



**SEFS 12**  
**Symposium for**  
**European Freshwater Sciences**

VIRTUAL CONFERENCE | 25–30 JULY 2021 | #SEFS12

# Abstract Book



## Welcome Message

This year, SEFS12 is running as a Virtual Conference due to the uncertainty relating to COVID 19 and the likely continuation of health risks and travel restrictions as well as restrictions relating to indoor gatherings. We deeply regret that we are not able to welcome you in person to Dublin as originally planned. There is no doubt that SEFS12 will be a different experience, but with the platforms available and creative programme design and promotion, we hope to deliver an exciting, welcoming and interactive conference.

This Virtual SEFS12 has the potential for a whole new audience of potential delegates and therefore the expansion of our SEFS community. This is providing an exciting platform and opportunity to communicate our research activities even further afield, as well as allowing for more interesting discussions and side-meetings. Equally, this year's conference may herald a new approach to future SEFS events, re-imagining the online element, which will no doubt become more commonplace in future as we try to reduce the carbon footprint related to air travel and in-person meetings.

We are delivering a typical programme, with parallel sessions, special sessions and poster sessions, and also a sponsor exhibition. We will extend our famous Irish welcome and provide opportunities for network meetings and online social events. Ireland abounds in a wonderful diversity of freshwater habitats that are an integral part of the island's rich and varied landscape. Field excursions have always been an important part of the SEFS programme and Virtual SEFS12 will host them in a unique way. We will give delegates an opportunity to join us on virtual fieldtrips to several interesting places, and unlike in-person trips, there will be no restrictions on the numbers attending or the number of trips that you may join.

Our conference provider is highly experienced in delivering virtual conferences and we will maximise the online facilities available to deliver a conference that meets the expectations of the delegates.

So, we look forward to welcoming you to join us at SEFS12 with an opening ceremony on July 26, 2021.

**SEFS12 Organising Committee - Irish Freshwater Sciences Association**

## Committees

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31. Petr Znachor - CLS, Institute of Hydrobiology, Biology Centre CAS, Czech Republic
32. Mary Kelly-Quinn - University College Dublin, Ireland and Eleanor Jennings - Dundalk Institute of Technology, Ireland (Coordinators)

AFL- French Limnological Society; AIL Iberian Limnological Society; AIOL – Italian Association for Oceanography and Limnology; CLS – Czech Limnological Society; FBA – Freshwater Biological Association; DGL – Deutsche Gesellschaft für Limnologie e.V.; MHT-LS – Hungarian Hydrological Society; PTH – Polish Hydrobiological Society; SER – Romanian Ecological Society; SLS – Slovakian Limnological Society; TLS – The Limnological Society of Turkey; VOL – Association of Austrian SIL members: SIL Austria - SIL-Austria, Austrian Association of Limnology; CAFÉ – Croatian Association of Freshwater Ecologists; IFSA – Irish Freshwater Sciences Association; SWPCS – Serbian Water Pollution Control Society; EFYR – European Fresh and Young Researchers. IBISS – Institute for Biological Research “Siniša Stanković” – National Institute of the Republic of Serbia, University of Belgrade; SGHL- Swiss Society for Hydrology and Limnology.

## Local Organising Committee

1. Mary Kelly-Quinn (Chair) - University College Dublin
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6. Simon Harrison - University College Cork
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# Oral Presentations

## 1A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions

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### Moving towards in-field eDNA monitoring: a CRISPR-Cas Lateral Flow Approach

Molly Williams<sup>1,2</sup>, Prof Fiona Regan<sup>2,3</sup>, Dr Anne Parle-McDermott<sup>1,2</sup>

<sup>1</sup>*School of Biotechnology, Dublin City University,* <sup>2</sup>*Water Institute, Dublin City University,* <sup>3</sup>*School of Chemical Sciences, Dublin City University*

