of riparian forests and to balance the multiple values, uses and needs in the management of stream-riparian green-blue infrastructure (GBI) on catchment scale. Using explorative modeling in an optimization framework can help to identify spatial configurations that minimize trade-offs and support the multifunctionality of a catchment. For selected case studies, we currently develop statistical models quantifying the impacts of spatial pattern of GBI, land use and other human activities on ecosystem processes, services and different diversity indicators. Challenges are defining appropriate variables and to transfer the models to the catchment scale. The models will be linked in an optimization platform to explore the functional relationships among different objectives and various allocations of riparian forests in the study catchments. We will discuss the procedure and show the functionality and potential of the optimization platform to support sustainable GBI-management.

SS6 Linking natural and social science in freshwater ecosystems

SS6_O1_Using citizen science for freshwater monitoring, management and impactful research: Lessons from FreshWater Watch

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FreshWater Watch (FWW) is a global citizen science project that engages non-scientists in the collection of water quality data in freshwater ecosystems. By enabling participants to collect the same core measurements (phosphate concentration, nitrate concentration, turbidity, and various visual indicators) and upload them to a common online platform, FWW aims not only to generate new information and knowledge for freshwater research but also to engage volunteers as stewards of their natural environment. Data collection started in 2012, and, to date, over 20,000 datasets have been collected globally. Here, we present three case studies that illustrate some of the successes and challenges of freshwater citizen science. Firstly, we use the global dataset to explore the factors that influence the retention of volunteers and their activity rate. Secondly, we explore the potential for integrating of citizen science data with statutory monitoring data, using the example of the Thames river catchment, UK. Finally, we show how the involvement of citizen scientists in environmental monitoring of freshwater ecosystems in the Mälarendalen region, Sweden, has empowered citizens to participate in decision making, cooperative planning and environmental stewardship. Collectively these case studies demonstrate that partnerships between researchers, policymakers, and citizen scientists through FWW not only contribute to scientific knowledge on the impacts of humans on freshwater ecosystems but also empower citizens as a driving force for change.

SS6_O2_Alpine rivers ecosystem services: exploring stakeholders' views

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Alpine rivers offer many benefits to people, as water, timber, food, and beautiful landscape with rich biodiversity which is very attractive to tourists. In the same time there are several threats to Alpine freshwater systems from intense land uses, hydropower production and various measures of water management, which severely impact the hydromorphological status of Alpine rivers. These uses and alterations of the rivers are perceived differently by the various stakeholders, and are regulated by different legal frameworks. Experience from management practice has shown that the development of integrative management goals for river is facilitated if a significant part of the stakeholders interests is considered. Thereby, the concept of the ecosystem services (ES) may be used as a communication basis which enables to document and compare the various stakeholder preferences. Therefore, we conducted a survey on various stakeholders from rivers and floodplains in Alpine rivers on their perception related to ES, and how they assess the impact of hydro-morphological alterations on various ES provided by these rivers. For that, we developed a web-based questionnaire which was sent to several groups of stakeholders from 13 case studies on the management of Alpine rivers in Italy, France, Slovenia, Austria, Switzerland and Germany. We received 252 valid questionnaires from several stakeholder groups. Among them the state authority and university/research institutes are the most represented groups in all countries. There are statistical differences among the respondents from different countries related with how they assess the impact of hydro morphological alterations on the ecosystem services.

SS6_O3_Urban Algae: ecological status of urban ponds and the public perception of their ecosystem services

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Primary producers (algae and macrophytes) play a key role in freshwater ecosystem functioning by converting inorganic carbon and nutrients to organic forms and fueling the food web. In urban ponds, these primary producers are subject to several anthropogenic environmental factors (e.g. shoreline structure) that affect the ecosystem functioning. Alterations in primary producers community could change the ecological status and the ecosystem services potential of the urban ponds. The ecosystem services provided by freshwaters, for example maintaining habitat for aquatic life, reflect their value and importance to society and are essential for management. However, this concept is less frequently applied to urban ponds, even though these ecosystems are often closely connected to society. We hypothesize that a good ecological status of urban ponds will be reflected by a high valuation of their ecosystem services. The Urban Algae project (FreshProject2.0) investigates the link between public perception of urban ponds, their ecological status and their provision of ecosystem services. FreshProject2.0 is a joint initiative by the European Federation of Freshwater Sciences board, the European Fresh and Young Researchers and representatives of the Fresh Blood for Fresh Water meetings, aiming to foster interdisciplinary collaboration among young scientists. Within the project consortium, 30 teams sampled 56 urban ponds across Europe in the summer of 2018 to assess their functioning and ecosystem services. Furthermore, an online survey was developed to assess public perception of ecosystem services of ponds. During the conference, preliminary results will be presented in the dedicated special session.

SS6_O4_Insights and learnings from social media data analysis for ecosystem services of river restoration

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River restoration activities aim at enhancing biodiversity of degraded freshwater systems by improving the water quality and habitat structure. Those measures reshape the riverbed and floodplain which is affecting the provision of ecosystem services (ES), like drinking water (provisioning ES), flood protection (regulating ES), or recreation (cultural ES). Cultural ES have a high potential to be impacted by restoration activities for people because the public can gain access to areas, which were formerly limited. However, cultural ES are time consuming to measure. We hypothesized that social media networks are suitable to detect cultural ES in restoration areas. Our case study is the park in the estuary part of the Kishon river restoration project in Haifa, Israel. We analyzed social media data to detect cultural ES, by studying use patterns of social media users. We completed our results with a survey among park visitors. The outcomes illustrate the opportunities and constraints of social media analysis for cultural ES assessment. They give insights about the variation of use pattern of visitors and how people perceive restoration areas and activities. This is important for planning processes, especially for highly modified or in densely populated areas where competition for land is common, or where investments in restoration are cost intense and become subject of discussion.

SS6_O5_Cultural values for freshwater management: learning from New Zealand

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Benefits people receive from nature like food such as fish or water for irrigation, have been conceptualized as ecosystem services. Among the four ecosystem services categories, cultural services are the ones providing non-material benefits, e.g. capabilities and experiences that arise from human-ecosystem relationships. With the exception of recreation and tourism, cultural services are rarely assessed and mostly missing from environmental policies. This is surprising considered the crucial role culture plays for societies. To account for this lack of consideration, a new framework based on the ecosystem services concept called nature's contributions to people (NCP), has recently been introduced. NCP emphasizes culture as being central to all links between people and nature and recognizes other knowledge systems, for example those of local and indigenous communities and peoples. The concept focuses on, and integrates the believe of many people that their cultural identity and well-being derive from their relationships with human and non-human beings, mediated by particular places. This work will 1) explain the potential and significance of NCP to improve freshwater management by including freshwater-based cultural values, 2) introduce a participatory decision support approach based on multi-criteria decision analysis (MCDA) that allows to consider cultural values concurrently with traditionally used ecological and socio-economic values when managing and/or restoring fresh waters and, finally, and 3) illustrate the MCDA-approach for New Zealand, one of the few countries in which regional freshwater management is mandated to uphold environmental quality standards, while safeguarding local and local indigenous community values and ecosystem services.

SS6_O6_A transdisciplinary research approach for the management of a dry, salinized river-basin in Morocco

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The Draa river catchment in southern Morocco is one of the driest river basins in the world and supports unique biodiversity and the livelihood of approximately 1 million inhabitants. The construction of Mansour Eddahbi dam for water storage has substantially altered flow regime and land-use practices in the catchment. These are now leading to soil and water salinization, which can negatively affect biodiversity and ecosystem services. The 5-year project SALIDRAAjuj uses a transdisciplinary research approach, where stakeholders work from the beginning with freshwater ecologists and social scientists to find solutions for a sustainable transformation of this socio-ecological system. The project concept that uses the ecosystem service approach as central element to allow for close integration of different sciences as well as research and society, will be presented and difficulties, especially regarding linkages between changes in ecosystem processes and ecosystem service delivery will be discussed.

SS6_O7_Is Danube Delta Biosphere Reserve (Romania) a hot spot for Harmful Algal Blooms?

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Harmful Algal Blooms (HABs) are a global concern and represent the consequence of any eutrophic aquatic ecosystem. Danube Delta experience cultural eutrophication and our focus is to survey their shallow lakes to describe the factors that lead to cyanobacteria (CB) mass development and even toxic blooms. During 2013-2014, phytoplankton (for taxonomy and genetics) and water (for N and P forms) were sampled, and in situ physical and chemical parameters were measured. To highlight the variability of CB communities the control factors were grouped in: chemical, hydrological and physical and analyzed using multivariate statistics. A geographic pattern of lakes based on the CB was revealed, and a segregation of CB in maritime delta in 2013 compared to 2014 was highlighted. Also, three genera were identified as responding to these changes. This suggests that elevation, biotope characteristics and weather conditions are major factors in CB dispersion, and between years, lakes are very distinctive from ecological point of view. *Anabaena* proved to be more receptive to water level changes and migrates from the river delta into the maritime delta when the water level is low. This genus was abundant during the summer of both years and can produce four types of toxins. Genetic analysis confirmed the potential of CB to produce cyanotoxins which represent a real concern and important aspect for the management strategy of Danube Delta lakes. This work was supported by the Swiss Enlargement Contribution, project IZERZ0 – 142165, “CyanoArchive” in the framework of the Romanian-Swiss Research Programme.

SS7 Linking habitat heterogeneity, biofilm diversity and biogeochemistry across spatiotemporal scales

SS7_O1_Bottom-up control of the top-down control: biofilm's food quality alters the foraging behavior of grazers

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Autotrophic biofilms in streams show dynamic changes related to eutrophication processes. Important control factors which control biofilm biomass and production are nutrient availability (bottom-up) and consumption by herbivorous invertebrates (top-down). Both control mechanisms act together: Increased nutrient levels lead to higher nutrient:biomass ratios in autotrophic biofilms, which implies a higher nutritional quality for their consumers. The nutritional quality of the resource may also alter the foraging behavior of consumers. Foraging strategies like compensatory- or selective feeding have been demonstrated for periphyton grazers, but the consequences for biofilms remain unclear. Further, as grazers are mobile, the impact on biofilms varies spatially and temporally. Thus, gazing alters biofilm characteristics in a spatially explicit manner, which ultimately results in distinct biofilm patches with different properties. To understand the consequences of the grazers' behavioural adaptations for biofilms, we implemented a mesocosm study using experimental flumes, in which we conducted video time lapse analysis to capture the grazers' behavioral patterns over time. We manipulated grazer density (presence/absence) using the common stream limpet *Ancylus fluviatilis* at either ambient or phosphate enriched conditions of a nutrient poor stream in the Harz Mountains, Central Germany. We observed distinct spatial grazing patterns according to flexible, nutrient-driven adaptations in the grazers' foraging behavior. Our study thus demonstrates the importance of considering the dynamics in consumers' behavior mediated by nutrients, which will help to understand the relative strength of top-down control on stream biofilms.

SS7_O2_The functional importance of shrimp and fish in stream nutrient remineralization

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Aquatic animals provide nutrients to the ecosystem through excretion of metabolic waste. They represent an important source of dissolved nutrients for primary producers and microbes. Knowing the factors that affect an organism's elemental composition and stoichiometry is fundamental to understand its nutrient demand and to predict its role in nutrient recycling. We studied streams in Brazil dominated by shrimp and dominated by fish to investigate variation in NH_4 and PO_4 excretion rates and potential differences in the fish and shrimp functional role as nutrient recyclers. We hypothesized that fish, due to their higher P demand (due to their bony structure), excrete less P and higher N:P ratios compared to shrimp and are thus more important recyclers of N. The 12 fish species studied significantly differed in their excretion rates, while the two shrimp species did not. Shrimp had much lower mass-specific PO_4 and NH_4 excretion rates and much higher N:P excretion ratios compared to fish. The interspecific differences in nutrient excretion may be due to differences in physiology (metabolism and stoichiometry), morphology, and/or diet differences. In the nitrogen limited streams with naturally high densities of shrimp, they provide an important contribution to the ecosystem NH_4 demand through their excretion. The two species of shrimp together, in spite of their small sizes, can provide approximately 40% of the ecosystem NH_4 demand, but their contribution to the stream PO_4 demand is insignificant. The fish species do not contribute significantly to the ecosystem nutrient demand, due to their overall low density.

SS7_O3_Direct and indirect effects of hydraulics on nutrient uptake by biofilms in gravel bed streams

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Biofilms are an important component of aquatic ecosystems. They integrate key primary and secondary producers and represent a main food source for higher trophic levels. Ecosystem functions, such as nutrient uptake, are mainly driven by epibenthic biofilms in systems where the ratio of solid substrate area to water volume is high, such as gravel bed streams. The functional significance of stream biofilms depends on their community composition and morphology as well as on nutrient supply from the water column. Both, biofilm characteristics and nutrient supply are depending on local growth conditions, which are shaped by the physical environment. To analyse the role of stream hydraulics on nutrient uptake, we performed ^{15}N-labelled ammonium injections in two gravel bed streams during two seasons and in a stream-site flume experiment. Our results show that the nitrogen uptake efficiency (i.e. biomass normalized uptake rate), was directly controlled by local flow conditions. However, uptake rates also depended on the prevalent biofilm biomass, which was not affected by flow. Our results suggest that higher mean (temporarily averaged) flow velocities and turbulence exert shear forces, which potentially diminish biomass but increase nutrient supply promoting biofilm growth. In the flume experiment, we were able to disentangle flow parameters and showed that the ratio of mean flow to turbulence is significantly controlling biofilm biomass. Overall, our results emphasize the importance of direct and indirect controls of hydraulics on biofilm functioning and nutrient uptake in streams.

SS7_O4_Variability of functional stream biofilm recovery at the habitat scale after disturbances from drying and sediment transport

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Microbial communities in sandy stream habitats can face patchy disturbance by flow intermittency (e.g. at banks or bars) and bed mobility (e.g. in migrating ripples) that both reduce biofilm activity. Transitions between disturbed (dry and migrating) and undisturbed conditions (wet and resting) are frequent in space and time. However, little is known about the extent and timing of the community recovery which likely depends on the specific type of disturbance. We investigated the dynamics and the degree of recovery of microbial community respiration (CR) and gross primary production (GPP) of disturbed sandy habitats. We exposed pre-disturbed communities in mesh bags on the river bed and compared their metabolic activity with an undisturbed control. CR in the formerly migrating sediments increased constantly from 43 % to complete recovery (related to the control) within 6 weeks. GPP recovered more slowly, starting from 37 % to a maximum of 69 % after 15 weeks. The function of formerly drying-stressed communities was initially reduced more severely to 15 % (CR) and 0 % (GPP), respectively, but then recovered fast to a stable level within 3 weeks. However, within 15 weeks of the experiment, the functional recovery reached only 75-87 % (CR) and 54-62 % (GPP) compared to the activity of undisturbed sediments. Our results show long-term ecological memory of the microbial function, which is related to the type of disturbance. Hence, knowledge about the pattern and timing of former habitat disturbance is essential to understand the spatio-temporal heterogeneity of stream biogeochemistry.

SS7_O5_Major forces shaping periphyton in tufa-depositing karstic freshwaters

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Tufa, a secondary calcium-carbonate deposit in freshwaters, creates a myriad of microhabitats for periphyton within hydrologically heterogeneous barrage-lake ecosystems. The aim of this study was to determine major forces shaping periphyton at a number of microhabitats spread within the two tufa-depositing systems (NP Plitvice Lakes an NP Krka, Croatia), using artificial substrata (AS) in a series of colonization experiments. In situ experiments included time series as well as one-month exposure of AS on tufa barriers through the year. Tufa deposition and chlorophyll a were measured, and protozoa and micro-metazoa determined upon retrieval. Tufa deposition was highest during summer in both systems. In NP Krka, the summer values on AS were up to fivefold higher in comparison to other seasons. In Plitvice Lakes, this was even more pronounced, with three orders of magnitude higher tufa deposition during summer vs. winter. It was likely due to lower winter temperatures in this system, when compared to Mediterranean NP Krka. Chlorophyll a showed clear seasonal differences in both systems. Ciliates dominated among periphytic protozoa, with around 80 morphospecies in each system. Periphyton community composition was mostly influenced by the position of microhabitats within the lake system. Communities on tufa barriers located closely below lakes were dominated by peritrichs and suctorians, using plankton-rich overflowing water as a food source. On microscale, flow velocity was the dominant factor structuring periphyton, evidenced by clear relationship between ciliate biomass and frequency of taxa within certain velocity range.

SS7_O6_Macroplastics in rivers: threat or opportunity for aquatic microbes?

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Macroplastics reaching rivers can behave as leaves arriving from the riparian forest, being easily transported by the water current and/or transiently stored depending on sections retentiveness. Once in the water, macroplastics can be colonized by aquatic microorganisms and become a new spot for organic carbon and nutrients recycling in the ecosystem. A field experiment has compared the microbial colonization, in terms of biomass, diversity and activity, among five different substrata including some natural ones (leaves, sediment, glass tiles) and two types of plastics (biodegradable bioplastic and low-density polyethylene). Bacterial density accumulation and extracellular enzymatic activities (beta-glucosidase, N-acetyl-glucosaminidase, and phosphatase) in plastics were more similar to those measured in tiles than to those measured in leaves and sediments. Indeed, macroplastics mostly act as an inert substratum (e. g. glass tiles) holding an active microbial community mostly relying on the dissolved organic matter present in the flowing water. However, the diversity of bacterial communities in macroplastics approaches to that of leaves suggesting that the polymeric nature of both leaves and plastics could play a role in the recruitment and selection of bacterial species. A predictive model based on the relative contribution of the five analyzed substrata to river organic matter decomposition capacity revealed an enhancement of the carbon-recycling in detriment of the nitrogen- and phosphorus-recycling in river sections covered by macroplastics. In conclusion, macroplastics are not preferred substrata for aquatic microorganisms development and they can potentially select some bacteria and threat nutrient recycling in rivers.

SS7_O7_Light and nutrient availability effects on organic matter quality and associated microbial community of macrophytes

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Macrophyte-associated biofilms are commonly known as important components of freshwater ecosystems. Their microbial diversity and community composition, however, is highly variable, depending both on abiotic conditions and on the abundance and organic matter quality of the host macrophyte. Here, we tested the effects of light and nutrient availability on the growth, elemental stoichiometry and phenolic contents of *Elodea nuttallii* and its associated microbial biofilm. *E. nuttallii* is widespread and has become one of the most abundant alien freshwater submerged macrophyte species in several European countries. The plants were grown in outdoor mesocosms for 8 weeks with two distinct sediment nutrient treatments (low and high nutrient availability). To manipulate light availability, half of the mesocosms were shaded. Shading led to significantly reduced biomass and C:N ratio of *E. nuttallii*, while phenolic content increased simultaneously. No effects of nutrient treatment on macrophyte biomass or tissue organic matter quality were observed. The bacterial community composition in the plant-associated biofilm after the experimental period was determined by Illumina Amplicon sequencing of the partial 16S rRNA gene and revealed dominance of the proteobacterial families Comamonadaceae, Methylophilaceae and Rhodobacteraceae. Surprisingly, the bacterial communities were similar between nutrient and light treatments. During the conference, possible consequences of altered organic matter quality on macrophyte biomass decomposition and related ecological processes will be discussed.

SS8 From source to sea – characterization and utilization of organic matter from different sources along the aquatic continuum

SS8_O1_A direct comparison of carbon processing in river and marine habitats

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Each year, one billion tons of carbon (C) are transported to the global ocean by rivers, and the fate of this carbon, such as whether it is sequestered in marine sediments or is converted to greenhouse gasses, depends not just on marine processing rates, but also on freshwater processing during downstream transport. The relative rates between marine and riverine habitats are largely unknown because very few studies have used comparable assays simultaneously in these two ecosystems. To fill this gap we deployed a cotton-strip assay in river and marine habitats in northern Norway and compared decomposition rates, and the isotopic composition of C and nitrogen (N) of the cotton substrate. Moreover, to simulate processing during downstream transport, some of the strips were translocated from the river habitats to the ocean. We were surprised to find that decomposition rates in the marine habitat were twice as fast as in the freshwater habitat. Cotton strips that were incubated in the freshwater habitat for 30% of the time and then translocated to the sea decomposed slower than strips exposed in the sea for the entire period, but the marine-only phase of decomposition was slightly faster for the translocated strips than those in the sea for the same period. Nitrogen concentration and proportion of heavy nitrogen isotopes ($\delta^{15}N$) were higher in the marine strips reflecting higher microbial activity in the sea. These results contribute to a more holistic understanding of carbon processing in connected freshwater-marine ecosystems.

SS8_O2_Biodiversity-mediated constraints on leaf litter decomposition across a river network

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Leaf litter decomposition relies on the composition and the diversity of both the litter and the consumer community. The dendritic structure of fluvial networks shapes the spatial distribution of litter resources and consumer species across the network by different mechanisms. The efficiency of decomposition can depend on the appropriate match between the traits of litter and consumers. Thus, high litter diversity likely needs a high functional diversity of consumers. However, mismatches may arise between leaf litter and consumer trait distributions across river networks, either prompted by network topology, river fragmentation or land use changes. The aim of this study was to test the implications for decomposition of diversity gradients of invertebrate consumers in river networks and litter diversity. To do so, we designed a decomposition experiment across 60 sites in a Swiss fluvial network, where we incubated mesh bags with one of four leaf litter species (alder, poplar, willow and oak) and a mixture of all the species. We measured litter mass loss, microbial respiration, fungal and bacterial biomass, and the density and diversity of litter-colonizing invertebrates. We hypothesized that decomposition rates across the network are modulated by interactions between litter diversity and the local diversity of consumers. At high consumer diversity, litter mixing is expected to have a stronger accelerating effect on decomposition compared to monospecific litter. The results of this study contribute to increase our understanding of the links between diversity and ecosystem functioning at the scale of river networks.

SS8_O3_Autochthonous organic material, not organic matter from the watershed, compose fluffy sediments of shallow Aquitaine lakes

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Shallow lakes often contain fluffy sediments that are very rich in organic matter (OM). These sediments represent a sink of carbon, but they also act as bioreactors, in which nutrient are recycled, methane is produced, and contaminant, such as mercury, are transformed. In order to establish a mass balance of biogeochemical compounds, it is necessary to determine the origin of the accumulated OM, and more particularly to discriminate the autochthonous fraction from OM coming from drainage basins. Four Aquitaine coastal shallow lakes, among the largest in France, contain fluffy sediments. In order to identify the origin of OM, we measured or estimated elemental and isotopic signatures ($\delta^{13}C$, $\delta^{15}N$ and C/N ratio) of possible OM end-members such as soils and litter of the catchment, sediments and suspended particles of rivers and lakes, lake macrophytes, DOC and phytoplankton (as deduced from dissolved inorganic carbon isotopic signature). Results show that the isotopic signature of OM-rich sediment is not affected by early diagenesis in the top decimetre. The isotopic and elemental ratios of the lake sediments show the leading contribution of the phytoplankton material and a smaller contribution of the watershed OM. Our results imply that the settling OM is very labile. However, as fluffy sediment accumulate over several meters, labile OM is buried in such environment, which has consequences on lake carbon budget. We also show how our findings allow to better explain the biogeochemistry of mercury in these lakes.

SS8_O4_In-situ and laboratory DOM addition experiments demonstrate the effects of DOM quality on DOM degradation and the activity of benthic biofilms

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Agriculture delivers significant amounts of dissolved organic matter (DOM) to streams, thereby changing biogeochemical processes at the benthic zone. Our project aims to clarify the effects of different DOM sources on the in-stream carbon and nutrient cycling. We performed lab experiments with DOM leachates (pasture soil, manure, maize, leaves) to study the effects of DOM quality on microbial abundances, benthic respiration, DOM degradation, and enzymatic activities in both autotrophic and heterotrophic flumes. Additionally, we conducted DOM plateau additions in an agricultural stream to analyse in-stream DOM retention. DOM absorbance and fluorescence were analysed by PARAFAC with our staRdom package for R. In the flumes, leachates of grassland soil, maize, and leaves were better degraded than those of manure. Both DOM degradation and microbial activities were higher in autotrophic flumes than in heterotrophic ones. Benthic algae profited from DOM additions through the additional P supply. In-stream DOM additions showed a decrease of DOC by 5-30% within the first 220 m. DOM fractions showed different uptake rates. The tyrosine-like peak decreased by up to 0.38 F_{max} (max. fluorescence, equivalent to 10–60% of initial F_{max}), while the coumarine-like peak was at background after 220 m. Phosphorus, ammonium and nitrite were taken up almost completely.

SS8_O5_Assessing stoichiometric control of nitrate and phosphate uptake by different DOC sources at laboratory-microcosm and fluvial-network scale

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Empirical studies imply dissolved organic carbon (DOC):nitrate ratios control nitrate uptake in many aquatic ecosystems. However, current research lacks experimentally verified information on links between the type of DOC source, DOC composition, and nitrate uptake; and virtually no information exists concerning DOC and phosphate uptake. We studied the effect of DOC:nitrate and DOC:phosphate ratios on nitrate and phosphate uptake in waters taken from four agricultural streams using two realistic catchment DOC sources (Alder leaf leachate and a forest soil DOC extract) and investigated how the DOC:nutrient stoichiometry and molecular composition of DOC control nutrient uptake. We measured DOC and nutrient bioavailability in small, oxygenated microcosms at 16 °C in the dark. For the leaf-leachate DOC, we found a fast, continuous removal, concurrent with a fast removal of nitrate and phosphate. For the soil DOC, we found little DOC and nutrient removal. Spectroscopic measurements indicated little transformation of soil DOC but showed that the significant consumption of humic-like leaf-leachate DOC resulted in intermediately produced protein-like DOC and, subsequently, more complex humic-like and fulvic-like DOC. For the leaf-leachate, DOC and independent of stream, a first-order decay model best explained the relationship between nitrate and phosphate uptake and DOC:nitrate (R^2 = 0.84) and DOC:phosphate (R^2 = 0.83) ratio. To assess the effect of natural DOC additions on nitrate and phosphate uptake at the fluvial-network scale, we currently develop a parsimonious landscape model, which will scale our laboratory uptake rates to stream-stretch and stream-network level and which we will show at the conference.

SS8_O6_The olfactory landscape of a river network: Dissolved organic matter guiding salmon migration

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Anadromous adult salmon may migrate thousands of kilometers from the sea to their natal freshwater stream. They are thought to use magnetoreception during their ocean phase of the spawning migrations to locate the river mouth, but then likely rely strongly on olfaction to navigate through the river network and find the stream they originated in with surprisingly high fidelity. This navigational capability has been shown to involve olfactory imprinting during downstream migration as juveniles. Based on the assumption that olfactory cues are part of each river's dissolved organic matter (DOM), we collected water samples at multiple confluences in the Elk and Sixes River networks (Oregon, USA) during the juvenile, spring (June 2017) and adult, fall (November 2016) migration seasons. In both seasons samples were collected over several days to capture variability of DOM associated with a dynamic hydrograph and diurnal processes. DOM was analysed by means of ultra-high resolution mass spectrometry and through targeted amino acid analysis, yielding a comprehensive chemical fingerprint of the olfactory landscape these fish move through twice during their lifetime. We aim to identify specific compounds or groups of compounds in DOM that guide salmon migration in particular at confluences, which are points of chemical discontinuity in the river network and likely critical for imprinting as well as adult decision-making. Olfactory cues that are important for river navigation are expected to show unique spatial patterns with high temporal stability across seasons.

SS8_O7_Spatial variation in organic matter concentration and quality in the Halladale catchment, N Scotland

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The delivery of organic matter (OM) from land to freshwaters constitutes a significant flux within the global carbon cycle, with particularly high OM loading in aquatic systems draining organic carbon rich peatlands. However, the reactivity and therefore the fate of OM within the aquatic continuum is not fully understood. In this study, OM concentration, quality and reactivity were investigated in the Halladale catchment, North Scotland, which drains the largest tract of blanket bog in Europe. A network of 13 sampling sites was established across the catchment, encompassing both the reach of the river from source-to-sea and the primary land types of interest: peatland, afforested peatland and peatlands with mixed land use including farming. Water samples were collected from each site on a monthly basis for one year from April 2018 to March 2019, and were subsequently analysed using a range of techniques to determine OM concentration and composition. Additional samples were used in incubation experiments, where oxygen concentration was measured under controlled temperature conditions over a number of days to infer sample reactivity. Early results from this study show unusually low concentrations of dissolved organic carbon across the catchment between June and August, coinciding with the driest conditions observed in the Halladale for ~40 years. The findings of this study will be used to improve our understanding of the fate of peatland derived organic matter in the aquatic environment.

SS8_O8_Dissolved CO_2 – seasonal and spatial variations throughout a rivers catchment

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The peatlands of northern Scotland are the largest reserve of organic carbon in Europe. However, large areas are subject to degradation, erosion, and loss of carbon, of which a large portion enters the draining river systems. Rivers act as a centre for degradation and remobilisation of DOM and emission of CO_2 to the atmosphere, but the extent of seasonal variations and within catchment variations is as yet unknown. This study looks at monthly variations in dissolved CO_2 concentrations throughout the catchment of a rural river in northern Scotland. Draining from predominantly peatland, but with forestry and agricultural inputs we investigate how land management and seasonal variations can influence riverine CO_2 fluxes.This study is run as part of the NERC funded project, LOCATE, which sees a national collaboration among the Centre for Ecology and Hydrology (CEH), British Geological Society (BGS), Plymouth Marine Laboratories (PML) and the National Oceanography Centre (NOC), with the aim of identifying the key processes relevant to decomposition of terrigenous carbon, particularly in peatlands.

SS9 Research needs for European water and nature directives

SS9_O1_Research needs for the Water Framework Directive

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Over the last 20 years, the Water Framework Directive has been the catalyst of an impressive body of research that has enhanced the scientific basis of its implementation. Much attention has gone to developing biological methods for single biological elements such as fish, macrophytes, and phytoplankton, and to better understanding the effects of single pressures such as nutrients and hydromorphological alteration. As a result, water managers now have numerous tools at their disposal, and huge amounts of data are collected and reported to the Water Information System for Europe. There are still gaps to fill in the assessment framework, but the main challenge is to make sense of all the information. Water managers need targeted monitoring to diagnose problems and to plan measures at water body and catchment scale. There is a need to better synthesize the information at national and European scale to evaluate if measures are in place to achieve the environmental objectives, and to detect the effects of those measures. Research aimed at better using the existing monitoring information, together with other information sources as remote sensing data or modelling, and the use of innovative monitoring and assessment techniques (e.g. e-DNA) is needed to achieve this.

SS9_O2_A new broad typology for rivers and lakes in Europe: development and application for large-scale environmental assessments

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To implement the EU Water Framework Directive, the EU countries have defined more than 1000 national river types and more than 400 national lake types. Only a low proportion of national types can be linked to the common types used for intercalibration of ecological status classification systems. This causes uncertainty concerning the comparability of the ecological status across countries. Therefore, through an extensive dialogue with and data provision from all EU countries, we have developed a generic typology for European rivers and lakes, reflecting the natural variability in the most commonly used environmental type descriptors: altitude, size and geology (calcareous, siliceous, organic), as well as mean depth for lakes. These broad types capture 60-70% of all national WFD types including almost 80% of all European river and lake water bodies in almost all EU countries and can also be linked to all the common intercalibration types. They provide a new tool for large-scale assessments across country borders, as demonstrated with an assessment of ecological status and pressures based on European data from the 2nd river basin management plans. They can also be used for a variety of other large-scale assessments, such as reviewing and linking them to habitat types under the Habitat Directive and EUNIS, as well as comparing type-specific limit values for nutrients and other supporting quality elements across countries. Thus, the broad types can build the basis for all type-related scientific outputs of managerial relevance.

SS9_O3_Clues for the establishment of reference conditions for the assessment of the ecological status of lakes under "special" circumstances: the exception or the rule?

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In Europe, according to the Habitats (HD) and Water Framework (WFD) Directives, the status of the structure and function of habitats of community interest, as well as the ecological status of waterbodies, respectively, must be assessed by the comparison between the current status and the ecosystem-specific reference conditions. Reference conditions represent the optimal situation to define the good status for the assessed site, and the values from which the thresholds in metrics are established. These references must be specific for each lake type, and usually come from pristine representing sites. However, these values are not always easy to determine, as many lake types do not have unaltered sites, show high natural variability, or are represented just by few sites. Besides, climate change is modifying the current environmental features defined as those recommended for the ecological and conservation status assessments. In this work, we show different approaches to establish reference conditions under these and other "not so exceptional" circumstances. To develop these different approaches, HD and WFD assessment procedures have been conducted for different sites, where pressures have also been estimated. When the variability of several indicators is intrinsic to the lake's nature, reference conditions need to collect this variability, by considering the behaviour of the metrics response to environmental variables (e.g. meteorology). This also opens options to deal with the expected shifts in the ecological features of waterbodies due to climate change that could be fitted through a dynamic assessment approach, as reference conditions may be progressively influenced by climate change.

SS9_O4_Establishing reference conditions and ecological status in Mediterranean rivers: a problem to solve

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The establishment of the reference conditions and the limits of ecological status for Mediterranean rivers was more difficult than for Atlantic rivers . In Mediterranean rivers, the IBMWP is the most used macroinvertebrate index. It requires less effort in sampling and processing data, obtains the same or better results than other more complex indexes, and properly classifies biological quality. IBMWP index shows a good correlation with the STAR-ICMi common intercalibration metric, except when the IBMWP index is applied to the temporary rivers. In the Mediterranean area, the temporality and the existence of periods of low flow, with very low concentrations of dissolved oxygen and high salinities, require an adaptive capacity to the components of the biological communities. Furthermore, loses in mesohabitat and microhabitat heterogeneity, implies adaptations to the water level fluctuations and requires a greater capacity for colonization. EPT (Ephemeroptera-Plecoptera-Trichoptera), which are more abundant in permanent rivers and score higher in the IBMWP index, are replaced by the OCH (Odonata-Coleoptera-Heteroptera), generally showing lower scores. Other non-arthropod invertebrates such as crustaceans and mollusks also show higher prevalence in Mediterranean rivers. Our work shows the need to make adaptations in the assessment methods used in Mediterranean environments to be able to establish the reference conditions and limits of the ecological status that reflect the particularities of this important biogeographic area in Europe.

SS9_O5_Mapping and modelling riparian forest distribution and composition: Meeting WFD and HD requirements

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The delivery of a wide range of riverine ecosystem services depends on the conservation status of riparian forests (i.e. distribution, structure and composition). Future riparian management and conservation actions (following both Water Framework or Habitats Directive requirements) need a good understanding of the main factors driving the spatial distribution and compositional patterns of riparian forests at large scales. However, approaches incorporating the continuous nature of the fluvial landscape at a whole catchment scale are not that common. This study presents a methodology to map the distribution of riparian forests to whole river networks using different criteria (i.e. physionomic or phytosociological classifications) to account for different EU environmental legislation (i.e. WFD or HD). The proposed methodology allows estimating the effects that climate change might have on different types of riparian forests, shifting their current distributions from pattern to process. The distribution of riparian forests was determined by combining modelling techniques with remote sensing data (multispectral imagery and LiDAR) and topoclimatic variables. Topographic and land use variables stood out as the main drivers that define the distribution of riparian forest as a physiognomic unit. On the other hand, altitude, climate and percentage of pasture land were the most relevant drivers determining the composition of riparian forests at a habitat level (phytosociological approach). Climate change produced an important reduction on the occupied areas of Eurosiberian riparian forest and increased the suitability for Mediterranean riparian formations.

SS9_O6_Applicability of DNA-based identifications for the European Water Framework Directive: a pilot DNA metabarcoding study for ecological status assessments

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Current approach to biodiversity assessments is based on morphological identification but the potential future application of DNA-based identifications for standard ecological status assessments to fulfil the European Water Framework Directive (WFD) requirements is a challenge under continuous discussion. Our study compares conventional and DNA metabarcoding identifications and evaluates the sensitivity of metrics, the possible modification of indices, and the discrepancies in the determination of the ecological status obtained from both approaches. For that purpose, a pilot study was carried out to test how metabarcoding data can infer existing biotic indexes and ecological status of a “mock community” made from individuals previously identified by a morpho-taxonomic approach. Benthic invertebrates were selected as a Biological Quality Element and identified using both morphological and metabarcoding data. The mitochondrial gene for cytochrome c oxidase subunit I (COI) and ribosomal mitochondrial 16S gene were employed as a DNA Barcodes. EcoPrimer programme was used to design a set of different primers tested initially by using in silico PCRs. The best-performance cocktail of primers obtained in silico was first tested over several taxonomic groups and, later on, used to identify a “mock community of benthic invertebrates” following a conventional metabarcoding workflow. The correlation between traditional and molecular indices as well as the ecological status assessments were analysed. Additionally, a DNA-Barcode reference library was created for this study.

SS9_O7_Optimizing freshwater fish detection with eDNA metabarcoding

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The DNA from water combined with high-throughput sequencing - eDNA metabarcoding - is a potentially useful approach for assessing freshwater biodiversity. While detecting threatened and introduced species is essential to inform managers and respond to Habitat and Water Framework directives, the widespread application of eDNA metabarcoding in freshwater monitoring is still hindered by the lack of standardised field, lab and bioinformatic protocols, and approaches for scaling up its use to regions. In the FRESHING project we aim to build a freshwater fish DNA reference collection developed at InBIO-CIBIO, and examine the relevance of field sampling strategies and lab procedures on the eDNA metabarcoding detection of freshwater fish. We sampled ten sites located at the Douro Basin watercourses during early summer 2017 and 2018, and performed eDNA metabarcoding experiments using multiple samples of water filters (approximately 12 filters per site) and accounting distinct microhabitats, and using distinct lab protocols for DNA extraction and amplification, totalizing 441 samples. Preliminary results show that with eDNA metabarcoding we were able to detect 18 fish species, being 15 also detected by electrofishing, and that eDNA metabarcoding detectability differs between lab treatments. We further discuss the relevance of distinct field and lab strategies.

SS9_O8_Preliminary results of the use of standard bioassays as a complementary tool to ecological quality assessments in reservoirs

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Water Framework Directive (WFD) was implemented to guide the assessment of the ecological condition of European waterbodies. However, its application does not contemplate the use of ecosystem function indicators or subindividual assessments. Additional metrics are necessary to detect impacts in aquatic ecosystems at different temporal and biological scales, as already argued by the scientific community. For reservoirs, only phytoplankton is currently used as bioindicator, and the identification process can be tedious and prone to error. Our aim was to perform bioassays with standard aquatic organisms and perceive if their use is a possible complementary analysis to the current applied ecological assessment methods for reservoirs. Two reservoirs were selected in the north of Portugal (Miranda and Pocinho). Water physical and chemical parameters were measured in situ, and additional water samples were collected for further analysis and to conduct the laboratory bioassays. Water parameters measured were within the threshold values of good quality, except total phosphorous. Bioassays with *Daphnia magna*, *D. longispina*, *Raphidocellis subcapitata*, and *Lemna minor* were performed using reservoirs' water with different treatments (non-filtered, filtered by 1.2 µm pore, and filtered by 0.2 µm pore). *R. subcapitata* and *D. longispina* showed unstable responses. However, there were significant differences between the treatments and the control group in the bioassays performed with *D. magna* and *L. minor*. *D. magna* showed feeding inhibition in all treatments and *L. minor* had a decrease in the fronds growth in all treatments. These preliminary results demonstrate the potential of bioassays in the assessment of the reservoirs.

SS9_O9_How the ecological and conservation status assessed according to the Habitats and Water Framework Directives can be related to the climatic regulatory role in Wetlands

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Freshwater ecosystems have an outstanding climatic mitigation capacity as they may act as natural carbon sinks. This capacity could vary because of their stress and alteration levels. There are two different approaches to assess their ecological condition, developed either following the Habitats (HD) or the Water Framework (WFD) Directives, and used across the European Union. However, none of them yet consider a climatic framework. Nevertheless, these assessments could also be used as indicators of the ecosystems' role in climatic regulation. The aim of this work was to study the relation between the results of the assessments of the status of standing waters inland ecosystems, and the carbon capture capacity and greenhouse gases exchange in these ecosystems, in order to insert a climatic perspective within the EU Directives enforcement. For that purpose, several wetlands of different ecological types and under different conservation/degradation circumstances, were used as models to study this linkage. The conservation status (HD) and the ecological status (WFD) were determined following the procedures and metrics established by the Spanish transposition of these Directives. On the other hand, carbon balance was studied in the same wetlands, by measuring, modelling, and integrating the carbon exchange between the different biological compartments. Our results showed a clear positive relationship between the conservation and ecological status, and their climatic regulatory role. Accordingly, habitats and standing water bodies with a bad condition can lose part of their climate regulatory capacity. This should be considered in the Directives implementation and European climate policies.

SS10 Balkan rivers, be dammed!

SS10_O1_How hydropower dams alter the flow regimes of Balkan rivers

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Balkan rivers, which harbour high aquatic biodiversity, face a boom of hydropower dam construction. We reviewed the distribution and trends of hydropower plants (HPPs) in Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Bulgaria and Montenegro. Furthermore, we analysed flow regime alterations induced by various types of HPPs (run-of-the-river, storage hydropower plants). Currently, 1043 HPPs are operating in the area, among which 779 plants are small HPPs (<1 MW), 174 medium (1-10 MW) and 90 large (>10 MW). An additional number of 1866 HPPs is currently planned to be built, mostly in Serbia and Bulgaria. Thereby, 463 of 1866 HP projects (25%) are planned in protected areas. The various HPP types have generally strong but varying effects on flow regimes, ultimately producing a flow regime differing from the pre-impact natural flow regime. Daily flow data show that depleted river reaches and those downstream of storage HPPs are subjected to most severe flow regime alterations, while run-of-the-river and diversion HPPs cause less severe hydrological alterations. Hydropeaking operation of storage HPPs induce additional impacts by rapid fluctuations of water levels, which strongly affect macroinvertebrate communities and they may cause the extinction of sensitive species protected by the Habitat Directive, and their replacement by more tolerant species or even invasive species. We conclude that the total extent of flow alteration by HPPs only gets visible if sub-daily hydrological data would be available, but this is not the case for most rivers in Balkans yet.

SS10_O2_Regional controls on photosynthesis-irradiance relationships of benthic algae in the Vjosa river network

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Research has identified mostly positive biodiversity-ecosystem functioning relationships. However, we lack strong validation in natural ecosystems likely due to functional redundancy, environmental controls and biomass effects. In a river network, local primary production of periphyton can be conceptualized as the product of a local algal community in given environmental conditions. Both algal dispersal, which links local communities to a metacommunity, and environmental conditions are constrained by flow directionality and the dendritic topology of the river network. Hence, spatially explicit considerations are mandatory to causally resolve patterns of primary production across an entire river network. We hypothesize that a river network hosts a spatially sub-structured benthic algal metacommunity, which is shaped by dispersal dynamics and environmental conditions, and whose structure (i.e. diversity and composition) contributes to spatial variation of primary production across a river network. We assessed local benthic algal community structure at the functional (photopigments) and taxonomic (18S rRNA) level at >40 sites distributed across the Vjosa river network in Albania and Greece. Photosynthesis-irradiance curves were fitted to on-site closed-chamber respiration-production measurements based on oxygen at four artificially produced light intensities. First results of constrained ordinations point towards the importance of dispersal and environmental conditions as co-controls of benthic algal community composition. Consequences for primary production were analysed by relating biomass-independent parameters of light physiology to functional and phylogenetic community structure. Understanding the spatial structure of benthic algal metacommunities and implications for ecosystem functions in a reference system like the Vjosa can guide regional-scale conservation and restoration of river networks.

SS10_O3_The last hideout: abundance patterns of the not-quite-yet extinct mayfly *Prosopistoma* in the Vjosa catchment

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The Vjosa represents one of the last near-natural European river networks, where a principally unregulated river corridor preserved both fluvial dynamics and biodiversity. However, hydropower development now threatens this natural heritage with multiple dams. In an effort to characterize geomorphic dynamics, biodiversity and ecosystem functions, we undertook a survey in October 2018, covering the Vjosa´s entire river network with 46 sites between the Pindos Mountains and the Adriatic Sea. We investigated macroinvertebrate communities using standardized multi-habitat sampling and found the monotypic *Prosopistoma pennigerum* (Müller 1785) – reported earlier from this river – in surprising abundances. Little is known about this putatively highly sensitive potamophilic species. Suggested preferred habitats are fast-flowing reaches with stony littoral stretches in large undisturbed rivers. This rare species is highly endangered and considered lost or extinct in many rivers of Central and Northern Europe. Surveys from Russia, the Iberian Peninsula and the Balkan region recorded sporadic presence with maximum abundances <11 ind. m^{-2}. Our records of *Prosopistoma pennigerum* in the Vjosa suggest unrivalled occurrence and abundance: It was found in a third of the sites with a median abundance of 24 ind. m^{-2}. Unexpectedly, specimens were found in small tributaries classically not deemed suitable for this species. Clearly, the Vjosa is still a vital habitat for this species and this finding corroborates the Vjosa´s model character: As one of the last in Europe, this reference river network can serve to guide conservation and restoration of European rivers at the regional scale.

SS10_O4_Science support required for conserving Balkan rivers

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Balkan rivers represent a major natural heritage due to their high biodiversity supported by a generally near-natural state. Recent surveys of Balkan rivers by the “Save the Blue heart of Europe”-campaign confirmed the exceptionally good hydro-morphological status, but also identified numerous hydropower plants planned or under construction. There is an enormous contrast between these apparent threats and the weak knowledge base on which management decisions are based. The necessity of science support is exemplified by Albania´s Vjosa river where two large dams are planned in braided river sections. To independently provide critical information, a multidisciplinary consortium of Albanian and international scientists produced evidence on the ecology of this unique river landscape with minimal funding. Our results demonstrate highest conservation value given by remarkable biodiversity in a river floodplain-system with fast habitat turnover – created by intact longitudinal continuity in water flow and sediment transport at a spatial scale that is unmatched in most of Europe. This suggests the Vjosa as a reference system capable of guiding restoration of large European rivers. The rather obvious necessity to create a strong knowledge basis for management decisions asks for multidisciplinary exploration of development scenarios integrating ecological, economical, social and cultural aspects of human well-being. Overall, we strongly request a stronger involvement of scientists in decision-making. Until this is politically supported, we regard the voluntary engagement of scientific experts as an act of strongly needed assumption of societal responsibility. Delivering a memorandum and creating networks for research and capacity building are ways to engage.

SS12 Mesocosm approaches to ecosystem-scale questions in freshwaters

SS12_O1_AQUACOSM & MESOCOSM.EU: networks of experimental aquatic mesocosm facilities offering opportunities to co-design ecosystem processed-based studies

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AQUACOSM is an EU H2020-funded network of leading European Aquatic Mesocosm Research Infrastructures (RIs) presently including 19 partners with 37 RIs, connecting mountains to oceans from the Arctic to the Mediterranean. AQUACOSM coordinates a growing world-wide cooperative network of mesocosm RIs through the MESOCOSM.EU portal. MESOCOSM.EU is a long lasting-low budget network that is a legacy from the marine EU FP7 MESOAQUA (2009-2012) project which has expanded to include mesocosm RIs in all aquatic systems, including rivers, ponds, lakes, estuaries and marine coastal and open systems in AQUACOSM. These networks of mesocosm RIs design large-scale process-based studies for testing present models and long-term trends, in order to understand underlying (ecosystem) mechanisms relating to the present global Grand Challenges (climate change, biodiversity loss, eutrophication, emerging pollutants, etc.). In this talk we discuss how process-based in situ mesocosms experimental research as a whole could benefit from more closely coordinating research with other RI's conducting Long Term Ecological Research and monitoring, in atmospheric, terrestrial and marine domains, locally-to-internationally. Such increased collaboration could be effectively conducted from grass-roots level. We aim to contribute to the debate and planning of closer and more effective RI-collaborations to yield process-data required to design targeted experiments testing present models. This will eventually yield better understanding of the ongoing processes to enable knowledge-based mitigation measures that are needed to tackle the Grand Challenges related to water, the source of life on Earth. Want to participate? Please also visit our open Workshop to be announced at this web site!

SS12_O2_Mesocosms are an excellent tool to show climate change impacts on aquatic ecosystems

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

SS12_O3_Top-down control modulates interactions between primary producers in lakes undergoing eutrophication and browning: a mesocosm modelling study

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Understanding the effects of combined nutrient loading and browning on primary production is important to assess carbon balances of freshwater lakes. We investigated the response of benthic and pelagic primary producers by comparing model predictions with observed patterns of a large-scale mesocosm experiment. Single additions of phosphorus and humic substances were combined at 7 and 3 different levels, respectively. Water temperature, PAR and total chlorophyll were recorded by multiparameter sondes mounted on automatic profilers. Nutrients were measured weekly. Periphyton and macrophytes were harvested for biomass determination after 4 weeks of exposure at 5 different depths. We developed a dynamic 1D-model to simulate four groups of primary producers: (a) phytoplankton; (b) periphyton growing on the enclosure walls; (c) periphyton growing on macrophyte surfaces (epiphyton); and (d) submerged macrophytes – dependent on water temperature, light and nutrient availability. Growth patterns were modelled under four different grazing scenarios assuming a linear relationship between grazing rate and phytoplankton concentration. Spatial and temporal patterns of phytoplankton biomass were best reproduced by a ‘no grazing’ scenario, where the absence of grazing was compensated by a higher senescence-related death rate. Spatial distribution patterns of periphyton biomass along a depth gradient, however, were best reproduced by a scenario with equally intense grazing pressures on phytoplankton, wall periphyton and epiphyton. These results highlight the importance of top-down control on both phytoplankton and periphyton. An accurate representation of grazing dynamics is therefore necessary to better understand the impact of nutrient loading and browning on primary production in freshwater lakes.

SS12_O4_Effects of skyglow on lake phytoplankton: insights from an ecosystem-scale enclosure experiment

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Light plays a key role in structuring biological communities. Since the 19th century, anthropogenic light emission from Earth has increased massively, disrupting the natural cycle of light and darkness. In addition to direct illumination such as from street lighting, ecosystems can experience light pollution even in remote areas when light that is backscattered to Earth by the atmosphere, generates so-called skyglow. Little is known about the effects of skyglow on aquatic ecosystems and phytoplankton in particular. We therefore conducted a large-scale enclosure experiment in summer 2016 to investigate effects of skyglow on a natural plankton community of a lake located in one of the darkest areas of Central Europe. White light emitting diodes (LEDs) installed above the enclosures emitted diffuse light at three different intensities (0, 0.06 and 6 lux) onto the water surface. Responses of phytoplankton in the epilimnion were recorded for 7 weeks at weekly intervals. Results indicate that skyglow affects primary production and biomass as well as phytoplankton physiology in terms of thylakoidal electron transport rate (ETR) and cell viability. Epilimnetic production rates of phytoplankton and biomass measured as chlorophyll a were reduced under high skyglow, whereas ETR and cell viability responded to both high and low levels of skyglow. These results show that exposure to even low light levels at night can affect aquatic primary producers, suggesting an urgent need to understand direct and indirect responses of plankton communities to light pollution by skyglow.

SS12_O5_Rapid automated assessment of fine-scale zooplankton distributions using a low-cost, handheld in situ imager and deep learning

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The results show that the Mini Deep focus Plankton Imager (MDPI) captures vertical mesozooplankton distributions at higher resolution, automatically and with higher sampling efficiency compared to conventional plankton nets. By combining the shadowgraph's large volume sample (42x52x100 mm per image) with high image resolution that allows for mesozooplankton determination down to 512 µm size. By sampling virtually undisturbed water on the downcast, we detect 24-40% more mesozooplankton compared when sampling with common net types, and between 9-19% more compared to a tube sampler. Because the test was done in oligotrophic conditions, clogging was likely insignificant, and these results underscore the unavoidable sampling inefficiency inherent in any net sampling approach, including nets adapted with an Apstein cone. Using a desktop computer, we processed the MPDI data automatically and were able to classify thousands of mesozooplankton with >90% accuracy into cladocera, copepods, rotifers and "other" at a 5 cm vertical resolution. Moreover, due to the MDPI's light-weight, small size, low energy demand and non-extractive sampling, it is suitable for deployment from small boats and in mesocosms. Shadowgraphs, like the MDPI system can become a new standard sampling gear for convenient high spatiotemporal resolution sampling in mesocosms, ponds, lakes and estuaries, which are often not accessible with large ships and heavy sampling gear. With further development and streamlining of the image processing, this approach can help better understanding of mesozooplankton specie specific responses to environment and spatiotemporal community development.

SS12_O6_First in-situ mesocosms experiment for investigating impacts of microplastics on littoral food web

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Microplastics (MPs) are ubiquitous pollutants found in marine, freshwater and terrestrial ecosystems, and MP pollution is a major environmental concern globally. Despite this, the impact of MPs on freshwater ecosystems is largely under-looked, with most research concentrating on marine systems and organisms. Owing to their small and wide range of size classes, and high abundance, MPs are potentially available for ingestion by a broad range of aquatic species. However, to date, no *in-situ* mesocosm experiment has considered the impact of MPs on freshwater lake ecosystems. Here, we investigated the impacts of MPs on the littoral food web of shallow lakes exposing water surface and column, and sediment in mesocosms simultaneously to the cocktail of microplastic polymers with environmentally relevant concentrations and 10x higher concentrations in all of its compartment together with control. We conducted the experiment in a lake using 12 mesocosms for 7 months. Each mesocosms were inoculated with phytoplankon, zooplankton, macroinvertebrates (chironomids, gastropods, dragonflies and mayflies). Sampling for physicochemical variables, microplastics chlorophyll *a* (chl-*a*) and zooplankton was conducted daily during the first 3 days and then weekly throughout the experiment. Excretes of macroinvertebrates were collected biweekly in the laboratory, and together with zooplankton they were analysed for microplastic accumulation and transfer through the food web. Furthermore, emergence of chironomids from the mesocosms was also monitored. The results will thoroughly be discussed for the faith of microplastic through the food web.

SS12_O7_How climate change enhances nanoparticle toxicity towards freshwater biofilms – A mesocosms study

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Release of toxicants such as engineered nanoparticles (ENPs) into aquatic systems and their effects on these ecosystems remain poorly understood. The combination of ENP pollution and the acceleration of global climate warming (ENP + ΔT°C) could have significant consequences for aquatic life. This study focus on responses of fluvial biofilms, as key points of ENP entry into aquatic food webs, and examines the effects of the combined stressors (ENP + ΔT°C) at community and ecosystem levels using an extended set of end-points as an integrated approach using an outdoor mesocosm (40 recirculating flumes). After 4 weeks of biofilm colonization at different temperatures (18°C and 25°C), ENP were added obtaining 4 treatments (x5 replicates each): control, AgNPs, Ag_2SNP (AgNP aged) and $AgNO_3$ (positive Ag^+ control). Sampling was at the beginning of ENP exposure (0h), and after 1, 3, 15 and 30 days. Functional and structural changes were assessed using a range of end-points. Metabolism increased with rising temperature but reduced in the presence of AgNP and Ag^+. Surprisingly, under warm conditions Ag_2S decreased the photosynthetic activity and algal biomass like the Ag^+ control, while AgNP increased both. Increased water temperature also caused homogenisation of biofilm composition and structure, and combined with AgNP or Ag^+, an increase of dead cells and a decrease of biofilm EPS. These results indicate that warmer water can enhance AgNP and Ag^+ toxicity as well as modifying the behaviour of "non-toxic" variants like Ag_2S. Results from chemical and further biological analyses will be presented in detail.

SS12_O8_Hot, dry, and deadly: climate warming, water abstraction and neonicotinoid exposure determine stream macroinvertebrate community dynamics

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Feeding a growing global population in the context of a changing climate will bring challenges for food producers and environmental managers seeking to mitigate the impact of intensifying agricultural practices. Water abstraction for irrigation and pesticide application are two practices that can be problematic for nearby streams. It is important to investigate the impacts of these practices on stream communities in the context of rising global temperatures to better understand their combined effects on stream ecosystems. We performed a stream-side mesocosm experiment in 128 experimental stream channels. We manipulated the neonicotinoid insecticide imidacloprid at four environmentally relevant levels (0-4.6 µg/L), stream flow velocity at two levels and water temperature at two levels (ambient, 3 °C above) in a full-factorial design. Reduced flow velocity and increased water temperature were manipulated for the entire experimental period, while insecticide application occurred in three 48-h pulses, ten days apart, to simulate realistic exposure scenarios. Invertebrate drift and insect emergence were monitored during the pesticide pulses and during the 48 h immediately following the first two pulses. Benthic invertebrate communities were sampled after 24 days of manipulations. All three stressors significantly affected benthic invertebrate community composition, with the strongest effects overall from increased water temperature and reduced flow velocity. Imidacloprid pulses strongly affected drift community composition, with the strongest taxon-specific effect on increased drift of Deleatidium spp. mayflies. Further, all three stressors affected EPT abundance and caused a shift to crustacean and oligochaete dominated communities. Notably, the snail Potamopyrgus antipodarum responded positively to increased temperatures.

SS12_O9_Short-term exposure to wildfire ash affects behaviour and condition of a potamodromous cyprinid fish, the Iberian barbel (*Luciobarbus bocagei*)

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Wildfires are a common phenomenon in Mediterranean regions that is becoming increasingly frequent and severe. With ash runoff representing an important source of disturbance for aquatic organisms, in particular for fishes. The goal of this study was to investigate in a 3-artificial flume channel mesocosm, the behavioural and condition responses of a native widespread potamodromous fish, the Iberian barbel (*Luciobarbus bocagei*), previously exposed for 24h to different concentrations of wildfire ashes: 0.0 g/L (the control, no ash), 1.0 g/L (low concentration) and 2.0 g/L (high concentration). Behavioural parameters included i) routine activity, ii) boldness and iii) shoaling cohesion. The hepatosomatic index (HSI) was further determined to assess the health condition of fish. Significant differences on fish behaviour parameters were detected between the control and the high concentration of ash. Accordingly, i) an increasing proportion of fish were found on resting activity, whereas the proportion of fish on searching behaviour decreased; ii) the proportion of bolder individuals was found to decrease and iii) the same trend was detected for shoaling cohesion. Such differences were paralleled by an increase in the HSI from 1.62% (control) to 2.40% (high concentration). The present study shows that even short duration exposure to ash-loaded runoff can alter fish behaviour and hepatosomatic condition and highlights the need to maintain an unfragmented river network, or, when this is not possible, to prioritize the removal or retrofitting of barriers to increase movement dispersal and provide conditions for species recovery from fire-disturbances.