1A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 10:30 - 12:00

Development of simple and rapid techniques to monitor species of conservation importance is vital to further the capabilities of eDNA. Conventional methods for eDNA detection pose a logistical challenge for on-site monitoring due to the need for high temperatures and thermal cycling. To circumvent this, we recently adapted an isothermal RPA-CRISPR-Cas based detection assay for single-species assessment of *Salmo salar* as a route to a cost-effective biosensor device. We subsequently showed its comparability to qPCR, when assessing detection/non-detection, in sampling sets from eastern Canada. To further simplify our assay, we have adapted our method to allow lateral flow visualisation (RPA-CRISPR-Cas-LF). The system utilises the same isothermal Recombinase Polymerase Amplification coupled to CRISPR-Cas12a detection as previously published, however, instead of using an ssDNA fluorophore-quencher reporter for fluorescence readout, the RPA-CRISPR-Cas-LF method employs a dual-labelled FAM-Biotin reporter (ssDNA-FB). This alteration ensures the specificity of the RPA-CRISPR-Cas methodology is maintained, whilst enabling a rapid detection/non-detection assessment of the species of interest. The lateral flow method uses commercially available lateral flow strips (Milenia Biotec) which utilise gold nanoparticle technology to detect the cleavage of the ssDNA-FB reporter when target DNA is present. This means, the sensitivity and specificity of the assay, determined by RPA-CRISPR-Cas, is unaffected. We demonstrate the RPA-CRISPR-Cas-LF method allows detection of *S. salar* tissue at 0.046 pg/ $\mu$ l in an hour at 37 °C and only requires an incubator. This further progresses the field of eDNA towards field-based applications, by removing the need for complex instrumentation and allowing rapid species detection.

## Temporal dynamics of eDNA in disconnected pools of temporary rivers

**Dr Cesc Múrria<sup>1</sup>**, Mr Ricard Fontseré<sup>1,2</sup>, Nieves López-Rodríguez<sup>1,2</sup>, Mr Guillermo Quevedo-Ortiz<sup>1,2</sup>, Dr Joan Gomà<sup>1,2</sup>, Dr Francesc Gallart<sup>1,4</sup>, Dr Pilar Llorens<sup>1,4</sup>, Dr Jérôme Latron<sup>1,4</sup>, Narcís Prat<sup>1,3</sup>, Mr Pau Fortuño<sup>1,2</sup>, Dr Dolors Vinyoles<sup>2</sup>, Dr Núria Cid<sup>1,5</sup>, Raúl Acosta<sup>1,2</sup>, Dr Miguel Cañedo-argüelles<sup>1,3</sup>, Mr Jose M. Fernández-Calero<sup>1,2</sup>, Dr Cayetano Gutiérrez-Cánovas<sup>1,6</sup>, Dr Maria Soria<sup>1,2</sup>, Iraima Verkaik<sup>1,2</sup>, Dr Núria Bonada<sup>1,2</sup>

<sup>1</sup>Freshwater Ecology, Hydrology and Management (FEHM) Research Group, UB-CSIC, <sup>2</sup>Departament de Biologia Evolutiva, Ecologia i Ciències Ambientals, Facultat de Biologia, Institut de Recerca de la Biodiversitat (IRBio), Universitat de Barcelona (UB), <sup>3</sup>Departament de Biologia Evolutiva, Ecologia i Ciències Ambientals, Facultat de Biologia, Institut de Recerca de l'Aigua (IdRA), Universitat de Barcelona (UB), <sup>4</sup>Institute of Environmental Assessment and Water Research (IDAEA), CSIC, <sup>5</sup>INRAE, UR RiverLy, Centre de Lyon-Villeurbanne, Villeurbanne Cedex, <sup>6</sup>Departamento de Ecología Integrativa, Estación Biológica de Doñana (EBD – CSIC)

1A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 10:30 - 12:00

Temporary rivers are characterized by progressive shifts in hydrological conditions from flowing waters to disconnected pools and dry phases. These hydrological changes result in shifts in community composition: species inhabiting flowing waters are replaced by species found in lentic habitats, which gradually disappear as the dry phase becomes dominant. These biological changes can be tracked using DNA-based community inventories, which provide identification at species level of unknown, rare and cryptic species or juvenile life stages. The metabarcoding of environmental DNA (eDNA) is specially well-suited for this purpose due to its non-invasive sampling nature. We assessed the short-term dynamics of eDNA and its effectiveness for detecting community changes. We sampled eDNA from water and sediments in two disconnected pools in each of three pristine temporary rivers that cover a gradient of hydrological and environmental conditions. The transition in hydrological conditions were sampled every two weeks from July to October 2020, when the pools completely dried up. Several environmental parameters were measured in the field (pH, salinity). DNA was extracted, amplified using the Leray-XT primers for the *cox1* gene and massively sequenced. The temporal variation of eDNA captured the transition in community composition over hydrological phases (e.g. temporal changes in ratio lotic/lentic species) and provided higher diversity and finer taxonomic resolution than morphological-based identification. Diversity decreased as total water depth was reduced. Overall, our results contribute to fundamental and methodological knowledge on the temporal composition of eDNA in dynamic environments such as disconnected pools in temporary rivers, which remains poorly explored.