SS12_O10_The hyporheic zone as an invertebrate refuge during a fine sediment disturbance

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Instream refuges are important habitats that support the persistence of benthic invertebrate communities during adverse hydrological and fine sediment (FS) conditions. We examined whether substrate composition effects the use of the hyporheic zone as a refuge for invertebrates during a FS disturbance using twelve open air, stream mesocosms. Each stream mesocosm comprised an aluminium flume of 0.33 m width, 12.4 m length and 0.30 m depth, and was split into two 6.2 m sections, which provided 24 sections. Twelve sections were filled with a coarse substrate mix comprising cobbles (>64 mm, 13.4%), pebbles (20 mm, 66.6%), gravel (10 mm, 13.4%), and sand (<2 mm, 6.6%). The remaining twelve sections were filled with a fine substrate mix containing pebbles (20 mm, 37.5%), gravels (10 mm, 37.5%), and sand (25%). In the experiment, three sediment treatments (0-30 kg) were used to mimic variation in FS loading: 1) a control (30 l of water and no FS), 2) 15 kg of FS and 30 l of water, and 3) 30 kg of FS and 30 l of water. Prior to the FS addition, hyporheic invertebrate abundance (i.e. at 18 cm) was higher in the coarse substrate compared to the fine substrate. During the experiment, we observed 1) increased hyporheic invertebrate abundance (at 18 cm) in both substrate types during and directly after FS addition, and 2) higher hyporheic taxonomic richness in the fine substrate during increased sedimentation, but no variation in taxonomic richness occurred in the coarse substrate with greater sediment addition. Our research reveals that the hyporheic zone is a refuge for invertebrates during a fine sediment disturbance.

SS12_O11_A new mesocosm-based field station in Western Italian Alps: The Alpine Stream Research Center – ALPSTREAM

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The use of mesocosms is assuming a great importance in many fields of stream ecology. Because of their ecological, morpho-hydrological and also anthropic importance, Alpine rivers represent unique ecosystems, increasingly threatened by impacts acting at global (i.e. climate change) and local (i.e. water withdrawal, hydroelectric use, etc) scales. For this reason, the Monviso Natural Park, the University of Piemonte Orientale, the Polytechnic of Turin and the University of Turin planned the realization of a Centre for the Study of Alpine Streams (ALPSTREAM), funded through the FESR INTERREG ALCOTRA 2014-2020 Terres Monviso Piter Project. The Centre will be built in Ostana, at the foot of the Monviso and near the source of the largest Italian river, the Po (90 km from Turin). The centere will be equipped with a mesocosm facility, consisting of six experimental channels 25 m long: three channels with a constant section of 30 cm wide and three with a variable section, presenting four 'pool' structures 60 cm wide. This facility will allow us to carry out several ecological and eco-hydraulic experiments under controlled but also realistic conditions. The overall mission of the Centre is to combine research (using mesocosms but also promoting field studies), teaching (the Centre will be equipped with a guesthouse, classrooms and a laboratory) and dissemination (for example promoting a more scientific approach in the governance and conservation of Alpine running waters and implementing citizen science). The aim of this poster is to present the Centre, its facilities and to stimulate collaborations and scientific exchange.

SS13 Spring habitats: research, assessment tools and conversation efforts

SS13_O1_Anthropogenic modification of spring habitats: current research, assessment tools and conservation efforts

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Natural springs are unique ecotones, which provide special environmental conditions for a highly adapted fauna and flora. In the Dinaric Alps, e.g., many endemic crenobiontic species were described in the past years. Springs are threatened globally by human impacts such as water abstraction, relocation, and cattle trampling. Climatic changes threaten springs additionally. Until now, no standard spring assessment protocol exists in Europe as springs are not included in the European Water Framework Directive. In this introductory talk we will give an overview of the current situation in Europe concerning assessment tools, management plans and conservation efforts. Hereby we will focus on springs in the Alps and in the Dinaric Karst. Alpine springs are heavily impacted by cattle trampling and water abstraction due to farming and tourism. An international spring research and conservation project will be implemented in the upcoming years to counteract the ongoing destruction of natural springs. In the Dinaric Karst a first spring-specific metric was applied for spring assessment. Using multimetric indices may help to provide a framework for assessing the response of macroinvertebrate assemblages to human impacts. Further joint investigations should verify the suitability of such metrics in assessing the deterioration of springs globally.

SS13_O2_Macroinvertebrates of post-mining calcareous brooks: comparison with natural calcareous spring brooks

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Surface brown-coal mining influences negatively well-developed ecosystems and results in creation of new anthropogenic habitats. The formation of extensive spoil heaps with specific bedrock chemistry, which determines an occurrence of brooks with a calcium carbonate (tufa) precipitation, is an unavoidable consequence of open-coast mining in the Sokolov Coal Basin (western part of the Czech Republic). These brooks characterised by basic pH and low levels of nutrients may provide suitable habitats for many rare and highly specialised invertebrates that are scarce in intensively exploited agricultural landscape. On the other hand, the colonization of these unique biotopes by aquatic biota can be strongly limited by harsh water chemistry. In our study we focused on the description of the macroinvertebrate composition of post-mining calcareous brooks (Velká podkrušnohorská spoil heap, Sokolov Coal Basin) and on the comparison of macroinvertebrate diversity between post-mining brooks and natural calcareous spring brooks, which are located on the western margin of Carpathians. For data analyses we used these groups of aquatic macroinvertebrates: Clitellata, Ephemeroptera, Plecoptera, Odonata, Trichoptera, Coleoptera and Diptera. In comparison with natural sites, taxa richness of post-mining sites was lower, however, the species composition was similar. Moreover, several nationally threatened species and spring specialists were shared between post-mining and natural sites. As a result, we may consider post-mining calcareous brooks as surrogate habitats for aquatic macroinvertebrate biota of natural calcareous spring brooks. The study was supported by mining company Sokolovská uhelná, a.s. and the research project of the Czech Science Foundation (project no. P505/16-03881S).

SS13_O3_Water mites (Acari: Hydrachnidia) in springs – A highly diverse taxon with unexpected dispersal abilities

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Water mites are among the most diverse organisms inhabiting freshwater ecosystems and especially in springs, water mites show a relatively high species diversity. In Europe, 137 species are known to appear solely in or near springs and new species are discovered frequently, mainly due to molecular species identification and delimitation methods. Water mites undergo a rather complex live cycle, which includes a larva parasitizing macroinvertebrate hosts, a free-living nymph and two resting stages prior to become adult. Because of their dependency on the actively flying hosts to disperse, Hydrachidia are considered as passively dispersing. Springs show a patchy appearance in the terrestrial environment and due to their unique physicochemical conditions, springs are considered island-like habitats. Therefore, crenobiont Hydrachnidia populations can be seen as rather isolated and a reduced gene flow is likely. To investigate the manly morphology based taxonomic knowledge of spring inhabiting water mites, we sampled crenobiont species across the central alps and investigated the suitability of a mitochondrial (CO1) and a nuclear (28S) marker for species identification. Results show a high degree of hidden diversity and indicate the necessity of further research. Additionally, first population genetic results derived from these markers and an AFLP dataset show complex dispersal patterns between alpine springs and indicate an unexpected low degree of isolation. Our results contribute to a better understanding of the habitat connectivity between alpine springs and foster the biodiversity assessment of a generally neglected taxon.

SS13_O4_Comparison of Odonata diversity and assemblage structure among perennial and intermittent springs: a case study in central Montenegro

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Springs are important habitats for maintenance of freshwater biodiversity. Little is known about assemblages of Odonata larvae in karstic springs, and particularly about those assemblages that inhabit intermittent springs. In this study, composition of assemblages of Odonata larvae was studied on material from 76 springs in the central part of Montenegro. The springs were divided into two groups: perennial and intermittent springs. Our goals were to determine the differences in Odonata assemblages between these two types of springs and to determine Odonata species characteristic for perennial and intermittent springs, respectively. The ANOSIM procedure has shown significant differences in faunistic data between perennial and intermittent springs ($R=0.302$; $p=0.002$). The analysis has shown statistically significant differences both in number of species ($p=0.001$) and in number of individuals ($p=0.0029$). The SIMPER procedure on faunal composition has shown high level of dissimilarity between the two compared groups – 86.70%. According to the results of SIMPER analysis, *Cordulegaster bidentatus* and *Calopterix virgo* were characteristic representatives of perennial springs, while *Sympetrum sanquineum* and *Onthetrum bruneum* were characteristic species of intermittent springs. It is of course necessary to perform additional studies on this topic, but the present research has its value in drawing attention to intermittent springs, which are significantly less studied than intermittent rivers. Our research has shown significantly higher species diversity of Odonata in perennial springs, and therefore it is necessary to pay more attention to conservation of these habitats in order to preserve this level of diversity.

SS13_O5_Homology-driven Proteome Characterization of the cold-stenothermal freshwater Species *Crunoecia irrorata* acclimatized to stressful thermal Conditions

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Limited dispersal abilities and habitat patchiness contribute to the vulnerability of ectothermic freshwater invertebrates to unprecedented rates of global climate change. The potential impacts on populations will depend on the magnitude of change and on the adaptive capacity of individuals. In many organisms, when exposed to stressful environmental conditions, a shift in protein-expression patterns can be observed. The resulting physiological changes often improve organismal fitness mediated by phenotypic plasticity. In a thermal acclimation experiment, we investigated shifts at the molecular level closest to the phenotype, the proteome, to aid in the discovery of plastic changes involved in the response to adverse thermal conditions. Populations of the freshwater invertebrate *Crunoecia irrorata* were subjected to one week of 10, 15 and 20 °C acclimation temperatures. Subsequently, via a novel homology-based Liquid Chromatography – Mass Spectrometry and Tandem Mass Spectrometry (LC-MS/MS) proteomics approach, we assessed differential expression of over 1350 identified proteins. After assigning protein functions, expression patterns were linked to a variety of adaptive responses of individuals acclimated to high temperatures. Our data shows the onset of cuticle structure alteration, a heat-shock protein response, modification of the open tracheal system in response to hypoxia and the accumulation of the sugar trehalose aiding in maintaining cellular homeostasis. Identifying plastic responses aids in understanding the relative sensitivity and adaptivity of freshwater species and helps us understand if and how exhibited phenotypic plasticity positively affects short-term thermal tolerance and long-term ecological success of populations in temperate freshwater ecosystems.

PROGRAM

POSTER PRESENTATIONS

- by sessions -

PhD awardees

Posters correspond to the respective oral presentations

1. Migratory waterbirds as key vectors of dispersal for plants and invertebrates – case studies from Europe (Ádám LOVAS-KISS) – Plenary lecture 4
2. Effects of artificial light at night on benthic primary producers in freshwaters (Maja GRUBIŠIĆ) - RS1_O1
3. Ecological and evolutionary physiology of aquatic beetles: coping with multiple stressors in inland saline waters (Susana PALLARÉS) - RS15_O1

RS1 Algae

RS1_P1_Adhesion behavior of algal cells under stress in laboratory conditions: electrochemical approach

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The aim of the study was to link the algal cell behavior in terms of its adhesion at the model interface and physiological activity under salinity change and the presence of heavy metal cadmium. A culture grown halotolerant green alga Dunaliella tertiolecta Butcher was selected as a model organism. Deficiency of a rigid cell wall makes this species very susceptible to changes in the ecosystem, thus making it an excellent applicant in stress research. Microscopic method and electrochemical methods of polarography and chromoamperometry at the dropping mercury electrode were used for characterization of cell suspensions. Optical microscopy was used to visualize cellular shape and to determine cell abundance. The electrochemical method of amperometry at the dropping mercury electrode was applied to characterize cell suspensions in terms of concentration, level of polydispersity and adhesion behavior of cells at the wide potential range. Adaptation of D. tertiolecta cell culture in lower salinity conditions suggests a somewhat faster growth, while the adhesion properties at the broader potentials area remains preserved. Adaptation of D. tertiolecta to the presence of heavy metal cadmium in culture resulted in decrease of cell density and size with increasing cadmium concentration, and the occurrence of released surface-active particles and microagregates in the cell culture, presumably as a consequence of metabolic activity under stress. The results of this study contribute to better understanding of survival strategy and cell adaptation of algal species in aquatic systems under pressure.

RS1_P2_Phosphorus removal by periphyton developed on the artificial substrate in the hypereutrophic pond

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Last decades of the 20th century faced us with the extensive eutrophication of aquatic ecosystems, which is one of the most serious environmental issues. Excessive phosphorus inflow is recognized as a key factor that causes this phenomenon. Shallow stagnant waters are particularly vulnerable to eutrophication that leads to their significant degradation and biodiversity loss. Plenty of methods have been proposed to remove the phosphorus from the water column so far. In this study, the potential of the biological method using periphyton developed on the artificial substrate in the hypereutrophic pond has been investigated. The artificial substrate carrier was submerged from May to October and samples were collected both continuously incubated (from the start of carrier exposure) and monthly developed. Qualitative and quantitative analyses of autotrophic periphyton component were done, and Autotrophic and Lakatos indices were calculated to describe the community. Total phosphorus content in periphyton was estimated spectrophotometrically. The investigated community was characterized as abundantly developed, inorganic and predominantly heterotrophic. The autotrophic component was dominated by Bacillariophyta with a low share of Cyanobacteria in total biomass. Those periphyton characteristics caused maximal phosphorus assimilation of 14.68 mg P/m2 only, after three-month exposure, but 12.66 mg P/m2 in the monthly sample in August. Obtained results indicate that considering such periphyton structure, employing the monthly developed communities in phosphorus harvesting during the remediation process could be more effective than using the continuous ones. At the same time, the potential large-scale employment of this approach would affect the existing biocoenosis to a lesser extent.

RS1_P3_Adaptability of tropical cyanobacterium *Raphidiopsis raciborskii* to thermal conditions in the temperate climate zone

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The alien cyanobacterium *Raphidiopsis raciborskii* (Nostocales) was first recorded on the island of Java in Indonesia and described as a tropical and subtropical species. Highly-developed adaptability such as phenotypic plasticity, occurrence of ecotypes, ability to produce toxins as well as climate changes and eutrophication have facilitated significant expansion of the geographical distribution *of R. raciborskii*. It's high flexibility against the temperature have been frequently reported. Temperature of 25°C as a optimal temperature for *R. raciborskii's* growth was determined. The minimum temperature at which *R. raciborskii* growth was observed in the environment was below 12°C, whereas the maximum temperature at which *R. raciborskii* was reported was 30°C. Much less in know about occurrence of different ecotypes among lakes in the same region differing in their temperature demands. The aim of the study was therefore to examine temperature conditions favouring the growth of *R. raciborskii* isolated from different lakes. The study was conducted using five *R. raciborskii* strains isolated from freshwater lakes in Wielkopolska region (Western Poland). It was observed that temperature of 10°C was too low for a significant growth of all investigated strains except one. Temperatures of 22.1°C and 31°C were found to be favorable for significant growth of the investigated strains, however the temperature of 22.1°C seems to be optimal for isolated strains from studied region.

RS1_P4_Motility as an indicator of algal cell stres in modified batch cultures

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Motility is a fundamental property which includes a number of highly attuned cellular functions that enable an organism to move in a coordinated fashion. Many microorganisms use different external chemical and physical factors in order to direct their search toward food or a suitable niche for survival and growth. The aim of this study was to develop procedure for the cell motion analysis in order to determine the cell speed changes in laboratory-induced stress conditions. *Dunaliella tertiolecta* and *Rhodomonas maculata*, two motile biflagellate algal species differing in cell symmetry and position of flagella, were selected as model organisms. Motility of algal cells was examined in dependence of changing concentrations of toxic heavy metal cadmium and different salinities in the growth media. Determination of cell motility, corresponding to length and shape of trajectories, were recorded with the open access bioimage software ICY (The Institut Pasteur, France). Differences in cell speed are related to morphological features of the corresponding algal species. Cell adaptation response to cadmium stress is manifested through decrease in cell speed, as well as changes in motion and pattern of movement. The obtained results give a deeper insight into the viability of algae population and will contribute in understanding of the adaptation response mechanism of cell to stress in aquatic ecosystems.

RS1_P5_*Watanabea acidotolerans*: A new coccoid green alga dwelling in pH < 3 freshwaters of two continents

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A new strain of unidentified coccoid green alga has been isolated from the epilithic biofilm of the extremely acidic (pH < 3) Hromnice Mine Pit Lake in Czechia. The strain fitted the morphology of the small and poorly known genus Watanabea with its characteristic production of both ellipsoidal and spherical autospores and other ultrastructural features. However, the species identity of the new strain remained unclear, therefore, we have analyzed its nuclear 18S+ITS2 rDNA and plastid rbcL molecular markers. The phylogenetic analyses placed the acidotolerant strain within the genus Watanabea and showed that it represents a species different from the type species W. reniformis. The secondary structure analysis of the ITS2 supported a distinct species identity of the new strain. Interestingly, the plastid phylogeny showed that the epilithic strain from Czechia was identical to a planktic strain from the volcanic Caviahue Lake (located in Argentina) with pH < 3. Both lakes have similar water chemistry in terms of heavy metals and increased concentration of phosphorus. Consequently, we described a new species, *Watanabea acidotolerans*, a monophyletic lineage of coccoid green microalgae with wide distribution and tolerance to low pH habitats. The presence of different life strategies shown by the European and South American strains let us conclude that W. acidotolerans effectively adapts to extreme environments of acidic lakes and that its distribution might be affected by both acidity and increased availability of phosphorus.

RS2 Climate change and freshwater ecosystems

RS2_P1_The charophyte decline and recovery in Lake Lednica in response to four decades of changes in water fertility and hydrometeorological conditions

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Lake Lednica (W Poland, 339.1 ha, 15.1 m) is a Historical Monument of the Polish Nation that due to a long history of settlement is a known centre of archaeological, ethnographic, limnological and paleolimnological studies. It is also a regional charophyte hot-spot with 12 out of 34 Polish charophyte species. Stabile nowadays, charophyte vegetation was highly dynamic in recent decades. This study aims to relate the charophyte dynamics to the trends of changes in the lake's trophy, alimentation basin character and the hydrometeorological conditions in the period 1976-2015. Gathered extensive data and the results of own study (since 2004) of vegetation, water chemistry and sediment cores evidenced the decrease in the submerged vegetation and the disappearance of charophytes in last decades of the 20th century. In addition to high nutrient concentration, an increase in water surface level and temperature after the period of long-lasting ice cover seem to be the crucial determinants. A spectacular charophyte recovery at the turn of millennia coincided with the reduction in the total phosphorus concentration, a drop in water surface level and a sequence of warm winters with short ice duration. Possibly, reduced nutrient run-off may have stimulated the recovery and expansion of charophyte meadows while the possibility to overwinter was the advantage over other photoautotrophs in the winter and early spring time. By means of numerous feedback mechanisms, recovered charophyte meadows improve water transparency, the basic ecological factor for their occurrence.

RS2_P2_Importance of temperature on the growth of native and alien cyanobacteria strains from temperate lakes

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Global warming promotes the growth of native cyanobacteria, and also is driving force for distribution and survival of invasive species northwards. To predict the potential of newcomers to spread out into the new aquatic ecosystems, it is important to understand drivers favouring their successful adaptation. The purpose of the present study was to experimentally assess whether alien (*Chrysosporum bergii*, *Sphaerospermopsis aphanizomenoides*) cyanobacteria have an advantage over bloom forming native species (*Planktothrix agardhii*, *Aphanizomenon gracile*) under increasing temperature from 18 to 30 °C, and to determine temperature effect on toxin amounts in the strains. Alien species acted differently along temperature gradient and their growth rate at elevated temperatures was greater than that of native species. Optimal temperature for S. aphanizomenoides growth was similar to native species. *Ch. bergii* was favoured to 26–30 °C, but was sensitive to 18–20 °C. Non-toxic strains of the native cyanobacteria prevailed over the toxic ones under all tested temperatures. Microcystins and other oligopeptides in *P. agardhii* biomass decreased in concentration with the increasing temperature. Temperature effect on saxitoxin concentration in A. gracile biomass remains undiscovered. From the perspective of highly uncertain future climate scenarios, the current work showed a great need for further studies of temperature effect on distribution and toxicity of both native and alien cyanobacteria species.

RS2_P3_North Atlantic Oscillation Position influences waterfowl abundance in a Mediterranean wetland

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Waterfowl abundance and composition in wetlands are strongly related to hydrological features, such as water availability and the extent of the inundated area. In the Mediterranean area, changes in the position of the North Atlantic Oscillation (NAO) can significantly influence the hydrological dynamics of wetlands mainly through changes in rainfall. Consequently, variations in this large-scale climate oscillator could affect local waterbirds abundance in Mediterranean wetlands. In this study, we examined the teleconnection between the position of the North Atlantic Oscillation, the meteorological and hydrological variability in a Mediterranean wetland (Guadalhorce river mouth, Málaga, Spain) and waterbirds censuses during a 14-years time period. We found a negative and significant relationship between the NAO index and dabbling ducks, diving ducks, grebes and Rallidae breeding pairs. During years with high NAO index, spring rainfall and wetland surface area decrease promoting, consequently, lower numbers of breeding pairs. The opposite scenario occurs during low NAO index years. Our results suggest that the number of waterbirds breeding pairs in the wetland decreases in around 10 units for every 1 unit increase in NAO index. In the context of climate change it is expected that NAO index will acquire higher values more often, which could promote more stable meteorological conditions in the Mediterranean area. This would result in longer drought periods, smaller wetland surfaces, and a decrease in the abundance of the waterfowl community in the Guadalhorce river mouth wetland. Implications of this relationship for wetland management and waterfowl conservation are pointed out.

RS2_P4_Groundwater carbon within a boreal catchment – spatiotemporal variability of a hidden aquatic carbon pool

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Groundwater is an essential resource providing water for societies and sustaining surface waters. Although groundwater at intermediate depth (down to 20 m) could be highly influential at regulating lake and river surface water chemistry, studies quantifying organic and inorganic carbon (C) species at these depths are still rare. Here, we quantified dissolved and gaseous C species in the groundwater of a boreal catchment at depths between 3 and 20 m. We found that the partial pressure of carbon dioxide (pCO_2), the stable carbon isotopic composition of dissolved inorganic carbon ($\delta^{13}C$-DIC) and pH showed a dependency with depth of the sampling well. A positive relationship was observed between pCO_2 and $\delta^{13}C$-DIC, whereas we found a negative relationship between pCO_2 and pH. We attribute the negative relationship between pCO_2 and pH along a depth gradient to a shift in the carbonate system caused by silicate weathering. Silicate weathering consumes carbon dioxide (CO_2) and releases base cations, leading to a pH increase and pCO_2 decrease. The pH increase with depth probably further resulted in a fractionation of $\delta^{13}C$-DIC, explaining the observed positive relationship between $\delta^{13}C$-DIC and depth. There was a large variability in pCO_2 across the catchment groundwater wells which may be due to local differences in silicate weathering. Overall, our results suggest that the carbonate system has a strong effect on carbon speciation in groundwater at intermediate depths. Thus, CO_2 concentrations in surface waters which are fed by groundwater are most likely strongly driven by the carbonate system in catchment soils.

RS3 Conservation

RS3_P1_Small peripheral basins sometimes means a lot: the implications for conservation of fish communities

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The Upper Dniester River basin (Central Europe, Carpathians) may contain a number of unique fish communities. Although data on the ichthyofauna of this basin are scarce, evidence indicates that these communities have declined. To fill the knowledge gaps and assess the role of the peripheral basin on fish species and community conservation, we conducted research on the Strwiąż River basin. Because data from the Strwiąż can be helpful for describing the diversity in the Upper Dniester River, we performed a detailed analysis of the fish communities, defined the primary morphological characteristics of sites that corresponded to the requirements of the fish communities, and identified anthropogenic threats. Data for the analysis covered the period from 2003 to 2016. The Strwiąż River basin is likely the only fragment of the Upper Dniester basin with a well-preserved fish community that presents unique characteristics. The Strwiąż River is an example of a peripheral basin that has survived in a good state. It features high species richness and numerous native Ponto-Caspian species functioning near the edge of their ranges. The peripheral fragment of the larger basin has survived in a good ecological status, and the extant ichthyofauna can provide a point of reference for other, more transformed tributaries. We draw attention to the fact that peripheral basins, which are not usually considered in conservation biogeography, can be important for the protection of fish species and entire fish communities. Our study is one of the most convincing arguments for a more in-depth investigation of peripheral populations.

RS3_P2_Lessons on riverine fish conservation learned by analysing population functions on the range edge

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Riverine fish fauna are highly altered by human impacts, i.e., population exploitation and natural habitat degradation. Small-sized species are not usually fished or restocked and thus represent a natural distribution and serve as a good model for analysing natural population functions. The racer goby (*Neogobius gymnotrachelus*) is a small, benthic riverine fish. We used precise habitat data and racer goby densities (638 sites) to disentangle the habitat selection patterns of the species at a river reach located at the edge of its native range. Spatial variations of the submountain river reach water depth and velocity were estimated by the inverse distance weighting method. The responses of racer gobies to environmental variables were analysed using generalized linear models. A significant portion of the river reach surveyed was unsuitable for racer gobies, mainly due to an excessively fast water current but most likely also due to bottom substrate granulation. Large gobies were mostly observed in boulder substrate regions, while small gobies were more numerous on finer substrates. Most small-sized racer gobies were caught in the shallowest zones, whereas larger fish occupied hiding places in slower water currents. Although patches suitable for the racer goby habitat were scarce and scattered, this species remained on the edge of its native range because of its mobility and separation of habitats occupied by specific size groups. Our findings show that even when separated by long sections of unfavourable habitat parameters, patches of suitable habitats can form a chain of stepping stone habitats and ensure fish recruitment.

RS4 Ecological modelling

RS4_P1_Differences in the structural and functional organization of macroinvertebrate communities in the sub-basins of the Tisza River

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The Tisza River is the largest affluent of the Danube and one of the most important rivers of Central Europe. Two side-tributaries of the Tisza watershed, the Sajó and Hernád Rivers (18.144 km2) and the Maros River (27 049 km².) were sampled for aquatic macroinvertebrates, environmental and spatial variables. Samplings took place during the summer of 2012 (7th-15th of July) on the Sajó and Hernád Rivers, and in the summer of 2014 (7th-14th of July) on the Maros River. The relationship between species and functional traits vs. the registered variables was studied using Principal coordinates of neighbour matrices (PCNM) and Redundancy Analysis (RDA), also experimenting for the most efficient use of the collected data. Thus, in addition to the raw dataset, two datasets were used, both generated from the original matrix, using the Self Organizing Maps (SOM) method. Also, our results suggest that, following the currently used method of retrieving data from the SOM analyses result in more significant correspondences compared to the raw data, yet, these results might be exaggerated. Instead, an improved method by filtering out virtual data generated by the method is offered to give enhanced, easily interpretable and yet more moderate results. Environmental factors significantly influencing individual functional traits and species were identified and compared between the side-tributaries. Contradicting the geographical closeness of the side-tributaries and the similarly distributed sampling sites, communities differed in both species, functionality and influencing factors. According to the results of the study, special care must be taken when comparing watersheds on a small spatial scale.

RS4_P2_Modelling of ecological status of lakes using artificial neural networks

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The lake assessment based on aquatic organisms has been carried out for a long time as a scientific issue but after the implementation of the Water Framework Directive it has acquired a broad practical importance. Since then, the significant development of biological monitoring methods took place and the approach to assessing the ecological status of aquatic ecosystems has become widely used. Currently, after over a decade of wide scientific research and monitoring we have been gathered extensive hydrobiological databases, the analysis of which give a chance to significantly increase our knowledge about aquatic ecosystems functioning. The amount of available data increases with each subsequent year of monitoring, and their efficient analysis requires the use of mathematical tools other than those used so far. Our study focus on modelling values of three indices of ecological status assessment of lakes based on plant organisms as algae (phytoplankton index – PMPL, phytobenthos index – IOJ) and vascular plants (macrophyte index – ESMI). The indices were modelled by artificial neural networks on the basis of physico-chemical parameters of water. The best modelling quality in terms of high values of coefficients of determination and low values of the normalised root mean square error was obtained for PMPL. A lower degree of fit was obtained by the networks constructed for ESMI and IOJ. The effect of physico-chemical parameters on the models was evaluated by sensitivity analysis. The use of ANN confirmed that although various biological elements are sensitive to different water quality parameters, water transparency has a main impact on ecological status of lakes derived by the values of three analysed indices. DG was granted by Polish National Agency for Academic Exchange.