## eDNA metabarcoding in the dynamic desert river system Draa, Morocco.

**Maren Nothof**<sup>1</sup>, Elyssa Dubois<sup>1</sup>, Khawla Lazrak<sup>3</sup>, Dr Elisabeth Berger<sup>2</sup>, Dr Sabine Filker<sup>1</sup>

<sup>1</sup>University of Kaiserslautern, <sup>2</sup>University of Koblenz-Landau, <sup>3</sup>University of Cadi Ayyad

1A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 10:30 - 12:00

Freshwater systems play pivotal roles for us humans providing multiple ecosystem services. Especially in Morocco, water is one of the most valuable commodities, mainly being used as drinking water or for agricultural purposes. Both climate change and the excessive use of water resources in catchment areas are enhancing a decrease in groundwater levels and salination of soils and water bodies. Increasing salinisation endangers human well-being by reducing drinking water quality and agricultural yields and also affects biodiversity, health and function(ing) of ecosystems. The Draa river valley located in southern Morocco thus appears as an ideal model for affected arid regions allowing a glimpse into the potential future of most freshwater systems. Due to their short generation times and rapid response to changing conditions microbes are supplying a reliable insight into ecosystem health and dynamics. We, thus, used eDNA metabarcoding to investigate (i) microeukaryotic and prokaryotic biodiversity and community compositions along the Draa river valley, (ii) impacts of environmental factors on community structures, (iii) specific microbial distribution patterns and (iv) aimed to identify environmental indicator species. Our results provide a baseline for follow-up experiments on future impact scenarios of climate change.



## Ecological assessment of Swiss rivers using eDNA for the monitoring of macroinvertebrates

Jeanine Brantschen<sup>1,2</sup>, Dr Rosetta Charlotte Blackman<sup>1,2</sup>, Dr Jean-Claude Walser<sup>3</sup>, Prof. Dr Florian Altermatt<sup>1,2</sup>  
<sup>1</sup>Eawag, <sup>2</sup>University of Zurich, <sup>3</sup>Genetic Diversity Center, ETH

1A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 10:30 - 12:00

Anthropogenic activities are changing the state of ecosystems worldwide, affecting community composition and resulting in the loss of biodiversity. Riverine ecosystems are among the most impacted. Documenting their current state with regular monitoring is important to assess the future trajectory of biodiversity. Monitoring methods based on genetic markers offer cost- and time-efficient approaches for routine ecological assessments. Here, we compare environmental DNA (eDNA) to traditional kick-net sampling in a surface water quality assessment at 92 sites spread across Swiss river catchments. The diversity of macroinvertebrate indicator communities was surveyed and the biological state assessed through a biotic index. The eDNA metabarcoding data was taxonomically assigned using a customised reference database. All zero-radius Operational Taxonomic Units (zOTUs) mapping to one of the 142 traditionally used indicator taxon levels ( $n = 205$ ) were used for subsequent analyses. At the site level, alpha diversity was correlated weakly between kick-net and eDNA data. However, we found strong congruence between the two methods on a gamma diversity level, as the same indicator groups were commonly detected. Further, we trained random forest models to predict the biological state of the sampled rivers using zOTUs as predictive features. The majority of the predictions (71%) resulted in the same classification as inferred from kick-netting. Thus, the sampling of eDNA validly detected indicators and provided valuable classifications of the biological state of rivers. Monitorings based on genetic markers have the potential to complement traditional surveys of macroinvertebrates in routine large-scale assessments in a non-invasive and scalable manner.