RS4_P3_Modelling ecosystem metabolism at the scale of entire river networks

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Ecosystem metabolism (i.e., gross primary productivity, GPP, and ecosystem respiration, ER) is a critical ecosystem function strongly linked to carbon fluxes in river networks. Existing models of ecosystem metabolism often estimate the constituent processes using measurements of dissolved oxygen (DO) from a single or two stations, providing point- or reach-scale estimates of GPP and ER. However, the data requirements to cover an entire river network using such models are prohibitively large. Also – when independently fitted to various locations – these models do not account for spatial dependence of metabolic parameters across locations within the network. This limits our understanding of how ecosystem metabolism varies in space and precludes precise estimates of GPP and ER for the entire network. We present a method for estimating metabolism in river networks at the whole-catchment scale using hierarchical Bayesian latent variable modelling. The model backbone is a simple transport-reaction model estimating dissolved oxygen concentration, similar to existing multi-station models. Parameters controlling GPP, ER, and reaeration flux are fitted with hierarchical priors that can flexibly account for spatial dependence as well as hypothesized environmental controls. The model is calibrated using simultaneous network-wide measurements of DO, water temperature, and irradiance. Finally, we estimate DO at unobserved locations using latent variables constrained by the requirement that DO is transported to and from observed locations. Derived variables, including GPP and ER, can thus be estimated (with confidence limits) for the entire river network, providing a metric of bulk ecosystem function and its variation across the network.

RS5 Ecotoxicology and stress responses

RS5_P1_Comparison of metal accumulation efficiency in acanthocephalans, gammarids and fish under the impact of municipal and technological wastewaters

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In addition to chemical water analysis, assessment of biologically available pollutants involves application of bioindicators, mostly presented by fish, crustaceans and bivalves. Regarding metal exposure, fish intestinal parasites acanthocephalans were suggested as promising bioindicators, since it was reported that metal accumulation was higher in acanthocephalans compared to the other bioindicator organisms. Thus, the aim of the present study was to compare spatial and seasonal metal accumulation efficiency in acanthocephalans (*Dentitruncus truttae* Sinzar, 1955) and commonly used bioindicators, fish brown trout (*Salmo trutta* Linnaeus, 1758) and gammarids (*Gammarus balcanicus* Koch, 1836). Metal exposure was evaluated in the wastewater impacted Krka River (polluted site) and in the river source (reference site) in autumn (2015) and spring (2016). Metals were measured by high resolution inductively coupled plasma-mass spectrometry in fish intestine, whole gammarids and acanthocephalans, which were wet digested in a drying oven at 85°C for 3.5 hours using concentrated HNO_3 and H_2O_2. The highest levels of Zn>Fe>Rb were found in fish, Sr>Fe>Zn in gammarids and Zn>Fe>Cu in parasites. In moderately polluted Krka River, acanthocephalans showed higher metal accumulation efficiency than fish and gammarids for Cd, Mn, Pb, Tl, while lower for Cs, Fe, Rb. Bioconcentration factors indicated 4-55 times higher metal levels (Cd>Tl>Pb>Sr>Cu>Ca>Mn) in parasites compared to fish and 3-22 times (Tl>Cd>Pb>Mn) compared to gammarids. Spatial differences were evident in both seasons and in all organisms as higher Co, Fe and Mn at polluted and Cd and Tl at reference site. Consequently, further investigation on sediment and dietary metal sources are needed.

RS5_P2_Metal bioaccumulation in the gills of Prussian carp (*Carassius gibelio*) from the Ilova River as the indicator of waterborne metal exposure

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The Ilova River is a lowland river situated in the central part of Croatia. In its lower course it is influenced by wastewaters of petrochemical industry, as well as by the municipal wastewaters. The aim of this study was to establish if the evident input of different wastewaters into the Ilova River has impacted the river water quality regarding the levels of dissolved metals in the surface water and the metals consequently accumulated in the gills of Prussian carp (*Carassius gibelio*), as tissue responsible for the waterborne metal uptake. Although Prussian carp represents an invasive species in the Ilova River, it is very abundant in its water and thus was considered as a suitable and representative bioindicator for this study. Fish were caught at two locations (the Ilova village as a reference site, and the Trebež village as a contaminated site) in two sampling campaigns (October 2017 and May 2018). Dissolved metal concentrations in the filtered and acidified samples of the river water, and total metal concentrations in the samples of acid digested gill tissues were measured by high resolution inductively coupled plasma mass spectrometry. The obtained results indicated that several elements (Na, Li, Rb, Cd, Cs, Tl, U, Al, and Ti), mainly nonessential and rather toxic, were present in significantly higher concentrations in the vicinity of the Trebež village both in the fish gills and in the river water in both seasons, thus pointing to observable impact of known contamination sources on the aquatic life in the Ilova River.

RS5_P3_Influence of repeated pulsed pesticide exposures on the biochemical biomarkers in *Lemna minor*

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The usage of pesticides in intensive agricultural production has been increasing, and among them herbicides are the most commonly used agrochemicals. Isoproturon is a highly selective phenylurea derived systemic herbicide. It is widely applied to prevent the development of annual grasses and broad-leaved weeds in agricultural fields. Isoproturon may enter the aquatic environment by a number of various pathways. Thus, it is released to aquatic ecosystems in a series of sequential pulses, which fluctuate considerably in continuance and concentration. Laboratory ecotoxicity tests employ constant exposure concentrations over defined duration and therefore may not realistically reflect the effects of certain xenobiotic on non-target organisms. The overall aim of this study was to evaluate the effects of isoproturon on molecular biomarkers and the occurrence of oxidative stress in the aquatic plant *Lemna minor*. Common duckweed plants were treated with 50, 100, 150 and 200 µg L^{-1} of isoproturon added in Steinberg's nutrient solution during 21 days. The effects of isoproturon were assessed by measuring the activities of ascorbate peroxidase (APX), catalase (CAT), guaiacol peroxidase (GPX) and total protein concentration. Additionally, the effects of pulse isoproturon exposures (48 h of herbicide treatment, as well as 5 days of post-exposure period in pure nutrient solution) were studied. Enzymatic activities as ecotoxicological biomarkers, indicated that isoproturon treated plants were under oxidative stress. Results from studies that include multiple pulse exposures, may contribute to the better improvement of standardized ecotoxicity tests.

RS5_P4_Combining metabarcoding and metabolomics to gain insight into the interactive effects of microplastics and emerging contaminants on river biofilms

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There is a current concern about the fate and environmental effects of microplastics (i.e. sized < 5 mm) derived from personal care products, medicines, and the degradation of larger plastics. Bioaccumulation of microplastics and spread across food webs is currently seen as a pressing challenge in aquatic ecotoxicology. In addition, microplastics in freshwaters are likely to co-occur with other emerging contaminants, such as pharmaceuticals, having the ability to accumulate them. In this way, microplastics may act as carriers that facilitate the transport of emerging contaminants. Therefore, it is crucial to gain knowledge about the effects of microplastics on lower levels of food webs, including benthic communities, and their interaction with other contaminants. To that purpose, we will use artificial mesocosms to evaluate the short-term (i.e. 72 hours) effects of the microplastic polyethylene (PE) on river benthic communities (i.e. river biofilms). Moreover, we will assess the interaction between PE and the antibiotic clarithromycin. The response of the river biofilm will be evaluated at the structural and the functional level. At the structural level, bacterial community will be characterized using high-throughput sequencing of the 16S rDNA marker. At the functional level, the metabolomic profile will be studied by means of a non-target methodology based on liquid chromatography coupled to high resolution mass spectrometry (LC-HRMS). The bioaccumulation of polyethylene and clarithromycin on the biofilm will also be assessed. We hypothesize that PE and clarithromycin will interactively affect biofilm community composition, and that this structural change will translate into an altered metabolome.

RS6 Fish (and other vertebrate) biology

RS6_P1_Demographics and survival in the European pond turtle *Emys orbicularis*: a 31−year study

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Two populations of the European pond terrapin (*Emys orbicularis*) separated by a distance of seven to nine km were studied in the tributaries of the Tordera River (northeast Spain). One population was observed from 1987–2018 (Zone 1) and the other from 2008–2018 (Zone 2). The specimens were captured by baited funnel traps and marked individually. We used capture-recapture data to determine population structures and sizes, survival rates and dispersal movements. The data showed that the sex ratio favored females in Zone 1 (males/males + females = 0.25) and males in Zone 2 (males/males + females = 0.57). The sex ratio remained stable for 21 years in Zone 1. Using the Chapman-modified Petersen method, we estimated the population size as N = 144 (2007−2018) in Zone 1 and N = 237 in Zone 2. In Zone 1, the population remained relatively stable from 2007–2018. A log rank test showed no significant differences in the survival rate between the sexes. The median survival period was eight years, with a maximum of 31 years in females and 30 years in males. The recaptured specimens showed an important fidelity to the capture sites, and only 19% of the females and 30% of the males moved between successive recaptures.

RS6_P2_Peculiar occurrence of *Cobitis bilineata* Canestrini, 1866 and *Sabanejewia larvata* (De Filippi, 1859) (Cobitidae, Actipteri) in Danube basin in Croatia

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Plitvice Lakes National Park is the oldest, the largest and the most visited national park in Croatia. It is located in the karstic region of Croatia, but belongs to the Danube drainage. Its ichthyofauna is mostly comprised of Danubian elements and it was not considered to comprise any endemic species. Although representatives of the family Cobitidae (loaches) were reported for Plitvice lakes in many older reports, they were usually determined as *Cobitis taenia* or *C. elongata*. In this presentation, we bring interesting results of more detailed analysis (on morphological, as well as molecular genetic levels) of loaches from Plitvice lakes. Surprisingly, all analyses conducted confirmed that they actually belong to two species in two different genera that were previously never reported outside the Adriatic watershed: *C. bilineata* and *Sabanejewia larvata*. Both species have restricted distribution ranges*:* *S. larvata* was thought to be distributed only in Italy, while proposed distribution range of *C. bilineata* comprised Italy, Slovenia, Croatia, Switzerland and France. Since this is the first record of *S. larvata* in Croatia and the second for *C. bilineata* (previously it was known only from the Zrmanja River), both species are now listed as Natura 2000 species, in order to ensure their adequate protection. Interestingly, although samples of both species are similar to Italian *C. bilineata* and *S. larvata*, they are not the same, opposing the hypothesis of anthropological translocation. Possible colonization routes and evolutionary pathways that brought these two species to Plitvice Lakes National Park will be discussed.

RS6_P3_Seasonal variability in perch diet in the northern lakes (Lake Krivoe, north Russian Karelia)

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The cold-water and low-trophic subarctic Lake Krivoe (0.5 km 2) is a small glacial lake located on the Karelian shore of the White Sea, 30 km southmore of the Arctic Circle. Currently, there are three species of fish in the lake: Eurasian perch *Perca fluviatilis*, European whitefish *Coregonus albula* and nine-spined stickleback *Pungitius pungitius*. The perch is the most widespread and prevails in amounts among these fish. The seasonal dynamics of feeding in the perch at the benthivorous stage was studied during 2004-2009 in this lake. It was found that the food spectrum and the intensity of feeding of perch vary during the season. The coastal amphipod *Gammarus lacustris* was the main food item in the diet of perch in the lake. The frequency of occurrence of this gammarid in the fish stomachs is determined by sufficient number of its large-sized specimens in the zoobenthos. The appearance of new generation in *G. lacustris* population and a shift in the structure of zoobenthos leads to a change in food spectrum of fish. The favorite food item *G. lacustris* during June and July give up their leading positions to other benthic animals, such as trichopteran, odonate and coleopteran larvae and chironomid pupae, in the second half of the summer. Thus, the range and intensity of feeding perch vary depending on the season and the presence of large benthic animals.

RS6_P4_Has the racer goby *Babka gymnotrachelus* (Kessler, 1857) failed to invade the Danube tributaries, the Sava and Drava Rivers?

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In recent decades, five species of Ponto Caspian gobies (P-C gobies) have experienced dramatic range expansions outside of their native habitat: monkey goby *Neogobius fluviatilis* (Pallas, 1814), bighead goby *Ponticola kessleri* (Günther, 1861), round goby *Neogobius melanostomus* (Pallas, 1814), racer goby *Babka gymnotrachelus* (Kessler, 1857) and western tubenose goby *Proterorhinus semilunaris* (Heckel, 1837) (Roche et al. 2013). All of these species have been recorded in the Croatian part of the Danube River (Polačik et al. 2008a; Szalóky et al. 2015), with *P. semilunaris* classified as native to Croatia (Jakovlić et al. 2015). During recent years of intensive research, monitoring and inventory programmes in Croatian large inland waters, 72 specimens of racer goby *B. gymnotrachelus* were collected at eight locations in 2016 and 2018, and of these, 61 were juveniles. This confirms the establishment of a self-sustaining population in the main channel of the Danube and its small tributary the Baranjska Karašica River in Croatia. However, no progress of this species in the tributaries of the Drava and Sava Rivers has been observed. This reveals that future research should be focused on tributaries, channels and backwaters to confirm their localization only to the Danube River and its North West tributaries in Croatia.

RS6_P5_In the eyes of the beholder-Evolution of vision and trophic ecology in the elephant fishes (Mormyridae)

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The elephantfishes (Mormyridae) occur exclusively in the freshwater systems of Africa and are scientifically mainly known for their use of electroreception. However, only scarce research was conducted on other sensory systems in these fishes and less is known about their ecology in general. The main aim of our project is to reveal the molecular basis of vision in the elephant fishes and to combine the findings on the genomic level with data about their trophic ecology. We studied nine species from the Sanaga River in Cameroon, which inhabit turbid waters with limited light conditions. We sequenced whole genomes and the retina transcriptomes by Illumina next-generation sequencing as well as conducted stable isotope analysis of the muscle tissue, and stomach content analysis to focus on the food source. The presence of opsin genes and the quantified gene expression in each species reveal intrinsic adaptations to their habitat. We found one short-wavelength and two long-wavelength sensitive photoreceptor (opsin) genes expressed in the retinas of seven mormyrid species. Two species were missing one of the LWS genes, namely *Mormyrops anguilloides* and *Marcusenius sanagaensis* are not expressing the LWS2 gene. Interestingly, the green sensitive RH2 opsin is absent in the genomes of all species. We aim to identify different ecological niches, based on the results of the stable isotope analysis. Although the ecology of the studied species remains to be further investigated, our results contribute to the understanding of the biology of these fascinating weakly electric fishes of Africa.

RS7 Freshwater science in policy, management, monitoring and restoration

RS7_P1_First empirical study of freshwater microplastics in West Africa: a comparison with a European freshwater system

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Rivers are major pathways that transport inland plastics to the ocean. However, only a few studies have investigated microplastic pollution in African freshwater habitats. The current study is the first to report microplastics in West Africa, namely in Nigeria, which is the most populated African country, a factor that is often correlated with severe pollution. We assessed microplastic concentrations in African (Lanistes varicus, Melanoides tuberculata) and European (Theodoxus fluviatilis) gastropods from the Osun River system (Nigeria) and the Rhine River (Germany) and drew a comparison between the microplastic loads in African and European gastropods. Using micro-Fourier-transform infrared spectroscopy (µFTIR), we detected polyethylene in Osun River gastropods, while nylon and polypropylene were found in gastropods from the Rhine. Regarding microplastic load per individual, African gastropods showed higher values than the European T. fluviatilis. In the African L. varicus we found black polyethylene films resembling the black polyethylene plastic bags regularly used in Nigeria and found at the study site. As the African gastropods contained higher microplastic loads per individual than the European gastropod species, this study suggests that microplastics may pose a greater health risk to the freshwater biota of Osun River than to the biota of the Rhine River. If African gastropods are consumed by a predator, a high microplastic load enters the food chain and may harm organisms occupying higher trophic levels through bioaccumulation and biomagnification.

RS7_P2_EU LIFE project „ALGAE – ECONOMY-BASED ECOLOGICAL SERVICE OF AQUATIC ECOSYSTEMS" (AlgaeService for LIFE) – filling gaps in a circular economy

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Accumulation of excessive amounts of micro- and macroalgae biomass in aquatic ecosystems worldwide has caused environmental damages and socioeconomic losses encouraging attention in harvesting of algal agglomerations. The goal of the project AlgaeService for LIFE (2018–2023) is to test and demonstrate innovative complex system that has three interlinked elements: 1) prototypes for cyanobacteria and macroalgae biomass harvesting to improve water quality and provide ecosystem service; 2) validation of distant methods to define hot-spots of algal agglomerations in real conditions; 3) redesigning of harvested waste biomass into valuable bioproducts for recycling of environmental resources and restitution of ecosystem service costs. The circular economy project seeks to address integrated management of nutrients and organic pollution caused by agriculture suggesting measures applicable at catchment scale. It supports green economy concept by testing harvested biomass for high value bioproducts, biogas production, slow release fertilizers. Project actions contribute to the implementation of some EU directives. Implementation of project actions will take place in freshwaters in Lithuania and Poland, and in the Curonian Lagoon with the purpose to abate eutrophication of the Baltic Sea. Project aims to increase public awareness on eutrophication, algal blooms and sustainable use of algae biomass, to elaborate replication and transfer strategy of the proposed measures for other coastal areas of the Baltic Sea with comparable problems. The project is implemented by the Nature Research Centre (LT), Adam Mickiewicz University in Poznan (PL), Institute of Nature Conservation (PL); business companies: Baltic Environment (LT), SPILA (LT); non-governmental organization Nature Heritage Fund (LT).

RS7_P3_Characterizing ecocide from the freshwater perspective

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Recently, Brazil has faced a huge environmental mining crime for the second time. The collapse of the mine-tailing dam in Mariana, Minas Gerais in 2015 and in Brumadinho, Minas Gerais 2019 generated two massive waves of toxic mud that spread down, killing many people (approximately 19 in 2015 and 160 in 2019), contaminating the soil and finally spreading the contamination across hundreds of kilometers by reaching 2 important rivers in the country (Doce and Paraopeba rivers). Owing to the nature of flowing waters, the toxic mud was transported downstream, damaging the freshwater ecosystem for about one thousand kilometers (600 km in Doce and 400 in Paraopeba approximately) until reaching the marine ecosystem off the Brazilian coast. The extensive environmental damage that directly and indirectly affected many people could be characterized as an ecocide, “the missing crime against peace”. Ecocide is the “loss or damage to, or destruction of ecosystem(s) of (a) given territory(ies), such that peaceful enjoyment by the inhabitants has been or will be severely diminished”. To characterize the environmental crime that occurred in Mariana and Brumadinho, Brazil as an ecocide, it is important to describe the mechanisms behind the impact of the toxic mud in the ecosystem by approaching the consequences for key ecosystem drivers. Therefore, the aim of this study is to propose a framework to support ecocide characterization from the freshwater ecology perspective, using Brazil as a case study. By doing this, our ultimate goal is to provide the scientific rationality behind classifying environmental loss as ecocide.

RS7_P4_Species origin metrics in biotic integrity indices: a global review

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Multimetric indices (MMIs) are commonly tools, used to assess the ecological integrity of aquatic ecosystems. However, not all the components of ecological integrity have been equally treated, since most of MMIs do not considered nonnative species. We performed a systematic review to identify if specific metrics related to both nonnative and native species have taken into account in the MMIs around the world. Also, we identified the most frequent metrics included in the MMIs. We searched for articles published in English up to 2016 that applied or developed an MM, using the keywords (MMI develop* OR MMI adapt* OR MMI application* OR IBI develop* OR IBI adapt* OR IBI application*) OR (“Multimetric ind*” develop* OR “Multimetric ind*” adapt* OR “Multimetric ind*” application*) OR (“Ind* of Biotic Integrity” develop* OR “Ind* of Biotic Integrity” adapt* OR “Ind* of Biotic Integrity” application) under TOPIC in the ISI Web of Science database. Following the PRISMA guidelines, we analyzed 409 articles. About 66% of articles did not test or did not provide the information if they tested metrics on native or nonnative species. Most of the articles (53%) that tested native or nonnative metrics were fish-based MMI’s. We found 97 different metrics, of which 69% were related to native assemblages, whereas 31% were related to nonnative ones. Native richness was by far the most used metric (23.5%). MMIs metrics quantify several community attributes and the occurrence of nonnative species could threat the ecological integrity, thus it should be considered in bioassessment criteria.

RS7_P6_The impact of industrial and agricultural activities on the concentration of sulphates and chlorides in surface water of border rivers

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Changes in the management methods in border areas are important for the quality of waters in transboundary catchments. Monitoring the effects of activities related to the removal of damages caused by the closed open-pit mines plays a significant role in assessing the effectiveness of undertaken actions. The aim of the study was to determine the variability of sulphates and chlorides concentration in transboundary rivers (Wisznia and Szkło) and to analyse the impact of industrial and agricultural activities on the concentrations of these compounds. The paper presents a detailed chemical analysis of water quality in selected sections of two rivers in 2010-2016. The concentration of sulphates, chlorides, orthophosphates, total nitrogen, nitrate nitrogen and nitrite nitrogen were analyzed. It was found that agricultural activity had no impact on the concentration of sulphates and chlorides in the waters of Wisznia and Szkło rivers. Deterioration of quality of the Szkło river, due to the increased presence of sulphates, was related to the method of reclamation of brownfields after the former sulfur mine in Jaworowo. Due to the lack of the bottom sealing of the sulfur mine and the possibility of contamination of the river Szkło by sulphates the monitoring of concentration of this parameter should be continued at the border point of the river.

RS7_P7_Algal-based assessments of deep lakes - does the metalimnion matter?

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In lakes characterised by thermal stratification and low water fertility, the phytoplankton is accumulated in metalimnion and upper hypolimnion under favourable morphometric and light conditions. Peak values of algal density in deeper layers of the water column are of particular importance for lake ecosystems when extreme weather events that disrupt lake stratification are intensified by global climate change. In 2012, 2013 and 2015, integrated samples from different layers of the water column were collected from ten lakes with low trophic status (Carlson index below 50) in the Masurian Lake District and Suwałki Lake District in Poland. In eight lakes, algal density and chlorophyll a concentration were considerably higher in deeper strata than in the top-most layer – epilimnion. The increase in algal abundance was accompanied by changes in the taxonomic structure of algal communities. Chlorophytes and cryptophytes accounted for a large percentage of phytoplankton taxa in the epilimnion, whereas cyanobacteria were predominant in the metalimnion and also in the hypolimnion in selected lakes. The results of taxonomic research and statistical analyses examining the relationships between biological and physicochemical parameters indicate that variations in the vertical distribution of phytoplankton communities play an important role in a lake's ecological status. The present findings support the methodological approach where ecological status assessments are not limited to the epilimnion and are expanded to include sample collection in the euphotic zone.

RS7_P8_Phytoplankton community in two slow flowing hypereutrophic rivers - ecological traits and potential toxic threat to environment

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Toxic cyanobacteria in hypereutrophic water systems can cause serious problems for water use, especially when nutrients are not the only limiting factor for their growth. The research of phytoplankton was conducted from April until September 2012 in two alluvial rivers of Pannonian lowlands, Spačva and Bosut. Spačva River is medium sized tributary to large Bosut River and both rivers are slow-flowing with large proportion of agricultural use in the catchment area. Except of the size, the rivers differ significantly according to sampling site. In Bosut River sampling site was covered with duckweed, while sampling site in Spačva River had no floating macrophytes, allowing direct sunlight to phytoplankton. Highest chlorophyll *a* concentration was similar in both rivers reaching 364.1 μgL^{-1} in Spačva River and 364.4 μgL^{-1} in Bosut River. Based on biomass calculations, phytoplankton in Bosut River was represented with shade-adapted cyanoprokaryotes belonging to functional group S1, as well as with functional groups C and D tolerant to low light conditions. In Spačva River succession from functional group E to H1 and S1 with subdominance of S_N, was detected. Cyanobacteria *Dolichospermum flosaquae, Aphanizomenon flosaquae*, *Planktothrix agardhii* and *Cylindrospermopsis raciborskii* were species which contributed most to the total phytoplankton biomass. All of the dominant taxa have high toxic risk suggesting potential threat to humans and animals and that monitoring of cyanotoxins should be designed in the near future.

RS7_P9_Hypolimnetic withdrawal and treatment as a new method of lake restoration and nutrient recycling

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A new application of hypolimnetic withdrawal is currently being developed as a restoration method for eutrophicated lakes. While in conventional hypolimnetic withdrawal, phosphorus-rich hypolimnetic water is diverted downstream, in this application it is pumped through a phosphorus-capturing chemical treatment unit and filter, and subsequently returned into the lake via a wetland. Apart from removing phosphorus from the lake, this method potentially allows phosphorus to be recycled as agricultural fertilizer. The prototype hypolimnetic withdrawal and treatment system (HWTS) is located in Lake Kymijärvi, a eutrophicated dimictic lake in Southern Finland. In 2017, phosphorus accumulation in the hypolimnion was studied throughout the summer stratification period, to determine the optimum timing of hypolimnetic pumping and the potential phosphorus yield. The HWTS itself was built and pre-tested in 2018. A suite of physico-chemical and biological variables were monitored in the lake and wetland waters, to investigate the efficiency of phosphorus capture and the potential environmental impact of the HWTS. Furthermore, laboratory experiments are currently being conducted in order to select the most suitable filter materials for further field tests in 2019. Here we present a summary of the initial field and experimental results.

RS8 Wetlands, brackish and coastal ecosystems

RS8_P1_How decomposition of organic matter and invertebrate communities respond to agricultural wastewater in constructed wetlands?

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In areas where nature conservation is in conflict with intensive agriculture, the use of constructed wetlands appear as an alternative to reconcile the economic development and environmental protection. This is the case of the natural park of the Ebro Delta, where agriculture and conservation of biodiversity go hand by hand. Two free water surface artificial wetlands were constructed in 2010 with the purpose of treatment the rice field effluents. The objectives of this study are: (1) to analyze the response of the zooplankton and macroinvertebrate communities to agricultural wastewater, (2) to analyze the effects of agricultural wastewater on decomposition as an indicator of ecosystem functioning and (3) to compare these results with two natural wetlands (coastal lagoon and bay) and with an agroecosystem (rice field). We sampled the rice field and the wetlands (constructed and natural) three times, before the rice field inundation (April), during the rice field inundation at the time of the crop period (July) and at the moment that the rice fields are emptied for harvest (September). We took samples to characterize the water, the communities' composition and the decomposition of organic matter. In general decomposition process was faster in natural wetlands than in artificial ones. Macroinvertebrate richness was higher in April before the rice field cultivation in natural wetlands in comparison with artificial ones, but in July and September no significant differences were observed. Nevertheless, we expect to find some particular species in the constructed wetlands that will contribute to enhance the regional diversity.

RS8_P2_Ecosystem metabolism of Mediterranean coastal lagoons and their main input canals

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Water hydrology of non-confined coastal lagoons is affected by the quality of water supplied and the water turnover rate, but they can also have a high influence of sea water. These variations in salinity, and the amount and quality of the water entering through the canals, can produce relevant changes in nutrient dynamics and community structure of these water bodies. These fluctuations can influence at the same time the aquatic metabolism. Daily net ecosystem production (NEP) can be estimated as the balance between gross primary production (GPP) and ecosystem respiration (ER), both parameters measured through diel changes in dissolved oxygen concentration. We selected three coastal lagoons at Baix Ter wetlands (Girona, Spain) showing a gradient in salinity and different degree of water turnover. In each lagoon and its main canal, high frequency monitoring of oxygen and other environmental variables were obtained along several months, and GPP, ER and NEP were estimated for that period. The preliminary results showed important fluctuations in water levels and salinity in the lagoons, which resulted in relevant variations in ecosystem metabolism.

RS8_P3_Identifying physical and chemical drivers of daily ecosystem metabolism in confined coastal water bodies

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Coastal lagoons are among the most productive ecosystems in the planet. Monitoring of ecosystem metabolism is a useful way to evaluate the whole system functioning and condition. We quantified the ecosystem metabolism of two brackish ponds located in the restored salt marsh of La Pletera (coast of Girona, Spain) using three years of high frequency oxygen data. A clear seasonal pattern in the metabolic rates was observed. Gross Primary Production (GPP) was similar to Respiration (R) for most of the period studied with very few exceptions making difficult to classify these water bodies as autotrophic or heterotrophic systems [Net Ecosystem Production (NEP) ≈ 0]. An analysis of the potential drivers of metabolic variability showed several periods where GPP and R were unbalanced, being water circulation, aquifer influence, nutrient dynamics, sea storms and other atmospheric events the main drivers of the ecosystem functioning and metabolism of these confined coastal lagoons.

RS8_P4_Floating macrophyte mat as a playground for freshwater invertebrates

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One of the largest and most preserved floodplains of the Danube, Kopački Rit, has characteristic wetland habitats (lakes, channels, river side arms) that function as a highly significant subsystem of the floodplain complex. Such complexity supports very high biodiversity of aquatic organisms, influenced by the Danube's water-regime. In July 2013, after one of the extreme floods (starting in June), waters from the parent river, trapped within the Rit, enabled the development of atypically abundant, dense, floating macrophyte mats. Sampling was conducted (with a cylindrical core) on the 2nd, 4th, 8th and 12th of July – when the canopy dispersed, at three sites in Kopačko lake and Čonakut channel. Standard physico-chemical water parameters were measured *in situ*, and the laboratory analyses included isolation and identification of plant material and macroinvertebrates, and chlorophyll analysis. Plant material was dried at 105°C for 24h to assess the dry weight. Twenty-seven invertebrate taxa were recorded, of what 14 belonged to Insecta. In total, 7370904 ind./100g d.w. were sampled, most abundant being Cladocera, Copepoda and Chironomidae larvae. The floating plant canopy provided perfect refugium and food source for the invertebrates. NMDS analysis (invertebrate abundance, Bray-Curtis similarity matrix) displayed the grouping of sampling dates and the statistical significance was confirmed by ANOSIM analysis. There was no difference in-between the sites or water bodies. The most important environmental parameters influencing community structure were water temperature and the Danube water-level, which decreased, thus causing the outflow of waters from the floodplain and the dispersal of this interesting community.

RS9 Hydromorphology, hydrology, hydrogeology, hydrochemistry

RS9_P1_Analysis of long-term trends in water quality data of the Plitvice Lakes National Park

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Water quality management requires monitoring of natural waters condition by both biological and chemical indicators thus measuring the ecological health of a catchment. General water quality characteristics are extracted through low-frequency dataset, which allows analysis of long-term trends and seasonality. Plitvice Lakes National Park (PLNP) freshwater ecosystem includes springs, rivers, streams and lakes with its specific process of tufa formation. The aim of this study was to examine monitoring data of water quality parameters based on the performed long-term monitoring in the PLNP. This period referred to 2006 until 2017, from April – October per each year and for thirteen sites including karst springs, streams and lotic biotopes. Physico-chemical parameters were measured monthly according to standard methods. Cluster analysis grouped the sites into three types (springs, streams and lotic biotopes). Increased trends were observed for dissolved oxygen, conductivity, hardness, alkalinity, chemical oxygen demand (COD) and nitrites. Decreased trends were observed for temperature, pH and other nutrients (nitrates, ammonia and orthophosphates). Temperature values showed different trend slopes among types. Negative correlations between water level and/or discharge with conductivity and alkalinity probably indicate the effect of dilution. Conversely, nutrients and COD had positive correlation with discharge, possibly indicating resuspension from sediment during high flows. The analysis of spatial and temporal variations in hydrochemistry through longer period implied annual alterations, correlations between hydrological components and water chemistry and significant differences among monitored types. Long-term monitoring and continuous data analysis can help in future planning of monitoring program and better understanding of climate variations.

RS9_P2_Evidences of diffuse water and nitrate input via river-groundwater interactions in a regulated river: flood irrigation as main driver?

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In the Alpine sector of the Po River Plain, discharge of lake emissaries is regulated in order to satisfy large water demand by agriculture. In this study we analyzed how the alteration of the hydrological cycle in an irrigated basin (Mincio River, originating from the Lake Garda) locally affects groundwater recharge, river-groundwater interactions and macropollutants (nitrate) transfer from cultivated land to groundwater. To this purpose we adopted an integrated, GIS-based approach, including the analysis of N soil system budget, surface and groundwater hydrology, pedology, conservative and non-conservative solutes and water budgets. During summer, the steep increase of nitrates concentrations in upstream reaches of the Mincio river supports the hypothesis of ground-water to river nitrate exchange. The underlying mechanisms seem driven by the irrigation loop: flooding permeable soils causes percolation of nitrate-rich waters, which feed shallow groundwater and supply the riverbed. Results of this study should be carefully considered if political actions will target nitrate reduction in surface and groundwater and in the context of climate-change alterations of the hydrological cycle.

RS10 Interspecies interactions

RS10_P1_Physiological responses of aquatic invertebrates to acute and chronic predation risk

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Prey species develop inducible or constitutive defences depending on stability of predation risk. Knowledge of the physiological costs of these strategies is limited. We tested the physiological responses of amphipods: *Dikerogammarus villosus* and *Gammarus jazdzewskii* to predation risk. Invasive *D. villosus* exhibits more efficient constitutive defences: harder exoskeleton, generally lower activity and stronger adhesion. We hypothesized that more efficient constitutive defences would be associated with lower physiological costs of defence reactions. We measured respiration (related to metabolic rate), cellular defence systems: antioxidant enzyme (catalase) activity and heat shock protein (Hsp70) concentration, as well as the level of oxidative damage (thiobarbituric acid reactive substances, TBARS) in both species exposed to acute (35 min.) or chronic (1 or 7 days) predation risk (the Eurasian perch). Short exposure to danger increased respiration in both species, but only *G. jazdzewskii* increased its catalase activity and Hsp70 concentration and exhibited higher level of oxidative damage (TBARS). Compared to the control treatment, chronic exposure to predation risk increased respiration in both species but did not affect any other measured parameters. The species exhibiting more efficient constitutive defences bore lower costs of the initial anti-predator response (no increase in antioxidant systems and yet no oxidative damage). Despite the increased oxygen consumption under chronic predation risk, the native species reduced its other physiological responses after a longer exposure, avoiding negative effects of the prolonged increased metabolic rate and costs of cellular protection. Our study was supported by a grant of the National Science Centre, Poland 2016/21/B/ NZ8/00418.

RS10_P2_Diversity and temporal shifts of the bacterial community associated with an *Anabaena macrospora* bloom

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During the last decades, the number of lacustrine cyanobacterial blooms has increased to alarming proportions. It is now well reported that cyanobacteria, especially *Microcystis*, can directly impact its associated bacterial community; in turn, the attached bacteria can sustain or impair cyanobacterial growth. However, not all cyanobacteria produce mucilage, which allow the integration and interaction of bacteria with cyanobacterial cells. The bacterial community composition (BCC) of blooms of *Anabaena* sp., a filamentous cyanobacteria that doesn't produce mucilage, has not yet been investigated, and its temporal dynamic is yet unknown. In this study, the BCC associated with *Anabaena macrospora* was followed over the duration of the bloom in eutrophic lake (Aydat, France), to link potential composition changes over time to its evolution. Using Illumina Miseq sequencing of 16s RNA has been used to identify potential actors of the bloom degradation to help shed a new light on cyanobacterial proliferations and better understanding of bloom mechanics. A bacterial temporal successions has been observed in the cyanosphere's BCC. A number of specific OTUs (order level) have been identified, either as "bloom specialists" (Sphingobacteriales), or linked to specific conditions in the *A. macrospora* cyanosphere (Clostridiales), for example. Some other identified orders are known to either enhance or inhibit cyanobacterial growth, and their succession over time was found to be correlated to different steps in the bloom's development. These findings could hold an importance regarding the understanding of how cyanobacterial blooms settle, develop, and later decay, and the potential role of the BCC in these processes.

RS10_P3_The potential of fish vs. waterfowl interaction in management of eutrophic water bodies

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Interactions between phylogenetically distant taxa can be significant in lake ecosystems. We found that changes in fish stocks were one reason for the recent severe declines of breeding waterfowl in eutrophic Finnish lakes and Natura 2000 sites. The mean biomass of breeding waterfowl was >10 kg ha-1 in fishless and eutrophic man-made habitats, 2.1 kg ha-1 in lakes with a balanced fish stock and 0.6 kg ha-1 in lakes with few piscivores and a high density of cyprinids (roach *Rutilus rutilus* and/or bream *Abramis brama*). Especially benthivorous bird species with a high conservation value, e.g. tufted duck *Aythya fuligula*, pochard *Aythya ferina*, and slavonian grebe *Podiceps auritus*, were depressed by cyprinids while they were abundant in fishless water bodies. Waterfowl biomass and ratios of herbivorous, benthivorous and piscivorous species can be compared with limnological and fish parameters used in ecological classification of European waters. It makes them “quick and clean” indicators of the ecological or conservation status of lakes and their management need. Biomanipulation and prevention of fish colonization should be recognized in management of waterfowl habitats and other water bodies to improve or safeguard their biodiversity and/or ecological status. Eutrophic lakes with algal blooms were characterized by dominance of piscivorous birds. Biomanipulation by fish removal and collapse of cyprinids in winterkill can improve water quality, lead to increase of benthivorous waterfowl and decline of piscivores, i.e. improve both the ecological status and conservation value of water bodies.

RS11 Invasive species

RS11_P1_Effects of habitat modification and invasive species on macroinvertebrate assemblages in the section of the Drava River between two reservoirs

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Macroinvertebrates assemblages in Croatian section of the Drava River have been drastically changed by habitat modification for the purpose of hydropower plants (construction of reservoirs and artificial channels) as well as alien invasive species. In this study we investigated macroinvertebrate assemblages structure at the upstream distribution front of the alien invasive amphipod *Dikerogammarus villosus* in the Drava: differences between the derivation channel and the old river course of the Drava between the Ormož and the Čakovec reservoirs were examined. Benthos samples were collected on different types of microhabitats (macrophytes, stony substrate) with hand net (25×25 cm, mesh size 500 µm) in summer of 2018 at five locations in the derivation channel and seven locations in the old course of the Drava. Non-metric multidimensional scaling analysis revealed a complete separation of sites in the derivation channel and the old course. The average number of taxa were significantly higher in the old course (20.1) than in the derivation channel (11.6), while Oligochaeta, Ephemeroptera, Coleoptera and Trichoptera had significantly higher densities in the old course. Invasive species *Dreissena polymorpha* had much higher densities in the derivation channel, while *D. villosus* in low abundance inhabited only sites close to the downstream reservoir Čakovec. Observed differences between the old course and the derivation channel, as well as between microhabitats (macrophytes and gravel) in the derivation channel, were due to a higher level of hydrological disturbance in the derivation channel which is exposed to hydropeaking, while almost constant low flow is present in the old course.

RS11_P2_Taxonomical and functional diversity patterns of native and exotic fish species

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Exotic species are a major threat to biodiversity and have modified native communities worldwide. Although the invasion processes have been extensively studied, studies focusing on diversity patterns of native and exotic species are rare. In this study, we focused on freshwater fish communities due to the high sensitivity of exotic invasions. We hypothesized that native and exotic fish communities showed different diversity patterns (both taxonomic and functional) and that diversity patterns are driven by different environmental drivers. We also investigated the relationship between functional diversity and species richness. Results showed that exotic species were more located at low altitude and peaked in the canal networks, whereas native species peaked at the higher altitude. Diversity patterns were strongly related to different environmental features, such as the stream order, total suspended solids and total phosphorus. A positive relationship was found between functional diversity and species richness, for both native and exotic species suggesting an effect of redundancy in communities. These results can help to identify biodiversity drivers in exotic and native fish communities, which in turn could be useful to improve management and conservation actions.

RS11_P3_Delayed parasite occurrence in a persistent fish invader – prevalence of *Ligula pavlovskii* in monkey gobies (*Neogobius fluviatilis*) in Lake Balaton

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According to the “enemy release hypothesis”, invasive species might lose some of their parasites during their invasion. Monkey goby appeared in Lake Balaton at the end of 1960’s and dispersed quickly along the shoreline of the lake. Despite the geographic continuity of monkey goby populations from the Ponto-Caspian region to the lake, first record of its native parasite *L. pavlovskii* in the lake is only from 2004. This delayed co-occurrence may be explained with its limited time in the final host that is responsible for its large-scale spread. In this study, we revealed the prevalence of *L. pavlovskii* in 17 monkey goby populations along the entire shoreline of Lake Balaton. Our results suggests that *L. pavlovskii* is persistent in Lake Balaton; prevalence of plerocercoids at the sampling sites ranged between 7.4-84.4%, and it was significantly higher along the northern shore of the lake. The spatial pattern of the parasite prevalence may be explained by the lack of suitable breeding habitat of the final host great-crested grebe (*Podiceps cristatus*), and the reduced abundance of the first intermediate host copepods on the southern part of the lake. Our results may suggest *that L. pavlovskii* follows monkey goby invasions, given that the invaded area is suitable for all the hosts. This study was supported by the GINOP-2.3.2.-15-2016-00004 project.

RS11_P4_Long-term fish monitoring underlines a rising tide of temperature tolerant, rheophilic, benthivore and generalist exotics, irrespective of hydrological conditions

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The invasion of exotic species is one of the main threats to worldwide biodiversity and can be aided by changes in environmental conditions. We hypothesized that a temporal trend of decreasing discharge and increasing temperature might have favoured the invasion of warm-adapted, lentic exotic fish species in the lower Po River, northern Italy. We used presence/absence data over a long-term period (over 20 years) to investigate the dynamics of exotic fish invasion along water temperature and discharge gradients. Mean annual discharge and temperature did not show a clear trend and did not affect exotic fish species invasion, which progressed with time irrespective of these factors. The total number of species fluctuated without a clear trend, which underlined a progressive substitution of native species with exotic ones. Perhaps surprisingly, the community composition changed over time towards more temperature tolerant but also rheophilic, benthivore and generalist fish species. These results highlight how species interactions could be one of the main factors driving the invasion. Furthermore, our data underlines a continuously rising tide of exotics, which questions the success of past control strategies. Considering the current conservation resources limitations, priority should be given to the development of prevention strategies in order to avoid new species introductions.

RS13 Lakes, reservoirs and ponds

RS13_P1_Effects of past land use on biogeochemical functioning of shallow lakes at the multi-decadal scale: example from Landes lakes (SW France)

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Lakes Cazaux-Sanguinet (CS) and Parentis-Biscarrosse (PB) are two shallow lakes (maximal water depth of 23 and 20 m respectively) located in the southwestern part of France. They are characterized by identical bottom morphology, surface area, catchment geology, and meteorological forcings. However, Lake PB is eutrophic whereas Lake CS is oligotrophic. This difference is attributed to industrial phosphorus loads in the main tributary of the PB lake. Despite a huge reduction of phosphorus emissions in the river since the nineties, Lake PB is still very eutrophic, with substantial hydrophytes biomass and recurrent cyanobacteria blooms. A monthly monitoring was performed in 2016 on lake, river, and rain waters, and lake sediments for both lakes. Additional, continuous in situ measurements of temperature and oxygen content were performed during summer. Results revealed that both lakes were affected by a summer thermal stratification of the water column. However, the biogeochemical gradients between surface waters and bottom waters were much more pronounced in PB, where bottom waters reached anoxia during several weeks. This anoxia in PB generated high benthic fluxes of reduced compounds (NH^{4+}, DIP, dissolved iron and manganese), probably supported by the mineralization of large amounts of labile organic matter. This revealed that despite an efficient management of watersheds, legacy P and organic matter in sediment affects the lake waters quality on a multi-decadal scale.

RS13_P2_Interacting effects of thermal and nutrient pollution on ecological processes at hydroelectric reservoir Moste (the Sava River, Slovenia)

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The stability of ecosystem functioning requires ecological resilience, which is the capacity of population, community or ecosystem to buffer environmental perturbations without loss of structure or functioning. When the anthropogenic pressures exceed the level that the ecosystem can still regulate, the imbalance in the processes is frequently observed as algal bloom. Due to occasional appearing of algal blooms in the reservoir of the hydro-power plant Moste on the Sava River (NW Slovenia) in recent years, the spatial and temporal dynamics of the crucial environmental factors were studied to identify the environmental drivers that had significant impact on the ecological functioning of the reservoir. According to the EU Water Framework Directive, the reservoir was categorized as a heavily modified water body with poor to bad potential in the period 2009-2015, mainly due to hydro-morphological status being determined as very bad. In addition, nitrate concentrations and total phosphorous indicated very good ecological potential between 2009 and 2015. To assess the impact of human pressures on the environmental conditions and processes in the reservoir, physico-chemical and biological indicators were measured in water and sediments of the reservoir and its main inflows (discharge from the waste-water treatment plant, discharge of industrial waste water from the steel factory, the streams draining the surrounding agricultural areas) in 2017. Our results suggest that the processes in the reservoir are driven by the temperature regime, the concentration of nutrients and water flow, which are all substantially modified by hydropower plant operation and human activities in the catchment.

RS13_P3_Aerobic respiration and production in a Mediterranean stratified reservoir

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Monomictic reservoirs and lakes undergo to a thermally stratified period during the year. Summer-autumn stratification in monomictic reservoirs isolates bottom waters (hypolimnion) from upper layers (epilimnion) and surface. During this period, hypolimnion would become anoxic and restrict aerobic processes, therefore, changing ecosystem metabolic paths and rates and altering carbon fluxes. Hydrological and temperature changes associated to global warming are expected to alter the extent and volume of the anoxic hypolimnetic layer. To understand how aerobic or anaerobic metabolic processes change throughout the stratified period is needed to evaluate how future hydrological changes affect the carbon balance in these ecosystems. In this study, we measured aerobic primary production (GPP) and community respiration (ER) rates during the stratified period in the whole water column of a warm monomictic reservoir located in South Spain. High-frequency data recorded from a moored automatic monitoring station were used to estimate aerobic respiration and primary production through the 'diel oxygen technique'. The monitoring platform was fitted with a meteorological station and a set of limnological probes performing vertical profiles (1 m depth resolution) of many physico-chemical variables (i.e. water temperature, PAR radiation, dissolved oxygen concentration, conductivity and chlorophyll a concentration) on a 4 hours frequency. Results demonstrated a net autotrophic epilimnion, with GPP and ER mean rates of 47.3 (±18.3) and 10.9 (±13.8) mmol O_2 m^{-3} day^{-1}, respectively. However, metalimnion depicted balanced ER and GPP rates, 15.4 (±20.6) and 16.9 (±19.2) mmol O_2 m^{-3} day^{-1}, respectively, with net ecosystem production (NEP=GPP-ER) close to 0. A negative relationship between epilimnetic ER and hypolimnetic ER suggests an increase of organic matter respiration in the reservoir upper layers throughout the stratification period.

RS13_P4_Vertical distribution of rotifers in three deep Mediterranean lakes

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We studied rotifer assemblage in three deep, monomictic, karstic Mediterranean lakes of Croatia, differing in their hydrogeology: Lake Vrana (Cres Island) is a deep (74,5 m) cryptodepression; Lake Crniševo is deepest (31 m) of six interconnected karstic cryptodepressions (Baćinska Lakes); Lake Visovac (30 m) is a karstic barrage lake, a lentic dilatation of the Krka River. We investigated the impact of main physico-chemical parameters on vertical and temporal rotifer distribution. Altogether 58 rotifer taxa were identified. Dominant and constant species were *Kellicottia longispina* in Vrana and *Synchaeta tremula/oblonga* group in Crniševo and Visovac. According to CCA analysis, temperature was the most important factor influencing rotifer assemblage in all lakes. Rotifer density was higher in epilimnion (Visovac, Crniševo) and metalimnion (Vrana) in comparison to hypolimnion, where rotifer density declined. In Lake Vrana, rotifer density was generally low, and in other two lakes it was conspicuously decreased. This was likely influenced by two environmental gradients: in hypolimnion of Lake Visovac hypoxia occurred, while high values of conductivity in hypolimnion of Lake Crniševo indicated mixing with nearby sea. These unfavourable extreme conditions were also reflected in temporal dynamics of rotifers. Hypoxia and increased conductivity were recorded in early summer, when also a sudden drop in rotifer density was observed. Present data confirm that rotifer assemblage is a very dynamic component of freshwater food webs. Rotifers react rapidly to environmental gradients, which makes them good model-organisms for monitoring ecological status of deep lakes.

RS13_P5_Stratification effects on the physical-chemical water quality of Abegondo – Cecebre reservoir

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The Abegondo – Cecebre reservoir (V= 20 Hm^3; Depth max = 17.78 m; Area= 335 ha) is a GLEON Site located in the NW of Spain. It collects water from Mero and Barcés rivers, being the only source of drinking water for the city of A Coruña and its metropolitan area (≈ 400,000 inhabitants). Is an eutrophic system in which algal blooms of toxic cyanobacteria have occurred during water stress periods. The reservoir dam is equipped with an YSI-Profiler monitoring system with an attached YSI-EXO water quality probe that provides continuous measurements of physical-chemical parameters along the entire water column (Tª, O_2, pH, E.C.25, ORP…). The data obtained during 2018 showed that is a monomictic system where the stratification period begins in April while the annual overturn takes place during November. The continuous monitoring allowed the detection of a nearly complete hypolimnetic oxygen depletion (i.e. anoxia) spanning from the beginning of June to mid-end October. During this anoxic period we detected an internal loading from the sediments showing a net release of Fe, Mn and As and also a change in REDOX conditions, that caused some species (i.e. sulfide) to appear close to the surface.

RS14 Large rivers

RS14_P1_Niche position and niche breadth of phytoplankton functional groups in fluvial ecosystems

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Although the niche concept contributed considerably to the understanding of diversity and functioning of ecosystems in the last decades, the numerical characterisation of species' positions in the niche space, especially in aquatic ecosystems remained largely uncovered. In this study using a large river phytoplankton dataset, we typified river phytoplankton assemblages based on the phytoplankton functional group concept (FGs) sensu Reynolds. Using the Outlying Main Index approach (OMI),we characterized the niche position and niche breadth in the niche space for each FG, defined by relevant environmental variables. We hypothesised that FGs with central niche position have wide, while those with marginal ones have narrow niche breadths. The realized niche space has been defined primarily by the trophic status related (nutrients, biomass) and the size of the rivers (residence time, discharge) considered. Our hypothesis that FGs with central niche position have wide, while marginal ones have narrow niche breadths has not been corroborated by the results. Centric diatoms, which are primary elements of productive riverine phytoplankton assemblages, had an intermediate and marginal niche position with wide niche breadths. On the other hand, a narrow niche breadth was characteristic for FGs that are rare, dispersed, non-productive secondary elements of river phytoplankton. We did not find a significant characteristic relationship between niche position and niche breadth suggesting that the mechanisms underlying the occurrence of FGs in can only be indicated by using the two niche characteristics simultaneously.

RS15 Invertebrates

RS15_P1_Freshwater macroinvertebrate barcoding in Cyprus: First steps and new records

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Although a monitoring program is currently running and thousands of previous biodiversity records are available, our knowledge about the aquatic macroinvertebrate fauna of Cyprus is still limited and highly unbalanced among invertebrate groups. DNA-based methods have open up new perspectives in taxonomy, ecology and environmental quality assessment, but there was practically no barcoding activity for aquatic invertebrates in Cyprus, so far. The outmost goal of this project is the revision of the freshwater macroinvertebrate fauna of Cyprus using traditional and novel methods, add new records, validate species occurrences by DNA records, explore unknown or hidden species and provide powerful basis for DNA-based water quality assessment in the country. We preliminary report here about the basic step: building a DNA barcode reference library. Specific qualitative samplings were conducted in February 2019 at 28 sites, including mainly lentic but also lotic waterbodies. Further 21 quantitative samples were selected from the 2018 stream monitoring. Processing of Crustacea, Mollusca, Odonata, Heteroptera, Coleoptera, Trichoptera groups from samples yielded 2762 individuals which belong to 102 species based on morphological identification. Oligochaeta, Ephemeroptera, Plecoptera, Diptera parts of the samples are still being processed. The occurrence of six species (2 Coleoptera, 2 Heteroptera and 2 Trichoptera) are reported here for the first time from Cyprus. Three individuals from all detected species were selected for DNA barcoding. Triplicates are currently undergoing DNA barcoding, sequences will be added to the BOLD Systems database as public records, forming a Cyprus Aquatic Macroinvertebrate Barcode Reference Library. Project was supported by DNAqua-NET CA15219 STSM43482.

RS15_P2_Mated or virgin female: a new sexual object is of male interest

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In sexual selection, individuals attempt to increase the chances of successful reproduction and hence spread own genetic material. Mate choice have therefore both, qualitative (to choose the best males) and quantitative (to mate with more partners) consequences. Crustaceans show a large variation of sexual rituals and specific mate requirements connected with social interactions and recognition of conspecifics, which may lead to success in offspring recruitment. Crayfish males are usually reported as not choosy as much as females, being interested mainly on quantity of females mated. Previous literature showed that males are able to recognize if females were previously mated but the study did not enable experimental animals to physically interact or even to mate. In presented study, we analysed male mate selection in spiny-cheek crayfish (*Faxonius limosus*) to investigate male's choice between previously mated and virgin female in set-up enabling free interaction between individuals. Experimental males (choosers) showed a higher interest in unmated females expressed by significantly higher number of pre-copulatory interactions and total number of mating events. Males then can spare some energy resources omitting one mated females to have higher chance in unmated females. Our crayfish mate choice study opens up a number of avenues in sexual selection research in invertebrates.

RS15_P3_Risks and side effects: Structural and functional responses of aquatic macroinvertebrate communities to restoration mediated alterations in a small lowland stream

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If a restoration treatment on a soda pan is worth the effort depends greatly on the overall value of success, and also on the unwanted symptoms on non-target biota and habitats caused by original and planned treatment, what we defined as side effects. Our goal was to provide evidence on the changes in macroinvertebrate communities for detecting the side effects on supply streams in case of a soda-pan related restoration case study. We investigated if taxonomical composition, functional diversity and biological quality differed among the treated and control site after the restoration treatment. During the analysis, the following diversity indices were calculated: Shannon Index, Evenness, Dominance, Functional Diversity and Functional Evenness. To test the change in functional traits over time two-way ANOVA was calculated. The restoration treatment caused profound changes in macroinvertebrate assemblages, manifested as the withdrawal of several previously occurring species and the formation of a new taxonomical structure that clearly distinct from the composition prior to the treatment and the control sites. Ecological quality ratios based on macroinvertebrates are significantly decreased after the treatment, as a result of this, the quality status decreased to moderate category. In the control section, the EQR is alternate a little bit, but the quality assessment is constantly good. The recolonization processes were dynamic, after a year the temporary depletion of fauna and reduction in taxonomical diversity indices have been counterbalanced. A lower change in trait-based metrics was observed; thus, despite the taxonomical changes, stream ecosystem has been preserved its functional stability.

RS15_P4_DNA knowledge gaps in reference databases about European freshwater macroinvertebrates

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Monitoring freshwater ecosystems has been central to environmental policies across the world. Biological indexes based on macroinvertebrates are widely used to assess the ecological status of inland waters. Traditional methods consist of obtaining samples and identifying macroinvertebrates to family level using morphological characters. However, the accuracy of the identification can depend on the taxonomic expertise of the researcher or the life stage of specimens. Over recent years, researchers are embracing molecular ecology as a powerful ally in biomonitoring. This methodology allows identifying specimens by comparing standardized genetic markers to DNA reference databases. Thus, molecular ecology offers several advantages over traditional methods. However, the usefulness of this tool depends on many factors as well, being the taxonomic coverage of the DNA reference databases one of these limitations. We aimed to assess the completeness of such databases about European macroinvertebrates. We compared the taxonomic coverage at species level of the most widely used DNA reference databases to the European macroinvertebrates checklist. We revised more than 14 million of DNA records from BOLD and NCBI databases belonging to 284 number of families from macroinvertebrates checklist. We believe that sequencing efforts should be placed in completing these information gaps to further enhance the use of molecular ecology in biomonitoring. We propose to orient these efforts attending to different criteria.

RS15_P5_Effects of fine woody debris on macroinvertebrate communities in littoral zones of undeveloped lakes

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Woody debris has been recognized as an important habitat for macroinvertebrate communities, providing suitable sites for attachment and feeding, and promoting biodiversity in littoral zones. However, previous research has mainly focused on coarse wood (≥ 10 cm diameter), while lake littoral zones are often dominated by smaller wood pieces. Less is also known about communities inhabiting wood in near-pristine conditions. Therefore, the aim of our study was to test the effects of fine woody debris (FWD) (Ø 1-5 cm; length up to 1 m) on macroinvertebrates in undeveloped lakes (Drawieński National Park, Poland) that are not subjected to intentional wood removal. Although freshly fallen branches were abundant, we found a high proportion of highly decayed wood (they constituted 34% and 46% of total FWD surface, respectively). The decay state of FWD significantly influenced the composition, abundance and species richness of macroinvertebrates. The highest densities and most diverse macroinvertebrate communities were found on wood with loose bark (5695 ind. m^{-2} and 31 taxa), offering numerous shelters, while undecayed wood supported relatively species-poor communities (2252 ind. m^{-2} and 20 taxa). With advancing wood decay, the contribution of collector-gatherers, shredders and burrowers that could benefit from organic matter from decomposed wooden tissue increased, as well as predators attracted by numerous potential prey. An IndVal analysis identified several taxa specifically associated with decayed wood. Our results demonstrate that decomposed FWD enhances the densities and diversity of macroinvertebrate communities and can provide valuable habitat in littoral zones, particularly in lakes with sparse macrophyte cover.

RS15_P6_Microcalorimetry: a powerful tool to investigate stoichiometric constraints on small ectotherms

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Environmental conditions constrain populations and ecosystem dynamics through their direct effect on individual metabolism. However, besides temperature, individual metabolic responses to environmental factors remain unclear. As an example, if dietary stoichiometric constraints are well known to reduce individual growth rate, their direct consequences on metabolic rate still require clarifications. It is commonly assumed that dietary stoichiometric constraint increases metabolic rate of small ectotherms but experimental support remains scarce. Using a microcalorimetric approach, we determined the standard metabolic rate (SMR) of *Daphnia magna*, fed with a stoichiometric balanced diet (C/P: 160) versus imbalanced diet (C/P: 1440). Regardless of dietary treatment, daphnids presented the same somatic C/P ratio demonstrating their strict homeostatic regulation. However, daphnids fed imbalanced significantly increased their SMR while reducing their growth rate. This result suggests that homeostatic regulation costs increases with increasing mismatch between consumers and resources. To meet these higher energetic demands, individuals reallocate energy from growth to maintenance, resulting in the reduced growth rate observed. Beyond this theoretical framework we showed that microcalorimetry is a powerful tool for monitoring small-sized organisms' metabolic rate. This method opens promising perspectives to understand the consequences of various environmental factors on organismal metabolism.

RS15_P7_Does the supplemental feed type used for carp nutrition influence on mentum deformities in *Chironomus plumosus* larvae?