## eDNA metabarcoding biodiversity of freshwater fish in the Alpine area

**Giulia Riccioni**<sup>1</sup>, Dr Isabelle Domaizon<sup>2</sup>, Dr Andrea Gandolfi<sup>1</sup>, Dr Massimo Pindo<sup>1</sup>, Dr Marine Vautier<sup>2</sup>, Dr Rainer Kurmayer<sup>3</sup>, Dr Peter Hufnagl<sup>4</sup>, Dr Stefanie Dobrovolny<sup>4</sup>, Dr Valentin Vasselon<sup>5</sup>, Hans Rund<sup>3</sup>, Dr Jonas Bylemans<sup>1,6</sup>, Dr Nico Salmaso<sup>1</sup>, Dr Josef Wanzenböck<sup>3</sup>

<sup>1</sup>Edmund Mach Foundation, Research and Innovation Centre (CRI), <sup>2</sup>INRAE, Université Savoie Mont Blanc, CARRTEL, <sup>3</sup>University of Innsbruck, Research Department for Limnology, <sup>4</sup>AGES, Österreichische Agentur für Gesundheit und Ernährungssicherheit GmbH, <sup>5</sup>OFB, Office français de la biodiversité, <sup>6</sup>University of Lausanne, Department of Ecology and Evolution

1A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 10:30 - 12:00

Environmental DNA (eDNA) based methods are proving to be a promising tool for freshwater fish biodiversity assessment in Europe within the Water Framework Directive (WFD, 2000/60/EC) especially for large rivers and lakes where current fish monitoring techniques have known shortcomings. Many freshwater fish are experiencing critical population declines with risk of local or global extinction because of intense anthropogenic pressure and this can have serious consequences on freshwater ecosystem functioning and diversity. Within the EU project Eco-AlpsWater, advanced high throughput sequencing (HTS) techniques are used to improve the traditional WFD monitoring approaches by using environmental DNA (eDNA) collected in Alpine waterbodies. An eDNA metabarcoding approach specifically designed to measure freshwater fish biodiversity in Alpine lakes and rivers has been extensively evaluated by using mock samples within an intercalibration test. This eDNA method was validated and used to study fish biodiversity of eight lakes and six rivers of the Alpine region including four EC countries (Austria, France, Italy, Slovenia) and Switzerland. More in detail, this metabarcoding approach, based on HTS sequencing of a section of the 12S rRNA gene, was used to assess freshwater fish biodiversity and their distribution in the different habitats. These data represent the first attempt to provide a comprehensive description of freshwater fish diversity in different ecosystems of the Alpine area confirming the applicability of eDNA metabarcoding analyses for the biomonitoring of fish inhabiting Alpine and perialpine lakes and rivers.

## Using eDNA to describe spatio-temporal biodiversity patterns and food-web dynamics

**Dr Rosetta Blackman**<sup>1,2</sup>, Dr Jean-Claude Walser<sup>3</sup>, Dr Hsi-Cheng Ho<sup>1</sup>, Prof. Dr Florian Altermatt<sup>1,2</sup>

<sup>1</sup>Eawag: Swiss Federal Institute of Aquatic Science and Technology, <sup>2</sup>University of Zürich, <sup>3</sup>Genetic Diversity Centre, Federal Institute of Technology (ETH)

1A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 10:30 - 12:00

Freshwater ecosystems are facing immense anthropogenic pressures, including global climate change, over abstraction, pollution and invasions by non-native species. In order to identify threats and protect biodiversity in freshwater systems, we must learn to understand communities encompassing spatially relevant scales and temporal dynamics. Here, we used high resolution and temporally replicated environmental DNA sampling across a complex river system to look at biodiversity across three groups (vertebrate, invertebrate and bacteria). By constructing local food-webs based on known interactions among the genera we detected, we show how biodiversity patterns and food-web characteristics change over space and time. Our study shows these dynamics are not congruent in space and time and highlight the importance of examining ecosystems in this way to understand the state of the ecosystem.

## 1B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges

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### Refining global spatial conservation planning considering freshwater biodiversity, environmental uniqueness, and connectivity

Maria Magdalena Üblacker<sup>1</sup>, Dr Jaime García-Márquez<sup>1</sup>, Dr Sami Domisch<sup>1</sup>

<sup>1</sup>*Leibniz Institute of Freshwater Ecology and Inland Fisheries*

1B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges, July 26, 2021, 10:30 - 12:00