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Supplemental feeding of carps reared in semi-intensive production system can cause changes in water quality which initiates changes in fish biocenosis, affecting other living organisms. We monitored the influence of different supplemental feed types used for carp fry on mentum deformities in *Chironomus plumosus* larvae, and the influence of carp as a predator on this phenomenon. The study was conducted in carp ponds at the Centre for Fishery and Applied Hydrobiology "Little Danube" (CEFAH), Experimental Station Radmilovac, Faculty of Agriculture, University of Belgrade, through four different treatments (A-D) lasting three months. Two commercial feed types (arranged in four treatments) were used for carp nutrition: Soprofish 25/7 and Omega 3-32/7*.* *Chironomus plumosus* larvae were collected prior to the experiment (control), in the middle of the experiment and at the end of the experiment. According to analysis of mentum deformities, the percentage of deformities was the same in the middle and at the end of the experiment in treatment A (10 %), while in treatment B and C the percentage of deformities decreased at the end of the experiment. Considering treatment D, where the fish were fed with Omega 3-3/27 feed during the entire period, the percentage of deformities decreased to the end of the experiment (6.6 %). In carp ponds where the fish were fed with Omega 3-32/7 feed, lowest percentage of mentum deformities in chironomids larvae indicate that carp consumed natural feed to a lesser extent. Actually, the most of their nutritional need they met with high quality supplemental feed.

RS15_P8_Effects of temperature and species on the duration of post-mating spermatophore storage of the freshwater crayfish

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After mating, the spermatophores are stored on the ventral side of the body until the beginning of egg laying in female crayfish in Astacidea. The objective of the present study was to investigate the duration of post-mating spermatophore storage as well as the timing and temperature of spawning in the signal crayfish *Pacifastacus leniusculus* and the noble crayfish *Astacus astacus*. The average duration of the spermatophore storage was significantly longer in the noble crayfish than the signal crayfish. The highest proportion of the post-mating spermatophore storage duration in the signal crayfish and the noble crayfish were 1, and 31 to 40 days, respectively. While there is an overlap in the timings of mating and egg laying in the signal crayfish, such overlap was not observed in the noble crayfish and there was at least 2 weeks gap between last mating and first egg laying individuals. Average mating and egg laying temperatures were significantly higher in the signal crayfish compared to the noble crayfish. The average temperatures for mating in both species were significantly higher than the temperatures for egg laying. In conclusion, female noble crayfish store post-mating spermatophores a longer duration compared to the signal crayfish. Also, the signal crayfish mate and spawn in temperatures that are higher than the noble crayfish. Spawning season is shorter in the signal crayfish compared to the noble crayfish.

RS15_P9_Quantifying the biotic and abiotic controls on river bank burrowing by invasive signal crayfish (*Pacifastacus leniusculus*)

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The introduction of invasive crayfish to Europe has had significant deleterious geomorphic consequences via their burrowing and foraging activities. The signal crayfish (*Pacifastacus leniusculus*) is not known to burrow in its native range in North America, although burrowing is common in invaded rivers in the UK. This causes extensive damage to river banks and increases fine sediment recruitment to rivers, as a direct result of transferring burrowed sediment into the channel and by promoting mass failure. Quantifying the volume of sediment that signal crayfish contribute to river systems is increasingly important for understanding and managing fine sediment dynamics in invaded catchments. However, we do not know what biotic and abiotic factors control the propensity to burrow. In order to understand the drivers of this rapid change in behaviour, and to quantify the volume of fine sediment that signal crayfish are responsible for recruiting to river systems, crayfish burrow densities, geomorphological, hydrological, and biological parameters were surveyed at 40 invaded rivers throughout the UK. Crayfish burrows were responsible for directly recruiting at least 4,865 kg of bank sediment per kilometre of river, with crayfish population density, sediment grain size, and flow velocity all being significantly associated with crayfish burrowing. These results demonstrate that animals have a significant impact on the geomorphic functioning of river systems, and understanding what drives crayfish burrowing will guide the development of models of how the range expansion of crayfish will affect future sediment recruitment, sediment dynamics and river channel change.

RS15_P10_Detection of *Cordulegaster* (Insecta: Odonata) species via eDNA

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The aim of this study was to investigate the potential of eDNA techniques to detect the presence of the two dragonfly species *Cordulegaster heros* and *Cordulegaster bidentata* in Hungarian freshwaters. Both species are classified as "near threatened" according to IUCN Red List and are strictly protected in Hungary. Monitoring these species with traditional sampling methods is often difficult, time-consuming and invasive. In this pilot study, we first collected tissue samples from *C. heros* and *C. bidentata* to sequence the traditional DNA-barcode gene fragment COI. We then collected further dragonfly COI sequences from BOLD to design species-specific primers. This, however, was impossible given the enormous variability of COI. Therefore, we refrained from species-specific eDNA assays and followed a eDNA metabarcoding protocol using universal (BF2/BF2) as well as a more dragonfly specific primer that does not target many of the abundant diatom species. For the evaluation of the method, we took water samples from places where *Cordulegaster* specimens is known to occur. After the extraction of DNA, we used two sequential PCR steps for obtaining the desired amplicon (two-step PCR) using universal primers in the first step, and group (dragonfly) specific primers or universal primers. Amplicons were sequenced on an Illumina MiSeq platform and then analysed the data with the JAMP pipeline. On the poster we will show the results and discuss advantages and disadvantages of the eDNA-based approaches.

RS16 Macrophytes

RS16_P1_Carbon deposition in *Chara*-lakes

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Both charophytes and phytoplankton store carbon in their biomass and as $CaCO_3$ encrustations on their cell walls. Thus, micro- and macroalgae provide organic (OC) and inorganic (IC) carbon to lake sediments. We aimed to investigate phytoplankton and charophyte contribution to C deposition in the littoral sediments of two Polish shallow mesotrophic and hardwater lakes: Lake Jasne in mid-western Poland and in Lake Majcz Mały in northeastern Poland. Water, phytoplankton and macrophytes were sampled in July and November 2017, and in April and July 2018, from three littoral sites in each lake. Sediment cores were taken once in October 2017 at the same sites and suspended solids (SS) were trapped three times in the study period (November–April, April–July, July–November). Lake Jasne had lower nutrient concentrations (Ca^{2+}, N-NO^{3-}, TN, TP), chlorophyll-a, phytoplankton biomass and higher alkalinity than Lake Majcz Mały. Dry weight of SS was correlated with phytoplankton biomass and OC accounted for 90% of its total carbon. Mean charophyte summer biomass in Lake Jasne was 2144.2 g DW m^{-2} and 350.1 g DW m^{-2} in Lake Majcz Mały and more than 60% and 21% of this summer biomass overwintered in the respective lakes. Concentrations of IC in charophytes did not differ seasonally and accounted for 15–29% of total carbon. Concentrations of OC and IC in a 6-cm-superficial layer of sediment indicated charophytes are a main source of carbon in littoral zones of *Chara*-lakes.

RS16_P2_Effect of invasive hydrophytes on lake benthic biogeochemistry

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Invasive aquatic plants can form dense mats, which may cover large surface areas of shallow lakes. This may change the nature of settling sediment and have an impact on benthic biogeochemical processes and fluxes. The objective of our study was to compare benthic reactions in vegetated and bare sediments in two shallow lakes of south-western France (Lacanau and Parentis-Biscarrosse), where more than 10% of the surface area is colonized by dense mats of exotic *Egeria densa* and *Lagarosiphon major*. For that, we seasonally collected sediment cores where we measured vertical profiles of C, N, P, Fe, Mn, S, and Hg compounds below the sediment–water interface. In the absence of plants, sediment consisted of organic-poor sands at shallower areas (0-5 m deep), whereas fluffy organic muds accumulated in deeper zones. In vegetated areas, dense mats of plants trapped several cm of organic muds above the sand. These muds had similar composition as those collected in deep areas, with additional macrophyte debris. Vertical profiles of nitrate and sulphate showed that all sediments were rapidly anoxic below the sediment surface. Muds trapped phosphorus as Fe-bound-P, even under anoxic conditions. Muds in vegetated areas were more reactive than deep muds, which were in turn more reactive than bare sands, as attested by calculated diffusive fluxes of dissolved ammonium, iron and methane. Invasive macrophyte dense mats may increase benthic nutrient recycling mostly because they promote fresh labile organic matter build-up at the sediment surface.

RS16_P3_Phytosociological analysis of the aquatic macrophyte vegetation of the main Greek freshwater lakes

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After the adoption of Water Framework Directive by European Union member states, the assessment of the aquatic macrophyte communities was set as a key element for assessing the status of their freshwater ecosystems. Phytosociological research of macrophyte communities in Greece has generally been fragmented and there are still many important gaps in the knowledge regarding which communities-associations exist where. Through the operations of Greek National Water Monitoring Network during 2013-2016, a total of 5690 phytosociological relevés were sampled in aquatic macrophyte vegetation in 18 important freshwater lacustrine ecosystems in Greece. Ninety-nine taxa belonging to 30 different families were recorded. The relevés were subjected to a number of hierarchical cluster and indicator species analyses in order to define plant communities and associations on an objective basis. Forty-six vegetation types were identified and interpreted, which correspond to 33 associations, 3 distinct communities, 6 transitional communities and 4 mixed communities being described by their ecological characteristics, diagnostic taxa and syntaxonomical status. One of the distinct communities and 11 of the associations, the majority belonging to the Charetea Class, are considered to be new records for Greece. The distribution of all the vegetation types recorded in the 18 Greek freshwater lakes was found to be highly affected by the ecological status of the lakes due to eutrophication pressure. Therefore, information about the presence/absence and the structure of syntaxonomic units of aquatic macrophyte vegetation in freshwater lakes could be also utilized in eutrophication indices for the assessment of their ecological status.

RS16_P4_Growth rate inhibition and recovery potential of *Lemna minor* after pulsed isoproturon exposures

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In aquatic ecosystems, concentrations of pesticides can increase remarkably during spray drift, surface runoff events and precipitations, resulting in repeated pulses and fluctuating pesticide concentrations. Following such exposures, non-target aquatic organisms may recover. Nonetheless, the effects of repeated pulsed exposures are not adequately covered by the standardized laboratory toxicity tests, since these aim at maintaining continuous exposure regimes, as well as constant concentrations of the xenobiotic, and commonly do not investigate the toxicity of pulsed exposures. Therefore, the objective of the present study was to investigate the effects of isoproturon on the growth rate, as well as the recovery potential of aquatic macrophyte *Lemna minor* over a 14-day period after 72 h of pulse treatment. Isoproturon belongs to the class of phenylurea herbicides, and it is extensively used in conventional agriculture for the control of pre-emergent and early post-emergent grass and dicot weeds in several different crops. Common duckweed plants were treated with 0.05, 0.1, 0.15 and 0.2 mg L^{-1} of herbicide in nutrient solution. In both 72 h pulse treatments with 0.05 mg L^{-1} of isoproturon, a slight recovery was reached within 14 days. However, recovery of plants treated with 0.1, 0.15 and 0.2 mg L^{-1} of herbicide was not achieved during the experiment. The results from this study imply that recovery is possible for non-target aquatic macrophytes. It is crucial to simulate these types of experimental scenarios in order to improve the ecological risk assessment of pesticide pulse exposures.

RS16_P5_Effects of selected chemical substances used to phosphorus inactivation on the growth of *Hydrocharis morsus-ranae*

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The pot experiment with *Hydrocharis morsus-ranae* was carried out in the period 18.06-30.07.2018. The influence of chemical agents used in phosphorus inactivation on the development of the tested plant was assessed. The experiment was divided into three series of 14, 28 and 42 days. The doses of the agents in the experiment (coagulants PAX 16, PAX 25. PIX 112, PIX 116 and $Ca(OH)_2$ and $CaCO_3$) were chosen so as to precipitate phosphate from the nutrient solution. Media supply and chemical dosing treatments were performed every 14 days. In parallel to the tests, a control was carried out without the addition of chemicals and a reduced content of phosphates in the nutrient solution. The results of the study were interpreted using the relative growth rate (RGR), the tolerance index (IT), the root growth inhibition index (IK), the percentage increase in weight and the percentage increase in root length. *Hydrocharis morsus-ranae* showed a high tolerance for the presence of chemical agents, as evidenced by the results of the IT at a level close to 1. The least favourable IT and IK values were recorded for $Ca(OH)_2$ after 28 days and for PIX 116 after 42 days. Lower values of percentage increase in weight and root length were noticed for $Ca(OH)_2$ in relation to the other variants. The results of ANOVA (Tukey's test) indicate the lack of statistically significant influence of effective doses of chemical agents on the overall development of *Hydrocharis morsus-ranae* both throughout the study period and in individual series.

RS16_P6_Charophytes in a eutrophic world: variability, performance, potential for bioindication

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Charophytes form a group of macrophytes inhabiting the Central European Lowlands that are especially sensitive to eutrophication. The high indicator value of charophytes toward eutrophication results in their wide use when the ecological status of waters is being assessed. In this study I explored the variability of stonewort communities' requirements to trophic conditions in lowland temperate lakes to determine their role in assessing the ecological status of lakes. The positions of 17 charophyte communities' niches along the trophic gradient were determined using environmental and floristic data from 740 Polish lakes and the Outlying Mean Index approach. Five associations can be classified as generalists, with a broad tolerance (high tolerance) and a relatively low sensitivity to eutrophication (low marginality). A few stonewort communities appeared to be highly specialised concerning water quality (high marginality and low tolerance). Most stonewort communities appeared in a broad range of ecological status classes, and in the case of 15 communities, 6 to 25% of occurrences were observed in lakes representing less than good status. This indicates that conservation status and ecological status do not necessarily coincide; hence, the presence of rare species does not guarantee high status and vice versa – ecosystems not inhabited by rare species may represent a high status, providing that they have a healthy macrophyte community structure and composition.

RS16_P7_The Balkan macrophyte index (BMI): a new tool for assessing the ecological status of lakes

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In Europe, macrophytes have for a long time been used as indicators of eutrophication and for the assessment of ecological status of lakes. Almost twenty assessment systems were developed in the last years, but most of them focused on lakes in Northern and Central Europe. The Mediterranean region, and especially the Balkan, lag behind, probably because of the relatively small number and high variability of natural lakes and the lack of collaboration among Balkan countries. The Balkan macrophyte index (BMI) we developed is designed to assess eutrophication in lakes in the Balkan region. The data we used were gathered in six Balkan lakes: Ohrid, Prespa, Lura, Biogradsko, Crno and Sava, located in Macedonia, Albania, Montenegro and Serbia. Submerged aquatic vegetation, water chemistry and sediment total phosphorus were analysed. Our results show that calculating a macrophyte index can be a problem in lakes with water level fluctuations of several meters, because the macrophyte vegetation may be absent or these lakes are dominated by “oligotrophic” or “eutrophic” species. Even though the number of lakes was small in our study, the BMI was loosely related to water phosphorus concentrations. If we analyse a larger number of lakes using the same methods, reference conditions and status class boundaries may be derived from the phosphorus – BMI regression.

RS17 Microbial ecology

RS17_P1_Does the presence of microplastics affect microbial communities in stream-bed sediments?

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The environment is constantly burdened by large quantities of waste, especially waste that takes longer to degrade, i.e. plastic. Scientists recognized the problem many decades ago, especially in the marine environments and many studies have now investigated the occurrence, distribution and fate of plastic in that environment. Plastic slowly weathers and pieces <5 mm are considered to be secondary microplastics (MP), while primary MP are produced mainly in the cosmetics industry. The presence of MP is alarming because of their persistence, their ability to carry potentially toxic chemicals and to be consumed by organisms in which accumulation can occur. One of the more heavily effected sites in freshwater ecosystems is the hyporheic zone – a region where surface and ground waters mix. Since little is known about the impacts of MP on hyporheic ecology, a comprehensive study will be carried out within next 3 years in which functional and structural profiling of bacterial communities linked with MP in the environment will be conducted as well as controlled experiments to disentangle the effects of MP from other stressors such as temperature, nutrients, siltation and water flow. This may lead to important insight to processes that occur in this habitat or even to the discovery of new bacterial strains that would be able to biodegrade plastic.

RS17_P2_Developing microbial indicators for the health of aquatic systems

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Globally, the value of measuring and incorporating microbial diversity and community composition into environmental management plans is becoming more broadly accepted. Microbial diversity is now recognized as one of the most sensitive indicators to detect differences between disturbed and undisturbed soils in terrestrial ecosystems. However, the use of microbial indicators in the management of natural aquatic systems, both freshwater and marine, is still in development. Here, we present two case studies illustrating the way in which rapid and cost-effective measures of microbial diversity and composition (e.g. 16S rRNA amplicon sequencing) can be used for improved management in the Swan-Canning catchment of Perth, Western Australia. In the first case study, we show how the use of 16S rRNA sequencing of microbial communities across riparian soil gradients coupled with qPCR of functional genes, can be used to guide restoration and management of urban and degraded freshwater streams. In the second case study, we show how we can combine traditional seagrass health metrics (e.g. biomass and reproduction) with 16S rRNA sequencing of seagrass microbiomes to develop indicators for estuarine health. These case studies are exemplars of how an improved understanding of fundamental microbial (both free-living and host-associated) aquatic ecology (i.e. community composition) can facilitate the development of novel management and restoration strategies for aquatic systems spanning entire catchments.

RS17_P3_Do leaf litter decomposers control benthic algae production and community structure? Insights from an outdoor mesocosm experiment

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Primary production is generally reduced in forest streams. It has been proposed that competition for nutrients with decomposers might be one of the factors reducing the abundance of primary producers. To test this hypothesis, we conducted a 48-days mesocosm experiment with 16 artificial streams inoculated with water and biofilm suspensions from a forested headwater stream. Four different treatments were applied: microbially-conditioned litter added at the beginning of the experiment, microbially-conditioned litter added at the beginning of the experiment and renewed three times during the experiment, control without litter, and a treatment without litter but with invertebrate grazers. We predicted that (1) presence of litter, through nutrient immobilization and allelopathy by decomposers, would reduce primary production, (2) this effect being amplified by litter renewal. We also predicted that (3) algal biomass reduction would be quite similar to those resulting from grazing, (4) but with different impacts on algal community composition and physiology. Our results showed that contrary to expectations, despite the presence of litter rapidly reduced the amount of dissolved nutrients, biofilm initial growth was higher in litter containing mesocosms. After 48 days, we observed lower biofilm biomass in the renewed litter treatment, but no differences between the three other treatments. Biofilms from treatments with litter addition showed different responses to light, suggesting changes in biofilm composition or physiological state. These results show that contrary to our expectations, decomposers can promote the first steps of prototrophic biofilm development despite strong reductions in the amount of nutrient in the water column.

RS17_P4_Where two worlds meet: marine sediments in a dammed freshwater lake

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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 rivers or sea. Therefore, water storage and flood protection in near-sea systems is regulated by dams and dykes, resulting in the creation of artificial lakes in these deltas. Lake Markermeer, a large (700 km^2) and shallow (average 4 meter depth) lake in the Rhine delta in the center of the Netherlands, was initially an inland lake in open connection to the sea, but was separated from the Waddenzee in 1932 by the Afsluitdijk and has turned into a freshwater system afterwards. However, the sediment is still mainly composed of marine clay, and it remains unclear how biogeochemical processes in this marine sediment influence the ecology of this freshwater lake. Therefore, we analyzed physical and chemical characteristics of the sediment, determined the microbial community composition using 16S Amplicon sequencing and performed nutrient flux experiments. We found that sediment sulfur content in lake Markermeer was 10 times higher than in nearby freshwater sediments and that microbial communities heavily relied on the metabolic processing of sulfur compounds. In the flux experiments, we observed that after oxic resuspension the sediment is a major source of sulfate that is released to the water column. Since the sulfur cycle is closely linked to the phosphorus cycle, these marine characteristics of the sediment have large impacts on the nutrient dynamics and ecological functioning of the lake, even 87-years after disconnection from the sea.

RS17_P5_Diversity and ecological preference of ciliates assemblage in a freshwater karstic river

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Ciliates (Protista) are an important component of aquatic ecosystems. In this study we investigated molecular and morphological diversity of ciliates in the Krka River (Croatia), a karstic aquatic ecosystem characterized by tufa barriers, high biomineralization rates and high biodiversity. Sampling of four representative habitats at the spring, upstream, middle stream and downstream parts of Krka was performed in September 2017. Samples collected from light- and dark-exposed sides of sampling substrates (biofilms from stones) were investigated using traditional morphology and environmental DNA metabarcoding (hypervariable V9-region of the SSU rRNA gene). A total of 364 taxa were detected by molecular approach, while 36 were determined via traditional microscopy. Considering the divergence between sampling locations, morphology did not show statistical significance in separation of assemblage as opposed to molecular analysis. The significantly different ciliate patterns in alpha diversity at distinct sampling sites can be explained by the ecological preferences of ciliate identities inferred from the taxonomic assignments of molecular operational taxonomic units (OTUs). This study confirmed that the molecular approach may provide deeper insights into ciliate assemblage of river biofilms. We show that, in accordance with previous studies, ciliates are excellent biomarkers for rivers and that eDNA metabarcoding has the possibility to fully unlock this bioindicator potential. Further research will include a comprehensive molecular approach in order to affirm the indicator potential of this group compared to other microbial groups.

RS17_P6_Cuticle-associated microbial communities of freshwater crayfish *Astacus leptodactylus* are affected by water temperature and the presence of pathogen *Aphamyces astaci*

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Native European crayfish species are in decline, mostly due to climate change-related habitat disturbances and spreading of oomycete pathogen *Aphanomyces astaci*. Increases in water temperature simultaneously affects the host and the pathogen, but also the host-associated microbial communities – an understudied component in host-pathogen relationship. Our aim was to characterize the cuticle-associated microbial communities of freshwater crayfish *Astacus leptodactylus* and to explore the potential changes in their composition related to water temperature and the presence of *A. astaci*. Crayfish were infected with *A. astaci* zoospores at two water temperatures – control temperature (18 °C) and increased temperature as a simulation of global warming (22 °C). Next, we isolated the total DNA from cuticle swabs and analyzed the epibiontic microbiome composition by Illumina MiSeq 16S rDNA sequencing. Overall, microbial diversity was significantly higher at 22 °C which could have influenced the increased host resistance to *A. astaci* observed at this temperature (lower mortality). Some bacterial groups were predominantly present at lower temperature, such as Actinobacteria and Flavobacteriia, while members of Bacilli were more dominant at higher temperature. We also detected differences in microbial community composition regarding the presence of *A. astaci*. Ultimately, this is the first study that describes the microbial community shifts in freshwater crayfish related to climate change and *A. astaci* presence. As such, it should provide a starting point to determine the potential positive effects of epibiontic microbial communities on the host health.

RS17_P7_Distribution and abundance of methagenic and methatrophic microorganisms across European streams

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Globally, streams and rivers emit a significant amount of methane, a highly potent greenhouse gas. However, little is known about stream sediment microbial communities, driving the net methane balance in these systems, especially on their distribution and composition at large spatial scales. Within the project EuroMethane we investigated the diversity and abundance of methanogenic archaea and methane-oxidizing bacteria across 16 European streams (from northern Spain to central Sweden) via 16S rRNA sequencing and qPCR. We determined environmental drivers of both abundance and community composition and explored the link to measured potential methane production and oxidation rates of the respective sediments. We found that the community composition of methane-oxidizing bacteria significantly differed among the studied streams, while methanogenic archaea were more homogeneously distributed. Beyond the overall diversity trends, indicator species for stream types were identified. Methanogenic *Methanosaeta* sp. and methane-oxidizing *Methyloglobulus* sp. increased with geographical latitude and dominated in headwater streams (orders 1-3) with high oxygen levels and high proportions of pristine land within the catchment, while methanogenic *Methanomethylovorans* sp. and methane-oxidizing *Methylocaldum* spp. were more common in larger streams (orders 4-6) with higher discharge and agricultural influence. Potential methane production rates significantly increased with abundance of methanogenic archaea, while potential methane oxidation rates did not show significant correlations with methane oxidizing bacteria, presumably due to the more diverse physiological capabilities of this microbial group. Our study represents a holistic large-scale biogeographical overview of two microbial groups to enhance our understanding of the methane cycle within a heretofore understudied ecosystem.

RS17_P8_Phyto- and bacterioplankton production in macrophyte dominated waters (Hungary)

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Lake Kolon is a macrophyte-covered shallow lake in Central Europe, in which a lot of different habitats are created by the aquatic plants. In macrophyte-dominated shallow lakes, the activity of bacterioplankton is largely unknown. Our aim was, therefore, to determine how heterotrophic bacterioplankton production depends on aquatic macrophytes and to assess how heterotrophic bacterial production relates to total primary production. Production was measured in the open water and in two macrophyte-covered parts of the lake monthly between November 2016 and October 2017. Primary production was determined by radiolabelled C uptake, while bacterial production from tritiated leucine incorporation method. According to our results, bacterioplankton and phytoplankton activity showed a characteristic seasonal dynamics. Production of the bacterioplankton was significantly higher in the macrophyte-covered parts of the lake (from 26 mg $C/m^2/d$ to 386 mg $C/m^2/d$) than in the open water (from 26 mg $C/m^2/d$ to 164 mg $C/m^2/d$). Primary production was higher than bacterioplankton production: in the open water it varied from 43 mg $C/m^2/d$ to 350 mg $C/m^2/d$, while in the macrophyte-covered parts of the lake it varied between 28 mg $C/m^2/d$ and 522 mg $C/m^2/d$. Positive relationship was found between bacterioplankton production and macrophyte biomass.

RS18 Molecular ecology, phylogeny and evolutionary studies

RS18_P1_Genetic structure of *Phoxinus* spp. (Teleostei: Cyprinidae) in western Po River basin identified as locus typicus of *Phoxinus lumaireul* (Schinz, 1840)

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European minnows (*Phoxinus* spp.), a complex of at least 15 cyprinid fish species, have a wide distribution range covering entire Eurasia. Among these, *Phoxinus lumaireul* (Schinz, 1840) represents an endemic species of southern Europe populating north Adriatic basins. Its locus typicus is localised in Po River probably in its western plain part, where is recorded both in large lowland Po River tributaries and in cold alpine lakes. The aim of this study is to test if the distinct ecological features of *P. lumaireul* acted in shaping its genetic signature, especially at local scale. 158 minnows from 5 lowland rivers and 12 alpine high-altitude lakes were sampled in western Po River basin. Phylogenetic tree, minimum spanning network (MSN) and population genetic structure were analysed sequencing mitochondrial DNA cytochrome oxidase I (COI). Preliminary results reported few widespread haplotypes shared in both lowland and alpine lakes, while three haplotypes resulted exclusively in an Alpine lake (Viana Lake). Through the phylogenetic tree reconstruction, two exotic species were detected in six alpine lakes, evidencing potential phenomena of translocation from a contiguous minnow species (*P. septimaniae*), native to the Mediterranean France basins, and from *P. csikii* widespread in central European and in the southern Balkan basins flowing into North Sea and Black Sea, respectively.

RS18_P2_The enigma of *Barbus euboicus* resolved

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During the last two decades knowledge on the diversity of the freshwater fishes in Europe has increased considerably. However, many endemic freshwater fishes in Mediterranean Europe are still poorly known and endangered. This is the case of *Barbus euboicus* (Cyprinidae; Cypriniformes), a barbel from the Greek island Euboea. There has been much confusion concerning the distribution of this species, and no knowledge about its biology and ecology. It was described in 1950 and mentioned to inhabit the streams on Euboea Island. Later publications assumed that the species is present only in the central-eastern parts of the island, and it was thought that another species inhabited the central and northern parts. Eventually, *B. euboicus* was considered to be endemic just to a single river basin, the Manikiotiko River, although this assumption was not corroborated by research. We sampled river basins throughout Euboea, and Barbus was discovered in four of them. The populations were analysed genetically, based on mitochondrial (Cytochrome b) and nuclear DNA (S7 and beta-actin). All markers unambiguously confirmed that all populations from Euboea belong to the same species, *Barbus euboicus*. Thus, we have an evidence that the species is not endemic to a single river in the central-eastern part of the island, but it is present also in its central-western and northern parts. The conservation status of *B. euboicus* should be further investigated and appropriate management strategies developed to protect the species, which is under considerable anthropogenic pressure.

RS19 Plankton

RS19_P1_How does phytoplankton overcome carbon limitation in acidic mining lakes – case study *Autumnella lusatica* sp. nov.

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Autumnella lusatica is a potentially mixotrophic green alga dominant during autumn in acidic mining lakes. It was taxonomically identified and characterized by Ulrich & Röske (2018). The special feature of this species is its ability to propagate and establish high biovolumes (up to 20 mm^3/L and 50 µg Chl a/L) at pH around 3 under oligotrophic nutrient conditions and carbon limitation of primary production (total inorganic carbon TIC < 0.5 mg/L). In our study, we want to answer the question: How does this species overcome resource limitation under extreme acidic conditions? We hypothesize that: a) mixotrophic metabolism favors the success of *A. lusatica*; b) epilimnion and euphotic depths of acidic lakes are mostly under saturated by CO_2; phytoplankton will assimilate CO_2 by atmospheric diffusion and/or by accumulated CO_2 from hypolimnion during stagnation; c) high intensity of internal recycling of organic matter by pelagic bacteria supports the availability of inorganic phosphorus and carbon for this species. Phytoplankton composition and biovolume, dissolved and total nutrients were measured monthly in acidic, dimictic mining Lake Halbendorfer See (Germany) from 2010 to 2018. Incubation of field samples in the lab under in situ conditions to estimate primary and bacterial production as well as bioassays with the addition of nutrients were done in 2017 and 2018. Acidic mining lakes are characterized as sinks for carbon.

RS19_P2_Different sources of the same fatty acids in lake zooplankton – a compound-specific stable isotope approach

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Fatty acids (FA) are commonly used as quantifiable source indicators in organisms of aquatic food webs. Based on their molecular composition, it is possible to distinguish FA from algal, bacterial, or terrestrial sources. However, whether these source-specific FA come from the same aquatic ecosystem as the consumers, in which they are retained, remains thus far unclear. In this multi-annual field study on edible seston (<30 um particle size) sources (lake inflow as well as epi-, meta-, and hypolimnion) and zooplankton (*Daphnia*, calanoid and cyclopoid copepods) of subalpine Lake Lunz, Austria, we investigated how zooplankton retained FA of various origins during seasonal changes of three years (2016-2018), using compound-specific stable isotope analysis (CSIA). Results indicate that inflowing seston was very poor in lipids and FA, whereas epilimnetic lake seston had on average 3x higher omega-3 FA than inflowing seston. Zooplankton contained on average 7-10x more omega-3 FA than epilimnetic seston. Overall, zooplankton FA were more closely related to epilimnetic FA than FA from other sources, suggesting that seston FA undergo molecular reworking at lower lake layers and/or preferential retention of epilimnetic FA by zooplankton. Similarly, preliminary CSIA data indicate isotopic differences in FA-$\delta^{13}C$ values between inflowing and lake seston. Further isotopic values of individual FA in seston and zooplankton will be presented.

RS19_P3_Life-history traits of *Daphnia* spp. in fishponds – the life between hypertprophy and overstocking

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We studied life-history traits of the keystone species in shallow, manmade, hypertrophic fishponds in the Czech Republic that represent unique freshwater ecosystems. We focused on abundance and life-history traits of *Daphnia*. We analysed abundance, body size and clutch size. We specifically aimed at the females bearing embryos which developmental stages were determined. The amount of daphnid primary food resource (phytoplankton C), food quality (seston C:P), and fish predation were considered as the most important factors affecting daphnid life-history traits. *Daphnia* frequently face poor food condition (high C:P seston ration) simultaneously with high fish predation in fishponds, which significantly worsen their success in reproduction.

RS20 Surpassing aquatic boundaries

RS20_P1_Trait-based approaches: a common framework for freshwater and marine ecologists

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Functional traits are phenotypic characteristics of organisms influencing individual fitness, such as size, trophic regime or resource acquisition strategy, reproduction mode, or abilities of escaping predation. Functional traits drive both the response of organisms to perturbations (response traits) and they effects on ecosystem functioning and associated ecosystem services (effect traits). They have been used for a better understanding of ecosystem functioning and for ecosystem management and monitoring. This work focus on trait-based approaches in aquatic ecology and argue that they could be a common language for freshwater and marine ecologists. Firstly, methods for measuring or estimating functional traits are presented, including in situ observations, dedicated experiments, literature review, or more recent technics such as automatic imaging and molecular approaches. Trait-based models are also discussed. Secondly, future research questions and opportunities are described. They encompass the estimation of aquatic functional diversity at various spatio-temporal scales, the study of aquatic food webs, community interactions, and biogeochemical cycles, and the investigation of potential effect of anthropogenic and natural pressures on aquatic ecosystems.

RS21 Streams

RS21_P1_Importance of essential nutrients from different carbon sources for the food chain structure of a headwater stream

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In headwater streams, macro-invertebrates are a key trophic level as main vector of energy and carbon from basal sources of organic matter to higher trophic levels. They play an essential role in the degradation of considerable amounts of litter entering streams. This allochtonous food source can roughly be split up in two aspects important to invertebrates, namely food quantity and food quality. If the quantity is not limiting, the quality of this food source is quite controversial. In contrast autochtonous sources (epilithic biofilms), although quantitatively limited, seems to offer a better food quality due to their biochemical compounds contents. Among others, it appeared that fatty acids and phytosterols could be critical for maintaining the fitness of a various number of freshwater organisms. Therefore, in the present study, we characterized fatty acids and sterols profiles from basal sources and several species of macro-invertebrates. These specific compounds were used to discriminate among the different food resources assimilated by invertebrate consumers from a low diversity community living in a mountainous headwater streams (France, Massif-Central). Application of these assimilation-based analyses helped to asses trophic links in order to have a better understanding of the stream food web structure.

RS21_P2_Annual variation in water quality parameters on Plitvica stream, Plitvice Lakes National Park

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Plitvica stream is a part of freshwater ecosystem of the Plitvice Lakes National Park in a unique way. It merges with the water from the lake system at its end, thus forming the river Korana. Its priceless value is that it forms the highest waterfall (78 meters high) in Croatia. Increasing anthropogenic influence in the past several years manifested in excesive construction of houses for tourism, and increasing use of water for drinking and sanitation. Conservaton Service has been conducting monthly water monitoring since 2012. on 2 locations, Plitvica spring and Plitvica stream after the settlement. In 2018 additional 4 locations have been added for the weekly monitoring of Plitvica stream thereby covering the entire watercourse. Basic physico-chemical parameters were measured on field, samples were collected in sterile bottles and microbiological analysis were performed within a few hours in Park's laboratory. The aim of this work was to establish how did the physico-chemical and microbiological parameters change during a period of 9 months in 2018, giving distinct spatial and seasonal distribution of the collected data. Interpretation of the data showed the influence of increasing anthropogenic pressure on sensitive balance of a small streams like Plitvica stream.

RS21_P3_Managing the small stream network for improved water quality, biodiversity and ecosystem services protection (SSNet)

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SSNet is a recently-initiated four-year project on the small stream network in Ireland funded by the Irish Environmental Protection Agency (EPA). The aim is to advance knowledge on the role of small streams in water quality, biodiversity and ecosystem services protection that will inform policy, measures and management options to meet water quality and other resources protection targets. The project started with a synthesis of available information on the importance of small streams to initiate communication with stakeholders. Three work packages are collecting new data on hydrochemistry (with a focus on nutrient limitation and impairment, and in-stream nutrient cycling), hydromorphology and aquatic biodiversity. All three investigations will share common sites and modelling based on the results from each of the aforementioned tasks will be used to estimate the level of intervention in the small stream network required to have measurable effects throughout a catchment. We will also engage volunteers in both biological water quality and hydromorphological assessments, and evaluate the potential of citizen science in facilitating greater monitoring coverage of the extensive small stream network.

RS21_P4_What if sand could walk? Sediment transport by Glossosomatidae caddisfly larvae in gravel-bed streams

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Aquatic invertebrates have developed a wide range of morphological and behavioural adaptations to the turbulent hydraulics of gravel-bed streams. For many taxa, avoiding areas of the river bed with high flow velocity is key. However, the construction of cases from sediment allows Glossosomatidae (*A. fuscipes*) caddisfly to avoid entrainment. Consequently, *A. fuscipes* larvae transport their case and constituent sediment from sheltered interstices to graze algae on the exposed upper surfaces of gravel particles on stream beds. However, the magnitude and direction of this movement has not been studied. Mesocosm experiments in a large laboratory flume allowed us to assess the importance of flow velocity and gravel particle protrusion as controls on the movement and case design of *A. fuscipes* larvae. 12 runs each lasting 21 hours and beginning with 50 larvae were conducted. After each run, the horizontal and vertical location of larvae was recorded and the mass, grain size distribution and silk content of the newly built cases measured. *A. fuscipes* constructed cases from fine sediment present in gravel interstices and then transported their cases on average 2 cm upwards, onto gravel particles. The upwards flux of sediment was maintained at flow velocities well above the entrainment threshold for caseless larvae. Case construction by *A. fuscipes*, therefore, increases their access to algal food and allows these armoured grazers to dominate grazer communities in many streams. The transport of substantial quantities of sediment may also have implications for the mobility of this sediment and microscale roughness of stream beds.

RS22 Taxomy and systematics

RS22_P1_Diversity of *Phoxinus* in Greece: insights from the genetic data

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The knowledge on the diversity of freshwater fishes in Europe has increased considerably during the last two decades. Especially the knowledge on the genus *Phoxinus* (Cypriniformes, Leuciscidae) has undergone drastic changes. A decade ago, only seven species were recognised. Currently, 18 taxa have been documented, of which seven are undescribed. Such considerable change is mainly due to genetic analyses, as Phoxinus species are morphologically very similar. *Phoxinus* is present in Greece only in the rivers of northern and eastern Aegean Sea slope, usually these populations are isolated in cool-water sections of streams or spring-fed waters. Apart from *Phoxinus strymonicus* in the Strymon basin, the remaining populations were of unknown taxonomic status until this investigation. We sampled *Phoxinus* populations in Greece from five river basins. Mitochondrial (cytochrome b and COI) and nuclear (RAG1) markers were used. The results revealed the presence of three different lineages in Greece. The Strymon basin and the nearby Marmaras river basin are inhabited by *Phoxinus strymonicus*. The more easterly located population from the Filiouris basin is closely related to *Phoxinus strandjae*, though with a considerable genetic divergence from the population of this species from its type locality (Bulgarian Black Sea rivers). Finally, the westernmost basins of Loudias and Aliakmon are, surprisingly, inhabited by populations related to *Phoxinus lumaireul*, the species otherwise known from the western Balkans. Our data suggest the necessity to re-evaluate the conservation status and management strategy for the genus *Phoxinus* in Greece.

RS22_P2_Morphometric differences of distinct Carpathian gudgeon (*Gobio*) haplogroups

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Althought stream dwelling gudgeons (genus: *Gobio*) are widely distributed fish in hilly streams of Carpathian basin, their phylogenetic and taxonomic relationships have not been revealed in detail. Results of a previous comprehensive study indicated three dominant haplogroups from the Hungarian hilly streams; which from the sole valid species (*G. obtusirostris*) is distributed in the North-West region of the country. While two unevaulated haplogroups so far proved to be dominant in the East and South-West area of Hungary respectively. The geographic distribution and the moderate genetic distances of these three haplogroups suggest ongoing allopatric speciation in the Carpathian basin. In order to reveal the potential morphologic and morphometric differences of these *Gobio* haplogroups (cryptic species?), phenotypic data of 103 genetically identified gudgeon individuals originated from five populations situated to the East, North, and South-West areas of Hungary were compared. Scale shape and lateral line scale number analyses showed only slight differences. But results of body shape and distance based morphometric analyses showed, significant detachments among the three haplogroups. Therefore it seems contrary the moderate (max. 2.1% of 608b long mtCR sequences) genetic detachments, if larger number (~20) individuals' data is analysed, these groups show detectable phenotypic differences. Even if the among haplogroup morphometric differences show similar magnitude as if the data would be analyzed on population level.

RS22_P3_Are minute moss beetles (Coleoptera: Hydraenidae) still overlooked beetles in Croatia?

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Minute moss beetles (Insecta: Coleoptera: Hydraenidae) are a cosmopolitan family of water beetles comprised of small sized insects. They inhabit various types of freshwater habitats, from springs and clean running waters to small ponds, hypersaline pools or hygropetric. Mediterranean region is considered as hotspot for water beetle biodiversity, especially for family Hydraenidae. Therefore, local endemism and presence of still undescribed species is highly expected in Croatia. Nevertheless, in Croatia, minute moss beetles were only sporadically studied until recent time, mainly as a part of benthic invertebrate community for water quality assessments. This is in contrast to the knowledge about family Hydraenidae in other parts of Europe, especially in the western Mediterranean. We focused on detailed revision of literature data and revision of entomological collections with the aim to provide preliminary checklist of the family. Secondly, we sampled hydraenids throughout Croatia to complement the species list. Additionally, we DNA barcoded species from the collections and sampled new ones to provide the basis for future studies. After the comprehensive analysis of literature data, museum collections, as well as recent sampling, new species for the country are continuously recorded. DNA barcoding of Croatian hydraenids is of special importance as the method is proven to be a good indicator in recognizing undiscovered taxa and/or cryptic species. We expect that our results will greatly contribute to the knowledge of this so far unduly neglected water beetle family in this part of Europe, as well as reveal taxonomically interesting taxa.

RS23 Urban freshwaters

RS23_P1_A simple molecular biology method to detect cyanobacteria blooms in a small urban lake

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Urban lakes provide essential ecosystem services, including recreational activities. Nutrient loading from the watershed associated with global warming rises the occurrence of cyanobacteria blooms. In bathing areas, threshold levels of cyanobacteria biomass and toxin concentrations must comply with regulatory standards. Currently, methods for determining potentially toxic species are based on microscopic identification. These methods require highly specialized skills and are time-consuming. Field sensors can supply high-frequency measurements of chlorophylls or cyanobacteria-specific pigments. However, these data do not provide information on the species and sometimes are affected by high uncertainties. Methods of molecular biology, increasingly affordable, promise efficient perspectives. This paper presents a fast and low-cost method for bloom risk monitoring, based on the FISH (Fluorescence In Situ Hybridization) technique. The study site was Lake Champs-sur-Marne (Great Paris, France). High-frequency measurements of physical-chemical variables, chlorophyll-*a* and phycocyanin were performed at a reference point. In summer 2018, field campaigns (n=8) were conducted. Lab analysis of Chl *a* and phycocyanin were performed as well as identification and counting of algal species. Regarding the FISH experiments, probes targeting the 16SrRNA specific for cyanobacteria were used. In parallel, a control probe for eubacteria was also applied. The FISH results show that the detected fluorescence is qualitatively proportional to the observed cyanobacteria abundance. The method, which can be performed by a non-specialist, is able to give a semi-quantitative insight, in around 12 hours. The FISH results are discussed against other proxies of cyanobacteria biomass (sensor data, lab analysis of Chl *a* and phycocyanin, species biovolumes).

RS23_P2_Resazurin push-and-pull tests to determine the impact of dynamic flow on microbial activity in an urban river

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Urban streams can show regular diurnal fluctuations of discharge, temperature and solute concentration and composition due to effluents from waste water treatment plants (WWTP). These environmental fluctuations are expressed at various magnitudes and synchronicities depending on habitat, i.e. surface water or hyporheic zone, and distance to the WWTP. The fluctuations impair microbial biota and its activity. The River Erpe, Berlin, Germany, is a eutrophic lowland river receiving up to 80% of its streamflow from a WWTP. Typically, the share of WWTP-water varies over the course of a day by 30% to 80%. Here, we present data on environmental fluctuations in the surface water and the hyporheic zone downstream of the WWTP. Pressure, temperature, and electrical conductivity were measured continuously in the surface water. Surface and pore water were sampled on an hourly basis to determine solute composition. We measured microbial activity in the hyporheic zone with single-well injection-withdrawal (push-and-pull) tests using the reactive tracer resazurin. We adapted resazurin models to accommodate non-constant discharge. Push-and-pull tests with resazurin allowed point measurements of microbial activity in the hyporheic zone at high temporal resolution, alongside the measurement of oxygen profiles with microsensors on an hourly basis. Microbial activity showed a positive correlation to discharge. Temperature and solute composition of the stream water followed the diurnal discharge pattern, with a growing phase shift along the water course. This study shows that resazurin push-and-pull tests present a good option to study microbial activity in dynamic rivers at high frequencies.

RS23_P3_Anthropogenic litter supports distinctive macroinvertebrate communities in urban streams

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Anthropogenic litter (AL; man-made waste present in the environment through inappropriate disposal) is an understudied, but pervasive component of many river systems worldwide. Riverine AL could have ecological consequences through acting as a novel habitat; both by providing an atypical physical habitat structure and by interacting with natural flow and sediment dynamics. This study compares the macroinvertebrate communities present on AL and natural gravel substrates to test whether AL could support distinctive communities. Macroinvertebrates were collected from individual gravel and litter pieces in three streams within Nottinghamshire and Leicestershire, UK. Litter varied widely in size (0.0005 m^2 to 2 m^2) and type (including plastic, metal, glass, fabric, wood, rubber and ceramic). In two of the streams, macroinvertebrate communities on gravel pieces were more diverse and contained more individuals than their litter equivalents. However, the community composition of macroinvertebrates present on litter and gravel pieces at these sites was clearly distinct, with plastic and fabric pieces supporting communities most dissimilar to those on gravel. No clear differences between communities were found in the third stream. Consequently, at least at some sites, the novel habitat provided by AL is important for macroinvertebrates. The management and removal of litter in streams needs consideration as litter could harbour organisms not found elsewhere. Understanding the functions litter provides for organisms, such as stable attachment sites or increased hydraulic complexity, could inform methods to provide these functions using alternative materials which are less environmentally damaging than AL.

SS1 Science and management of intermittent rivers and ephemeral streams: a European perspective

SS1_P1_Ecological responses to an experimental increase of flow intermittency in an alpine stream

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Flow intermittency occurs naturally in alpine catchments, but is expected to increase with climate change. Thus, characterizing ecological responses to increased flow intermittency is key in conservation and management of alpine fluvial ecosystems. We conducted a paired-stream experiment in Val Roseg, a glacierized alpine catchment, where we experimentally increased flow intermittency within a stream channel over summer. We measured and compared the diversity and abundance of macroinvertebrates within the experimental channel with those of a reference stream. The overall richness and density of macroinvertebrates decreased sharply with an increase in flow intermittency, and did not recover following resumption of the natural flow. EPT taxa were the most strongly affected by the loss in surface flow. Community composition followed different trends over time in the experimental compared to the reference stream, and did not converge after resumption of natural flow. Our results suggest that increasing flow intermittency results in fundamental changes in macroinvertebrate assemblages of alpine streams.

SS1_P2_Effects of drought length on the hyporheic microbial processes of intermittent streams

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Intermittency in streams is expected to become more common as the climate changes. Previous work on intermittency has largely focused on Mediterranean streams. This research project aims to evaluate how drought affects the microbial processes in the hyporheic zone of temperate streams. We use experimental hyporheic flumes (5 m long, 0.5 m wide, 1.2 m deep) to examine how drought duration affects the state and activity of hyporheic biofilms. Initial tests were completed in fall 2018 with dry periods ranging from five to 48 days. During the dry period, the flumes were allowed to fall dry in the upper sediment layers (0-60 cm depth) while retaining subsurface flow in the deepest layer (60-80 cm depth). The flumes were then rewetted. Preliminary results show that in dry periods below 41 days, effects on extracellular enzyme activities were negligible or low with recoveries within 24 hours of rewetting. Only the flume that had the longest dry period (48 days) showed an effect on enzyme activities and a slow recovery upon rewetting. Possible explanations include high moisture contents at the end of the dry periods in most flumes and water temperatures below 10°C, which generally restricted microbial activities.
To further explore these questions, a follow up experiment is planned for spring 2019, which will include extended dry periods.

SS1_P3_Stream drying and stream pollution: similarities in impact on benthic invertebrates

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Due to the ongoing climate change which brings unbalanced summer precipitations together with higher evapotranspiration related to rising temperatures, there is an increasing risk of stream intermittency in continental temperate zone. Intermittent streams are exposed to diverse anthropogenic impacts including the input of organic pollution. The discharge of wastewater from sewage treatment plants is one of the most common forms of pollution in stream ecosystems and has adverse effect on benthic invertebrates. The response of stream biota to saprobic pollution is well described in perennial systems. However, the evidence of structural and functional aspects of benthic invertebrate assemblages in polluted intermittent streams is scarce. We analyzed the impact of such pollution and flow cessation on freshwater invertebrate community within the dataset of 16 sites from the Czech Republic. Perennial and intermittent sites and polluted and non-polluted sites (4 replicates from each combination) were compared to disentangle the impact of wastewater pollution and flow intermittency. We found that the benthic invertebrate assemblages from four studied groups (perennial non-polluted, perennial polluted, intermittent non-polluted, intermittent polluted) differ. Our results indicate, that this type of water pollution and stream intermittency can have similar yet not the same effect on benthic invertebrates.

SS1_P4_An invertebrate-based index to characterize ecological responses to flow intermittence in rivers

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Intermittent streams occur across global regions, and are increasingly recognized to support high biodiversity and perform important ecological roles within catchments. New tools are needed to better characterize biotic responses to the full spectrum of environmental conditions that occur in these dynamic systems, in which the biological indices developed to assess ecological responses to flow in perennial rivers may be inaccurate. We present the Monitoring Intermittent Streams index (MIS-index), a new biological index that can be used to assess invertebrate responses to environmental changes spanning flowing, ponded and dry? states. As well as fully aquatic taxa, the index includes semi-aquatic and terrestrial invertebrates from marginal habitats, which are collected during standard surveys used by regulatory agencies to assess ecological quality. We explain the development of the MIS-index and explore its performance compared with other indices. We suggest index combinations that can be used to detect different aspects of ecological responses to variation in instream conditions, and highlight the advantages of including semi-aquatic and terrestrial taxa. We call for researchers to test the performance of the MIS-index across a wide range of intermittent stream types, to enable its development into an international tool for the holistic assessment of ecological responses to changing hydrological conditions including drying.

SS1_P5_Advancing metacommunity ecology in intermittent rivers to improve their conservation and management: the MECODISPER project

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Intermittent rivers (IRs) are the most common fluvial ecosystems in the world. Despite the unique biodiversity that they support and ecosystem functions they provide, important aspects of their ecology and management that remain poorly understood. The MECODISPER project aims to understand how river network fragmentation caused by drying shapes the dispersal of aquatic organisms and structures metacommunities in IRs, and to assess the importance of perennial water refuges for maintaining biodiversity. To do that we will study 8 pristine subcatchments in Catalonia (Spain) that cover a wide range of hydrological conditions. We will model river network connectivity using field data from water temperature sensors. Then, we will assess metacommunity assembly by investigating community similarity distance-decay relationships of three main groups of aquatic organisms with contrasting dispersal abilities (diatoms, invertebrates and fish) that will be quantified using experiments, molecular approaches and capture-recapture techniques. We will also use the systematic conservation planning tool Marxan to identify biodiversity refuges and ecological 'stepping-stones' that facilitate species dispersal. Overall, our results will inform the development of monitoring and management activities for protecting regional aquatic biodiversity in IRs.

SS1_P6_Significance of intermittent rivers and ephemeral streams in agricultural and natural landscape of Slovakia and Portugal

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Intermittent rivers and ephemeral streams (IRES) are specific to three hydrological phases – flow, pools and dry. The mosaic of agricultural landscape varies within the world. The present study presents a significance of IRES in agricultural and natural landscapes in Slovakia and Portugal. Different conditions of both countries – position within Europe, climate conditions, history, and landscape management procedures – determined different perceptions of IRES by society and their relevance in the landscape. While in Slovakia natural ephemeral streams are mainly situated in natural landscape, and artificial and modified channels with intermittent flow appear generally in agricultural landscape, in Portugal natural intermittent rivers are crossing both natural and agricultural landscapes, characteristics impossible to find in Slovakia. Therefore, the use of water from the rivers/streams and surrounding landscapes is different. According to climate change we expect a significant increase in the number of IRES in Slovakia, so the developed research highlights some managements procedures applied in Portugal which might contribute to improve riverscape resilience in Slovakia.

SS1_P7_Are all intermittent streams the same? Multiple hydrological components driving invertebrate community changes

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During the last years, there has been a growing interest in the study of intermittent streams as they represent a great part of the global river network and have a key contribution to biogeochemical cycles. However, to date, despite flow intermittency is a complex phenomenon, it has been characterized based solely on the number of dry days, ignoring other crucial hydrological aspects. For example, streams with a similar number of dry days can have a different number of flowing days (rewetting) before sampling campaign, different number of non-flow periods, or varying durations of the last dry period, all this could lead to different biological communities. These become even more relevant in a context of climate change where flow intermittency is expected to increase globally. In this line, and sampling 33 streams across Catalonia (NE Spain) along an intermittency gradient, we identified which temporal hydrological component shaped different aspects of invertebrate biodiversity. To do so, we deeply characterized hydrology during one year before sampling, accounting for non-flow periods, flow periods and their duration. We also collected samples of the invertebrate community on each stream to analyze taxonomic and functional diversity. Our results showed that the main hydrological variable related to both taxonomic and functional metrics, was the number of flowing days before the sampling.

SS2 Aquatic metacommunities: research and applications

SS2_P1_Chironomid metacommunity patterns in intermittent rivers and ephemeral streams

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Chironomids are pioneer colonizers in intermittent rivers and ephemeral streams (IRES), ubiquitous and numerous throughout flowing phases and, thanks to their adaptations, can resist desiccation with some taxa persisting during dry phases and recolonizing quickly upon rewetting. Metacommunity organization is increasingly explored in dynamic ecosystems like IRES, but to date, most studies have examined the Chironomidae at the family level, missing pivotal information about underlying community patterns and processes. Here, we analysed whether flow intermittence, by disrupting hydrological connectivity, influences chironomid metacommunities in IRES. We predicted that the higher the alteration of hydrological connectivity, the higher the role of regional (i.e. dispersal) processes over local (i.e. species sorting) ones. We tested this idea by comparing the metacommunity dynamics of 5 river basins comprising IRES with a different magnitude (i.e. percent of intermittent sites varied from 14% to 49%) in south-eastern France. The distance-decay relationships approach (DDR) indicated that chironomid communities were spatially structured in 4 basins, and that dispersal was the key driver of metacommunities when flow intermittence increased. We detected the effect of environmental conditions only in one basin. These results highlighted the benefit of using a fine taxonomic resolution when studying metacommunty dynamics in IRES and confirmed that dispersal is a key driver of biodiversity patterns in IRES.

SS2_P2_Fish metacommunities in stream network: Do spatial processes influence the bioassessment metrics?

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In the last years, the rise in number of studies that explore metacommunity ecology of fish has been observed. However, there is a little information on how metacommunity dynamic could affect the ability of bioassessment methods to assess the environmental quality. In this study, we have chosen the South Morava River system to assess how local environmental factors and dispersal processes affect fish community structure and bioassessment metrics. Fish assemblage data was collected in 2010 at 36 sampling sites distributed on 15 rivers. Moran's eigenvector maps (MEM) generated 9 variables modelling the spatial relationships among the sampling sites. Redundancy analysis (RDA) revealed that both spatial and environmental variables were significant predictors of fish communities. Two of 11 the most commonly used fish community metrics were influenced by spatial processes. Mantel correlogram, used to plot spatial correlation values against the distance classes, indicated that any pair of sites beyond 30 km can be considered as spatially independent. Knowledge of spatial processes in fish metacommunities could enhance the sensitivity of bioassessment methods to reflect the environmental condition.

SS3 Hydrology, biogeochemistry and ecology of mountain freshwaters

SS3_P1_Peatlands on Semolj (Montenegro) and their environmental and geological features

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The pass Semolj is located on south-western slopes of Sinjajevina Mountain in the central region of Montenegro at 1497 metres above sea level, with subarctic (boreal) climate without dry period during the year. There are several smaller highland acid mires at this locality, two of which we explored geologically, floristically and herpetologicallySemolj 1 (Jezero, area of 19 892 m²) and Semolj 2 (Kolakovića Poljana, area of 18 519 m²). At peatland Semolj 1 there is open water area, while at Semolj 2 there is a wet meadow. Characteristic for both peatlands is that they are fed with water through precipitation as well as through a number of smaller diffuse springs. Cliffs participating in the construction of this locality are of Triassic age and they are limestones in contact with andesite and keratophyres. The chemical analysis of the peat show the content of organic substance 62.9%, mineral substance 32% hygroscopic moisture - 4.9% and pH (in water) 5.3. On this peatlands there is a mosaic rotation of water and amphibious vegetation as well as wet meadow vegetation. Floristic research registered 125 taxa and recognised two NATURA 2000 habitats7140 Transition mires and quaking bogs and 7230 Alkaline fens. Herpetological researches registered five species of amphibians and two types of reptiles. Our environmental and geological research are the first detailed data for peatlands at Semolj, which are very important ecosystems. To that regard, these habitats need additional research that would contribute to their better understanding and more efficient protection.

SS4 10th UAMRICH (Use of algae for monitoring rivers and comparable habitats)

SS4_P1_Comparison of existing pipelines handling species assignation and OTUs classification for freshwater and marine diatoms in Europe within the framework of water quality assessment

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The aim of this project is to compare the results of official European biotic indices using diatoms for environmental assessment and the resulting ecological status classifications, and analyze the impact on ecological status classification. The diatom communities in biofilm samples from 30 sites in Scandinavia (broad ecological and geographical range, available water chemistry data) will be identified using 6 bioinformatics pipelines that are currently used in Europe (Croatia, France, Switzerland, Germany, France, UK and Sweden). The species taxonomic assignment will also be compared to the Operational Taxonomic Unit classification. This project was supported both by bioinformaticians and taxonomists, to strengthen the DNAqua-Net network with collaborative work of diatomists from several countries, through exchange of knowledge and sharing large-scale data. The project Contributions to the scientific objectives of the COST-Action CA15219 are to: (i) detect the need for development in all the pipelines; (ii) encompas the data analysis by including the OTUs classification method, which allows the use of almost 100% of the DNA data; (iii) compare taxa assigned to the DNA sequences and water quality scores (obtained both by taxa assignation and OTU classification) with the data obtained from microscope valve count by a taxonomic expert; (iv) understand the effect of different data analysis pipelines (and their theoretical background) on resulting ecological index values; (v) highlight which of the pipelines show the highest congruence with traditional diatoms indices and ecological status class of the studied aquatic habitats.