Global freshwater biodiversity is in a constant decline and more efficient protection schemes are needed. To date, however, existing protected areas are rarely tailored towards freshwater biodiversity and habitats since they do not account for freshwater species or longitudinal connectivity along hydrographical networks. In addition, coarse spatial data resolution and related data uncertainties further limit systematic spatial conservation planning. This study addresses these limitations and aims to identify freshwater regions that are potentially deemed irreplaceable regarding their environmental uniqueness, connectivity, and their importance for freshwater biodiversity. We first delineate sub-catchments of individual stream reaches at a spatial resolution of ~90m globally. To identify environmentally unique freshwater habitats, we aggregate environmental catchment characteristics and human stressors, and employ a k-means cluster analysis. In addition, we determine the relative importance of stream reaches regarding the river network connectivity using betweenness centrality indices and patch-based graphs. The resulting clustered sub-catchments and connectivity indices are then combined with Species Distribution Models (SDMs) of aquatic insects and implemented in integer linear programming (ILP) solvers to identify potential areas for protection. The talk will outline the overall project and present first results of the cluster analysis.

## Comparative macroinvertebrate analyses of mountain rivers in the Alps and the Altai

**Dr Martin Schletterer**<sup>1,2</sup>, Roberta Bottarin<sup>3</sup>, Alberto Scotti<sup>3</sup>, Wolfgang Lechthaler<sup>4</sup>, Luibov V. Yanygina<sup>5,6</sup>

<sup>1</sup>TIWAG - Tiroler Wasserkraft AG, <sup>2</sup>Institute of Hydrobiology and Aquatic Ecosystem Management, University of Natural Resources and Applied Life Sciences, Vienna, <sup>3</sup>Institute for Alpine Environment, EURAC Research, <sup>4</sup>EUTAXA - Consulting Engineer for Biology, <sup>5</sup>Department of Zoology and Biochemistry, Altai State University, <sup>6</sup>Institute for Water and Environmental Problems, Siberian Branch of the Russian Academy of Sciences

1B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges, July 26, 2021, 10:30 - 12:00

Rivers experience different anthropogenic impacts and stressors. Therefore, the ALFFA project (INTERREG ITAT1041) focused on the analyses of multiple stressors in different alpine catchments of the Danube and Adige River. We sampled 81 points across 22 sub-catchments in the region of Tyrol (Austria and Italy), covering an altitudinal range between 219 and 1800 m asl. Macroinvertebrate sampling was carried out in early spring 2018, using a multi-habitat-sampling method. Overall, we identified 407 Taxa, including new species to the region. In the Altai Mountains, macroinvertebrates were sampled at 34 sites located at altitudes from 134 to 1724 m asl. The sampling sites are located within the Russian Altai and belong mainly to the basins of two major tributaries of the Ob River (Biya and Katun River). Samples were taken during the autumn-winter low-flow period 2010 and 126 macroinvertebrate taxa have been identified. We compared monitoring data from geographically distant, but ecologically similar habitats. The analyses of biological indices and traits show clear differences between upper and lower courses as well as regional specifics. Our study reveals the functional characteristics of benthic invertebrates along an altitudinal gradient and supports the analyses of anthropogenic stressors. The data from the Altai mountains provides a basis to analyse species traits in least disturbed catchments, i.e. with minor hydromorphological changes and very low human activities. Our case study highlights the importance of the biological quality element macroinvertebrates for the analyses of the ecological status of water bodies and the comparison of different catchments.

## Environmental change threatens freshwater insect communities in Northwest Africa: a meta-analysis

Nils Kaczmarek<sup>1</sup>, Dr Ralf Schäfer<sup>1</sup>, Dr Elisabeth Berger<sup>1</sup>

<sup>1</sup>*Institute for Environmental Sciences, University of Koblenz-Landau*

1B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges, July 26, 2021, 10:30 - 12:00

A climatic shift from temperate to arid conditions is predicted for Northwest Africa. Temperature, electrical conductivity, and river intermittency are likely to increase, which may impact freshwater communities that are important for maintaining ecosystem functioning and related ecosystem services. Quantitative data and information on the impact of climate change on insect communities (e.g., family richness, community and trait composition) are still scarce for Northwest Africa. In this study, we extracted information on freshwater insect occurrence and environmental variables in Northwest Africa from the results of a literature search to study potential consequences of changing climatic conditions for these communities. Our data set covered 96 insect families in 165 sites. We quantified the impact of environmental variables (climate, altitude, water temperature, conductivity, intermittency, flow, aridity, dams and land cover) on invertebrate richness, community and functional trait composition using multiple regression analysis and constrained ordination. Family richness in arid sites was on average 37 % lower than in temperate sites, where flow, river regulation and electrical conductivity were the major explanatory variables in statistical modelling. With 36 % of temperate sites predicted to turn arid in the coming decades, a loss of insect families can be predicted for Northwest Africa, mainly affecting species adapted to temperate environmental conditions. Resistance and resilience trait modalities such as small size, aerial dispersal and the ability for air breathing promote survival in arid climate. Future research should take species level into account to better predict climate change effects on local insect communities and ecosystem functioning.

## Effects of macrophytes on lentic macroinvertebrate assemblage and implications for water management

**Benjamin Misteli**<sup>1</sup>, Nompumelelo Catherine Baso<sup>2</sup>, Lorraine Kengme Fosso<sup>3</sup>, Dr Sarah Faye Harpenslager<sup>4,5</sup>, Frédéric Labat<sup>1,6</sup>, Dr Samuel Nkopane Motitsoe<sup>7</sup>, Dr Gabrielle Thiebaut<sup>1</sup>, Dr Alexandrine Pannard<sup>1</sup>, Dr Christophe Piscart<sup>1</sup>

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1B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges, July 26, 2021, 10:30 - 12:00

The structure and complexity of freshwater ecosystems shape the macroinvertebrate community inhabiting this environment. Macrophytes can play an important role in structuring aquatic communities by increasing heterogeneity, especially in lentic ecosystems. They can modify environmental conditions such as the availability of oxygen, nutrients, and light. Furthermore, macrophytes can provide additional habitat, shelter against predators, and food resources for macroinvertebrates. Aquatic macrophytes can thus promote diversity and abundance of macroinvertebrates but results vary strongly among different freshwater ecosystems, plant types, and plant density. In this study, we sampled macroinvertebrates within macrophyte stands and in nearby plant-free habitats from multiple study sites in Africa and Europe. The aim of this cross-continent study was to find global and local patterns of the effects of macrophytes on macroinvertebrates. Overall, we found higher macroinvertebrate diversity and abundance within macrophyte stands. Furthermore, we identified the plant's growth form (e.g. submerged or floating) as an important explanatory variable determining the magnitude of the impact. Differences found in macroinvertebrate communities with and without macrophytes also provide new insights into the sampling efficiency across different habitats. To fully cover the increased macroinvertebrate diversity, one can expect that more samples should be collected from macrophyte stands compared to plant-free sites. Our results therefore not only provide insight into the effect of macrophytes on macroinvertebrate communities but also support water managers and researchers to improve assessment of these communities in freshwater sites harboring macrophytes

## Benthic invertebrate community composition of small water bodies in an agricultural landscape

**Fee Trau**<sup>1</sup>, Stefan Lorenz<sup>1</sup>

<sup>1</sup>*Julius Kühn-Institut*

1B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges, July 26, 2021, 10:30 - 12:00

There is growing awareness that small water bodies (SWB) are important freshwater habitats. Due to their strong dynamics, they represent a unique habitat. SWB can act as biodiversity hotspots and stepping-stone biotopes in a landscape where agriculture is prevailing. On a regional level they host more species and also more rare species compared to other water body types. However, intensive agricultural practices can lead to habitat losses or water quality degradation that in turn lead to biodiversity declines and especially to a decrease in insect diversity. Biodiversity loss can result in a shift from species diverse communities, including a lot of specialized taxa, to more simplified associations dominated by generalists. This can have wide ranging cascading effects on other trophic levels and consequently on the whole ecosystem and its functions.

This study is based on a comprehensive dataset from more than 100 SWB sampled for benthic invertebrate diversity as well as for criteria describing water quality and surrounding landscape parameters. The benthic invertebrate communities of SWB located in the northeast German lowlands are described. This results in new insights into the community composition of different SWB and on the distribution of insects and other invertebrates in the study area. Indicator species will be derived for SWB clusters. With this set of indicator species agricultural measures promoting the indicator species should consequently lead to a general promotion of the invertebrate communities and thus bring forward conservation approaches.



## Mapping global freshwater insect biodiversity at a fine spatial resolution

**Afroditi Grigoropoulou**<sup>1</sup>, Dr Jaime García-Márquez<sup>1</sup>, Dr Sami Domisch<sup>1</sup>

<sup>1</sup>*Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB)*

1B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges, July 26, 2021, 10:30 - 12:00

Along with the ongoing decline in freshwater biodiversity emerges the urgent need to protect what is being threatened. The accurate mapping of global freshwater habitats and biodiversity at a fine resolution is fundamental for assessing their vulnerability and directing effective conservation planning.