SS4_P2_Diatoms as indicators of water quality in small watercourses of the Magura National Park (Lower Beskid, South-East Poland)

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Studies of diatom assemblages were carried out in the headwaters of the Wisłoka River and selected tributaries in the Magura National Park and its protective buffer zone. The study aimed to determine the structure and dynamics of the diatom assemblages, and to use the ecological preferences of diatoms as indicators of water quality. An attempt was also made to determine factors that could affect the differentiation of diatom assemblages and to indicate possible sources of pollution and threats to the aquatic environment. The physico-chemical parameters of waters in the Park indicated a high water quality. Diatom assemblages in most sampling localities were dominated by taxa with a broad spectrum of tolerance to trophic conditions, β-mesosaprobic and oligosaprobic. Regarding pH, the predominant taxa were those indicating alkaline or near-neutral waters. The results of the statistical analyses showed that the main factors affecting the structure of diatom assemblages resulted from natural processes, including fluctuations in the water level, degree of shading, detritus deposits and substratum type. The assessment of the ecological status, using diatom indices, showed that the studied waters mostly have good or very good ecological status. The most reliable results were obtained by means of SPI (Specific Pollution Sensitivity Index) and IO (Polish Diatom Index) indices. The degree of anthropogenic impact on the waters studied seems to be small. This research is the first scientific study of algae in the Magura National Park, and the first comprehensive study from the Lower Beskid.

SS4_P3_Longitudinal patterns of epiphytic diatom communities from a small river in the African Eastern Rift Valley (Kenya)

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Studies on tropical, especially African, river diatoms are scarce compared to those published for other regions of the world, such as temperate and boreal areas. In particular in Kenya, limnological studies investigating diatom community structure are mainly focused on lakes. We examined the composition of epiphytic diatoms collected in eleven sites along a small river and two tributaries, located within the Eastern Rift Valley in Kenya. The area is characterized by a crystalline lithological substratum, with volcanic rocks, and consequent low conductivity of the water. Human activities include small livestock farms and subsistence farming in the North of the river basin, and larger breeding farms and large horticulture and floriculture activities in the South. The aim of the work is to investigate biodiversity in an area that is currently unexplored, to examine specific richness, and to identify the main spatial-distribution environmental controls along a longitudinal gradient in a tropical climate setting. Physical and chemical parameters, such as pH, turbidity, conductivity, nutrients, and land use, were considered. Our results will implement the knowledge on the composition of African tropical diatom communities, and be useful in order to understand water quality features and to contribute to evaluate the applicability of biotic indices used in temperate regions.

SS5 Understanding cross-habitat linkages between stream and riparian zones to optimize management of biodiversity and ecosystem services

SS5_P1_Transfer of essential lipids from aquatic to terrestrial ecosystems

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Emerging aquatic insects (EAI) are important vectors through which freshwater-derived organic matter can enter terrestrial food webs. Aquatic-derived dietary energy can support terrestrial consumer fitness, especially via its polyunsaturated fatty acids (PUFA) that are otherwise short in supply from terrestrial diet. Considering qualitative aspects of resource subsidies is thus crucial for understanding energy and nutrient fluxes between ecosystems and for assessing effects on food web processes in recipient habitats. In this context, the objective of this study is to, (1) quantify the export of PUFA from four peri-alpine lakes, (2) evaluate the PUFA transfer from aquatic to terrestrial invertebrate consumers via EAI along an altitudinal lake gradient, and, (3) identify trophic pathways for riparian consumers. We hypothesize that, a) PUFA-flux via EAI will decrease with increasing lake depth, and, b) the effect of aquatic subsidies on terrestrial invertebrate consumers decreases with distance to lakes. To test this assumption, insect biomass and total export of PUFA will be quantified from four lakes at different altitudes. In addition to bulk stable isotopes and fatty acids, compound-specific stable isotopes (d13C and d2H of fatty acids) will be used to assess PUFA export via EAI and the distribution of aquatic PUFA in adjacent terrestrial ecosystems and invertebrate consumers. Laboratory feeding experiments will be conducted to test which aquatic or terrestrial insect prey are preferentially consumed and support the growth of riparian predators (i.e. spiders) more efficiently. This approach will provide novel insight into the potential role of essential nutrients in mediating cross-ecosystem effects.

SS5_P2_Importance of natural sediment regime on cross-ecosystem fluxes

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Ecosystems are open units, depending on energy and nutrient transfer across boundaries. If we consider a stream and the adjacent terrestrial system, it is obvious that the boundaries are highly permeable to subsidy flows. One important energetic connection between the systems are emerging amphibiotic insects; they develop in the water before becoming an important prey item for riparian predators like spiders. Along this pathway, aquatic organic matter of high nutritional quality is exported. However, this energy transfer across systems might be threatened by human activities like river engineering with severe consequences for riparian predators, which depend on the high quality nutrient input. Among the many changes, one phenomenon we observe in many rivers is a severe reduction of bed load due to structures impeding free bed movement. We examine how human-caused bed load deficits in rivers alter the lateral trophic connection to adjacent riparian systems. Stable isotopes and fatty acid analysis provide the means to follow the lateral food web link and estimate the amount and quality of aquatic food in the diet of riparian predators.

SS5_P3_Relationships between riparian properties, land use and the composition and diversity of riparian macroinvertebrates in a catchment impacted by agriculture

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Research at the catchment level is of particular interest in the attempt to identify factors that influence the state of water bodies. Riparian areas, as transitional zones that connect stream and terrestrial systems, are among the most diverse and vulnerable ecological systems. Riparian invertebrates represent important links between aquatic and terrestrial food webs which contribute to maintain resilience at landscape level. Land use changes, waste disposal, overgrazing and nutrient discharge from agricultural sources threaten riparian biodiversity and ecosystems services supply. We assessed the responses of riparian invertebrate communities to changes in the composition, structure and properties of riparian vegetation in an agricultural catchment in Romania. Riparian invertebrates were sampled through visual and sweep-netting methods, in 29 sites with different anthropogenic pressures. Patterns in community composition and diversity are revealed, the relative and shared effects of land use (catchment scale), riparian vegetation and soil type (reach scale) on invertebrate community are discussed, as well as diversity of trophic groups.

SS5_P4_Variation in benthic diatom communities in urban streams and the role of riparian buffers

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Urbanization has altered stream ecosystem worldwide, through having a strong impact on water quality, hydrology and physical habitats, as well as on riparian structure. Rehabilitation of riparian vegetation can have particular value in urban environments in creating “green corridors” that improve instream environmental quality and provide a space for recreation. However, the extent to which riparian buffers help to support in stream biodiversity is unclear. This study, performed within the CROSSLINK project, focuses on the benthic diatom communities, which are often used as suitable indicators for environmental changes, within the Oslo stream network. Our sample sites included paired reaches with and without riparian buffers, as well as reference forested sites and highly impacted downtown sites. The diatom community structure and species richness is examined in the relationship to the degree of urbanization reflected by water chemistry and both in-stream and riparian characteristics. The poster presents summarized major community trends and the occurrence of pollution-sensitive and pollution-tolerant species, also the novel insight into these patterns in the light of both longitudinal and lateral aquatic-terrestrial connectivity in the given stream network. The outcomes of this research will contribute to the management optimization for stream-riparian networks in urban areas.

SS7 Linking habitat heterogeneity, biofilm diversity and biogeochemistry across spatiotemporal scales

SS7_P1_Hydrological history impact on streambed microbes: insights from a multi-site study in the Mediterranean basin

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Microbes inhabiting dry streambeds manifest adaptations to intermittent flow conditions, although the increasing aridity could jeopardize their structure and function. Currently, freshwater intermittent ecosystems are impacted by a range of stressors arising from hydrological and various environmental stressors. This study address insights on whether and to what extent the hydrological history affect streambed microbial communities structure (density, diversity and composition) and functions (extracellular enzyme activities and respiration). To this aim, a network composed of 37 sites was selected including perennial and temporary streams in the Mediterranean region (NE Spain). The hydrology was monitored at each site over 8 months previous to the sampling that occurred during the last warmest autumn of 2016. In parallel, several environmental stressors, both at the site and watershed scale, were measured and considered for further modelling of microbial community responses. Our results show that the environmental sites' characteristics and land use prevail over hydrological history conditions in explaining variation of prokaryotic community diversity and density. Contrariwise, the dryness antecedents shaped significantly the microbial community composition towards a soil-like assemblage. Besides, microbial functional metrics were partially affected by the hydrology history, where remarkable increase of recalcitrant carbon degradation activity at sites with extended dry phase was observed. The global respiration of dried sediments punctually responded to temporary rewetting events, by increasing abruptly. Overall, given the stressors and microbial response variables addressed in this study, dry streambed management should consider prevailing stressors, as land uses and extreme dryness, to preserve in-stream processes carried out by sediment microbiota.

SS7_P2_Characterization of diatom adhesion properties on different substrates: from population to individual scale

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Phototrophic biofilms are essential ecological players acting at the interface between the water column and the sediment. They are complex aggregates of microorganisms among which diatoms often dominate. These microalgae are known to produce copious amount of extracellular polymeric substances (EPS) which provide a physical structure to the biofilm community (i.e. matrix) and influence sediment stability. EPS composition vary due to environmental factors (light, temperature…) which in turn may influence their ecological roles including adhesion and cohesion of the biofilm. However there is still a gap of knowledge to be filled. In this context, this study focuses on the characterization of the link between EPS composition (quantity and quality) and adhesion properties of benthic diatom biofilms. A first experiment was carried out at the population scale. Pure cultures of several common benthic diatoms (*Nitzschia palea, Fistulifera saprophila, Gomphonema gracile* and *Gomphonema parvulum*) were maintained in exponential growth in controlled conditions (18°C, 75 µmol photons/m2/s, 12:12h). The adhesion of each culture on two test surfaces (glass and plastic) was characterized under inverted microscope using a short-term assay. These properties were confronted to the composition of colloidal and bound EPS fractions, characterized by colorimetric assays (total sugar and protein contents) and by GC/MS (monosaccharides profiles). In a second experiment, adhesion properties of *Nitzschia palea* were further characterized at the cellular scale using Atomic Force Microscopy (AFM). The results of this study helps to better understand the role of EPS in shaping benthic diatoms biofilm at micro-habitat scale, which is known to affect its functioning at a larger scale.

SS8 From source to sea – characterization and utilization of organic matter from different sources along the aquatic continuum

SS8_P1_Anthropogenically altered flow affects compositional variance of dissolved organic matter

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Studying the effects of altered flow regimens on the riverine carbon cycle is paramount to update the role of rivers in the transport and transformation of organic matter. However, the effects of flow dynamics – natural or anthropogenic – are so far largely not understood. Dissolved organic matter (DOM) is the largest active carbon reservoir in rivers and its chemically diverse composition and reactivity are determinants for heterotrophic ecosystem functioning. At any one location in a river network, dynamic flow implies temporal variance of DOM composition due to changes in relative input rates among DOM fractions, affected transport rates through upstream portions of the river network, and altered transformation rates during upstream riverine passage. Here, we look into the compositional variance of DOM in rivers whose flow regimes are affected by hydropower production and irrigation. DOM was sampled in 20 streams in the North of Spain at 6 occasions spanning the hydrological conditions of one year (2018). The set of streams covered two different hydrological classes with streams of each experiencing two different types of anthropogenic alteration of flow. We chemically characterize the composition of DOM and its temporal variance by means of optical methods (absorbance and fluorescence) and ultrahigh-resolution mass spectrometry. We expect season-specific compositional changes across all streams, while changes in the hydrology due to anthropogenic alterations will mainly drive the temporal variance of DOM composition.

SS9 Research needs for European water and nature directives

SS9_P1_Chemical discontinuity in the Vjosa river network

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Confluences are biodiversity-rich points in river networks locally contrasting the idea of a smooth riverine continuum. In fact, two strongly environmentally differentiated tributaries may form almost a new river with many environmental factors undergoing dramatic step changes. Especially hydrochemistry, important for microbial communities, may change markedly, although it can show increased temporal stability due to hydrological averaging. Here, we assess concentrations of various solutes within the Greek-Albanian Vjosa river network in two hydrologically contrasting seasons. We hypothesize hydrochemistry to reflect: (i) land cover and geology of the terrestrial matrix, and (ii) upstream riverine processing, i.e. the turnover including removal and de-novo formation of organic and inorganic solutes in the aquatic realm. Discharge likely influences the relative weight of these two forces, as it correlates with land-water interaction and drives residence time in the river network. Our analysis targets the localization of chemical discontinuity and increased temporal stability in the river, which could influence microbial diversity and the formation of biogeochemical hotspots. Conceptually, we postulate a balance between terrestrial influence and intensity of riverine processing: Natural river networks likely switch between states of strong and weak terrestrial influence on in-stream hydrochemistry, implicating the emergence of chemical discontinuity. Strong matrix-driven influence is likely associated with fast transport and little opportunity for riverine processing, whereas weak terrestrial influence is accompanied by intensive processing supported by long residence times. Together with its naturally complex geological setting, moderate land use and intact hydromorphology, the Vjosa can serve as a reference river network at European scale.

SS9_P2_Who is the better candidate? Macroinvertebrates and diatoms for ecological status assessment of Sava Lake (Serbia)

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Sava Lake was created from the right arm of the Sava River, and the inhabitants of Belgrade use the lake intensively for swimming and bathing. We analysed macrozoobenthos and epilithic diatom communities at six sites from April to October 2017, to assess the ecological status of Sava Lake according to the National legislation of Serbia. Considering macrozoobenthos communities, the mean values of Zelinka and Marvan saprobity index indicated high ecological status. In contrast, results obtained from the mean values of BMWP (Biological Monitoring Working Party) scores suggested moderate to poor ecological status. The mean values of the IPS diatom index (Indice de Polluo-sensibilité) indicated high ecological status, while the TDIL index (Trophic Diatom Index for lakes) was slightly more sensitive and indicated good ecological status. Water chemical parameters indicated that Sava Lake was mainly oligotrophic during the study period (average total phosphorus concentrations were 10.7 µgL^{-1} and average total nitrogen concentrations 410 µgL^{-1}). Before being able to adopt an integrative approach for ecological status assessment (combining two or more biological quality elements), more studies must be performed on how to choose the most sensitive and adequate indices. This is especially true for lakes experiencing intensive anthropogenic pressure during the summer season. Also, the boundary values in the National legislation of Serbia must be adapted for lakes, such as Sava Lake.

SS9_P3_Searching for common macroinvertebrate metrics for assessment of ecological status of Western Balkan lakes

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We investigated benthic macroinvertebrates from the littoral zone of six Balkan lakes: Lake Ohrid, Lake Prespa, Lake Lura, Lake Sava, Lake Biogradsko, and Lake Crno, located in North Macedonia, Albania, Serbia and Montenegro, to search for common evaluation metrics to be applied for ecological status assessment. Samples were taken by Kick and Sweep sampling and using a van Veen grab. We sampled in different depths, from six localities in each of the six lakes, and recorded data on water chemistry, habitat heterogeneity and lake typology. A multivariate analysis was carried out to identify the main trends in the macroinvertebrate data, to select reference versus impaired sites, to detect multicollinearity between metrics, and to identify metrics that were independent of lake typology. Several metrics were tested representing structural and functional properties of macroinvertebrates. Our data so far indicate that the best suitable metrics for ecological status assessment of these lakes (which may also be used at regional level) could be some functional metrics as well as indices sensitive to organic pollution, mainly ASPT (Average Score Per Taxon) and BMWP (Biological Monitoring Working Party Score). Our results indicate that these metrics should be ecologically sound for monitoring of lakes and that they provide information relevant for the assessment of ecological status according to the Water Framework Directive, independent of the actual uses of those water bodies.

SS9_P4_Freshwater habitats in Greece: crosswalks between the Habitats and Water Framework Directives

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Freshwater habitats are important biodiversity features in eastern Mediterranean region. Measures need to be taken to maintain and/or improve their status. Greece hosts nine freshwater habitat types of Annex I to Habitats Directive - four standing and five running waters. Among them, Mediterranean temporary ponds (3170*) are priority for conservation. The main pressures that they face include: changes in hydraulic conditions, fertilization and pollution, invasive alien species, changes in abiotic conditions, grazing (only for 3170). According to the Habitats Directive assessment results at national level, during 2001-2006, six habitat types were found at favourable conservation status and three at inadequate one. Results from next reporting period (2007-2012) showed that one habitat type (3150) improved to favourable conservation status and three deteriorated from favourable to inadequate conservation status. Differences were due to increase in knowledge/more accurate data rather than genuine change. Almost all freshwater habitats are also found in inland surface water bodies designated by the Water Framework Directive (WFD). In these water bodies, similar pressures as for habitat types were recorded (e.g. eutrophication, hydromorphological alterations, water abstractions). The assessment system of WFD considers aquatic macrophytes (e.g. typical species of habitat types 3140, 3150) as biological quality elements for the classification of the water bodies' ecological status. Synergies in monitoring efforts will deliver assessment results for both directives more effectively. Improved knowledge of status and trends of freshwater ecosystems is essential in controlling and lifting of pressures, thus helping to achieve the goals of both directives.

SS10 Balkan rivers, be dammed!

SS10_P1_River barriers in the Balkan region: validation of existing database

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Balkan rivers are considered as one of the hotspots for the future construction of dams and hydropower development (Zarfl et al., 2015) and at the same time they are the wildest river ecosystems in Europe. In this work we present the preliminary results of a field survey campaign conducted in summer 2018 in collaboration with the AMBER project (https://amber.international/), to check the distribution, type and frequency of river barriers in the Balkan area. Walking along river banks we surveyed different type and characteristic of barriers in 28 rivers in 8 countries, for a total surveyed length of 550 km. We identified a total of 207 barriers, with the most common type being weirs lower than 0.5 meters, and a mean of 1 barrier every 2.65 km. As expected, compared with other rivers in Europe, the density of barrier in the field is lower, where it can reach up to 1 barrier every km for countries such as Poland, Spain, Switzerland and Wales. Our results highlighted how the Balkan rivers, especially in remote areas, maintain natural hydromorphological features and processes. However, the survey was used to provide an estimate of the accuracy of existing barrier databases collected by the AMBER project for the Balkan area. It emerged that, for the surveyed rivers, the information on barrier presence is scattered or not easily accessible, making difficult an estimation of the potential impact of such structures on Balkan river ecosystems.

SS10_P2_Baseline conditions of greenhouse gas evasion from the undammed Vjosa river network

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Hydroelectric damming is a major driver of freshwater greenhouse gas (GHG) emissions to the atmosphere. Global studies have shown that through flooding and sedimentation, both CO_2 and CH_4 dynamics are altered. Approximately 2500 dams are planned for construction in the Western Balkan in the upcoming years. Hydropower development strongly contrasts the good hydromorphological status of many of the region´s rivers and the high freshwater biodiversity. To contribute to a realistic assessment of environmental implications of dams planned or under construction along the Vjosa River in Albania, we here present an assessment of baseline GHG conditions measured during spring 2018. The study includes in situ CO_2 and CH_4 concentration and flux measurements along a river network length of 300 km, including the main stem and various tributaries from the Pindos mountains in Greece to the Adriatic Sea in Albania. Land cover, geology and hydromorphology are used to understand spatial patterns of GHGs at the river network scale. We advocate the assessment of GHG evasion – prior to development, as projected given local conditions, and after eventual construction – as a component for conservation and development planning and impact assessment. For this, data on baseline conditions must be collected at the local scale, i.e. in yet unmodified river reaches prior to hydropower development, and at the regional scale, i.e. in whole near-natural river networks like the Vjosa in Albania. For the latter, the data and projections in this study inform about possible carbon budget changes due to damming the river – and may guide appropriate decision making.

SS10_P3_Environmental status of Western Balkan rivers threatened by hydropower construction – a preliminary assessment

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The tsunami of planned hydropower plants is one of the most important threats to aquatic biodiversity of rivers in Western Balkan which are known as the most important hotspots of aquatic biodiversity in Europe. In order to identify the most valuable river reaches, in the natural or near natural conditions, we made an assessment of the environmental status of selected rivers, mostly those threatened by planned hydropower plants. In total, 418 rivers were analysed in five Western Balkan countries: Croatia, Bosnia and Herzegovina, Montenegro, Serbia and Albania. Main units of analysis, the Evaluated River Reaches (ERRs), were identified after all river types were distinguished. ERRs are contiguous sections of a river belonging to one river type chosen so that they are approximately homogenous according to elements of environmental condition. The environmental condition of each ERR was assessed by calculating the Index of River Reach Condition, which is a combination of five criteria: hydrology, channel morphology, riparian vegetation, water quality and land use. The final condition of ERR was scored by summing scores for the five criteria (max. 50) and each ERR was categorized in five classes: high, good, moderate, poor and bad. In total, 28,823 km of river length was analysed where 14% was in high and 39% in good condition, while 23% had moderate, 4% poor and 20% bad condition. Protection of ERR of high and good condition would ensure the long-term persistence of the most important features of aquatic biodiversity in Western Balkan.

SS10_P4_River Intellectuals: connecting scientists and conservationists – for free and wild rivers in the Balkans

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The Balkan Peninsula is home to many of the last wild and free-flowing rivers in Europe. The planned construction of more than 3000 dams within the region threatens the survival of these rivers that support hotspots of aquatic biodiversity at the European scale and are essential to the identity and life of local communities. The "River Intellectuals" are a network of conservationists, activists and researchers from the Balkans and the wider European region sharing the concern of river conservation. The network aims to bring together those studying science, technology, the humanities and law with those who do conservation work in their home countries and with activists who volunteer their time and money to protect nature. It also aims to join experienced communities, that have already felt the degrading effects from uncontrolled hydropower and dam constructions, with conservation-minded communities in the Balkan Peninsula that are fighting to keep their still pristine and free-flowing rivers untouched. From July 7 to 13, the network will be kickstarted by the "Students for Rivers" camp, a week-long summer school held in Kobarid, Slovenia, on the banks of the river Soča. By combining lecture-based education with outdoor experience, we will start the process of connecting academia with the world of Balkan river conservation. The "River Intellectuals" wish to become a bridge between science, activism and conservation. With our work, we want to set examples of successful cooperation, while keeping Balkan rivers wild and free.

SS10_P5_Morphological changes in two large river catchments of Kosovo and Albania in the last 50 years

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We present an analysis of the long-term (50 years) morphological changes of several river reaches in the upper Drini i Bardhe river basin in Kosovo, and in the Mat, Seman, Shkumbin and Vjosa river basins in Albania. We performed a multi-temporal satellite and aerial image analysis, and extracted ecologically-relevant morphological indicators. For selected reaches, in-situ field observations have been also obtained. Tributaries of the upper Drini i Bardhe show a pronounced channel narrowing and riverbed incision, without any relevant levee construction. Less marked, similar narrowing has been observed for many unconfined piedmont reaches of the Mat, Seman, Shkumbin and Vjosa rivers. Strong sediment mining has affected the sediment regime of many reaches in the Drini i Bardhe and Mat river basins, and can therefore be considered the major driver of the observed channel adjustment. Cause-effect relations are less clear in nearly pristine river reaches like the Vjosa, where narrowing occurred in the apparent absence of analogous anthropic effects, at least before the late 1970s, when the strongest narrowing has been observed. Despite hydropower is presently receiving major attention as the highest hydromorphological pressure on these and many other Balkan rivers, other effects like sediment mining shall not be underestimated, as they already had a considerable impact on many reaches. We advocate the need of detail studies of the hydro-morphological dynamics of rivers in the Balkan region for which heavy exploitation plans are ongoing, to develop the needed knowledge base to support decision making and the analysis of environmental impacts.

SS10_P6_Grassroots ecology for Balkan rivers – a minimum-funds research network to produce region-wide evidence of hydropower impacts

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Balkan rivers are experiencing a massive escalation in hydropower development unparalleled anywhere in Europe. This is largely prompted by the perceived need for renewable energy to fulfil a European Union Directive (2009/28/EC) through creating publicly subsidized investment opportunities. Decision-making processes sometimes lack evidence-based knowledge and ignore environmental and social impacts. This openly conflicts with Sustainable Development Goals since exceptionally widespread good hydromorphological status, high biodiversity, and significant potential for sustainable development prevail along rivers throughout the Balkans. Evidence-based planning integrating ecological, economic, social and cultural aspects is in some cases apparently not taking place. To address deficiencies in ecological data and risk assessment we here call for formation of a network of researchers motivated to produce scientific evidence for the ecological functioning of Balkan rivers and hydropower impacts. Our motivation is three-fold: (1) Demonstrating our wish to be heard as experts and our ability to produce scientific data that could support wise (trans)national decision-making; (2) Assuming societal responsibility by pinpointing destructive impact and promoting conservation as senior experts while meaningfully fostering careers of young engaged colleagues; and (3) Producing high-quality science with minimum means by collaboratively gathering data at a hitherto unachieved, sub-continental scale. We suggest campaigns aiming at collating data on selected key aspects of 4 domains of ecological knowledge: habitat properties, biodiversity, ecosystem functioning and ecosystem service provisioning. We search for senior partners and young scientists throughout the region and beyond, ready to contribute expertise, facilities and manpower – to produce ecological evidence at a scale matching the current plans for hydropower development.

SS12 Mesocosm approaches to ecosystem-scale questions in freshwaters

SS12_P1_AQUACOSM Research Infrastructure Network offers Transnational Access opportunities to European Aquatic Mesocosm Facilities

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Large-scale experimental mesocosm or enclosure facilities are a powerful tools to obtain mechanistic understanding of complex natural ecosystems and organism interactions, to test complex ecological models, and to assess performance of environmental instrumentation. However, not all scientists and developers have access to such facilities. The EU Research Infrastructure project AQUACOSM – Network of Leading European AQUAtic MesoCOSM Facilities Connecting Mountains to Oceans from the Arctic to the Mediterranean opens for applicants (students, scientists, SMEs, developers, other stakeholders) from all over the world to participate in or lead activities using AQUACOSM partner experimental facilities. As access may be granted for up to 20% participants outside the EU, this allows for global collaborations. We especially encourage persons that do not have access to similar facilities, to apply. In the last call for the 2020 season AQUACOSM will offer >3500 person-days of Transnational Access (TA) to >30 leading and highly complementary European mesocosm facilities located at 19 AQUACOSM partners throughout Europe. The mesocosm facilities represent a cross section of European aquatic ecosystems ranging from the Sub-Arctic to the Mediterranean and beyond, from mountains to lowlands, from freshwater to estuarine and fully marine systems, and spanning from ultra-oligotrophic to hyper-eutrophic conditions. Please join this presentation as well as the following workshop to be announced on the SEFS 11 web portal.

SS12_P2_Use of semiartificial flumes in stream ecology: an overview of simulations to assess anthropic impacts on alpine streams

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The assessment of the ecological impacts of anthropic alteration of stream ecosystems is often difficult due to the presence of confounding and interacting factors. Starting in 2008, we have been using a set of five open-air, stream-side steel flumes, directly fed by a 2nd order gravel-bed Alpine stream (Trentino, NE Italy). The system diverts water directly from the river via a weir into a collecting tank, and the tank feeds five 30 cm wide, 20 m long U-frame metal flumes that contain a sluice gate at the upstream end to control discharge. Hence, periphyton and benthic invertebrates can colonize the substrate naturally and complete their life cycles in the flumes. We have been conducting sets of simulations to disentangle the effects on macroinvertebrates and periphyton of: 1) sudden changes in discharge (hydropeaking) caused by hydropower plant operations; 2) sudden changes of temperature (thermopeaking) associated to hydropeaking; 3) fine sediment waves caused by dam flushes; 4) light pollution; 5) flow intermittency; 6) minimum vital flows. We present the setting of the different simulations, and the main results achieved in terms of alterations of microbenthic communities abundances, composition, and functional groups; of periphytic communities biomass, composition, and nutritional quality.

SS13 Spring habitats: research, assessment tools and conversation efforts

SS13_P1_Mayflies in karst springs: species composition and relation to environmental factors

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Due to the high level of biodiversity, including high number of endemic and rare organisms, springs were recognized as unique habitats of high conservation value. Moreover, they represent an important source of drinking water. Nevertheless, the ecological data related to these habitats and their assemblages are still rather scarce. As mayflies are no exception, we studied composition and abundance of their assemblages in 13 springs in the area of the Dinaric karst in Croatia. All major microhabitats at four different seasons were sampled using the Surber sampler. With 24 recorded species (30 % of Croatian mayfly fauna), this study represents an important contribution to our knowledge of mayflies in karst springs. Moreover, one species of *Rhithrogena* from the group hybrida was for the first time recorded in Croatia. The future steps will include the species identification. In NMDS analysis, perennial and temporary springs generally separated based on their mayfly assemblages. Moreover, temporary springs had lower species richness compared to perennial ones. Mayflies are widely used as bioindicators of freshwater habitats' quality, and our study showed that they can be used as such also in spring habitats. Although springs are generally not mayfly biodiversity hotspot, their fauna showed to be very interesting and should be investigated in more detail. Influence of physical and chemical water properties on recorded mayfly species will also be analysed.