Our work is one of the first coordinated efforts to map freshwater habitats and capture the actual spatial patterns of aquatic biodiversity on a fine resolution, at the global extent. We are using a newly developed seamless, standardized stream network of 90m spatial resolution to model the potential genus distributions of four insect orders that are used as proxies for the overall state of freshwater biodiversity (Ephemeroptera, Plecoptera, Trichoptera and Odonata; EPTO). In this talk, we will explore the environmental and topographical variables that mostly influence EPTO distributions based on an extensive dataset of insect occurrence records and the Random Forest algorithm. The most relevant predictors will be used for mapping genus distributions using spatially explicit Species Distribution Models (SDM), taking into account the connectivity between basins. The output of these analyses will aid in indicating irreplaceable habitats worldwide under a novel freshwater-specific spatial conservation planning framework.

## 1C\_SS14 Securing and managing biodiversity, functional integrity and ecosystem services in drying river networks

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### A global perspective on functional responses of stream communities to flow intermittence

**Dr Julie Crabot<sup>1</sup>**, Cédric Mondy, Philippe Usseglio-Polatera, Dr Ken Fritz, Professor Paul Wood, Dr Michelle Greenwood, Dr Michael Bogan, Prof. Dr Elisabeth Meyer, Dr Thibault Datry

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1C\_SS14 Securing and managing biodiversity, functional integrity and ecosystem services in drying river networks, July 26, 2021, 10:30 - 12:00

Due to global change, an increasing proportion of river networks are drying and shifts from perennial to non-perennial flow regimes represent ecological thresholds with dramatic and irreversible changes to community and ecosystem dynamics. However, there is minimal understanding of how biological communities respond functionally to drying, which can weaken the functional integrity of river networks and disrupt the services provided to society. Here, we shed light on the taxonomical and functional responses of aquatic macroinvertebrate communities to flow intermittence across river networks from 3 continents, to test predictions emerging from underlying trait-based conceptual theory. We predicted a high functional redundancy resulting from niche selection filtering taxa from adapted to drying, increasing flow intermittence to be associated with a reduction of taxonomic alpha diversity but not functional diversity, and a selection of specific trait modalities related to resistance or resilience to flow intermittence. Surprisingly, functional redundancy declined sharply with increasing flow intermittence: even weakly intermittent sites were functionally altered relative to perennial ones. Both taxonomic and functional alpha diversity decreased with flow intermittence. Last, a set of functional trait modalities including small body size, short life span and high fecundity were selected with increased flow intermittence. These results demonstrate the functional responses of river communities to drying and suggest that on-going biodiversity reduction due to global change in drying river networks is threatening their functional integrity.

## Responses of macroinvertebrate communities to a flow recession in mixed bedrock-alluvial streams

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Long periods of flow recession, streambed drying, and flow resumption are key components of hydrological droughts, but can impact ecological functioning and the stability of lotic communities. In this study, we examined benthic macroinvertebrate diversity and community composition during a flow recession and streambed drying in four distinct habitats within two temperate, bedrock dominated headwaters. The habitats included bare bedrock, bedrock covered with moss (e.g. *Fontinalis squamosa*), and pebble clusters in a mixed bedrock-alluvial reach, and gravel patches in a nearby alluvial reach. Taxonomic approaches indicated significant differences in macroinvertebrate alpha and beta diversity during lotic conditions in spring and through out the flow recession and upon flow resumption. Post flow resumption, alpha and beta diversity were significantly lower in all habitats, especially in bedrock habitats dominated by *Fontinalis squamosa*. Faunal traits (including respiration, locomotion, and substrate preferences) also identified the effects of the flow recession on macroinvertebrate communities, but the findings were not as clear. Our results highlight that flow recession and drying initiate decreases in lotic diversity, but recovery of macroinvertebrate communities following a flow recession and drying depends on the substrate and vegetation characteristics of habitat patches. Identifying the ecological recovery of invertebrate communities following streambed drying from different habitat patches can provide useful information for effective biodiversity conservation and management programmes.

## Behaviour of *Cordulegaster heros* (Odonata) larvae in a simulated drought experiment

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In case of dryings, the hyporheic zone is one of the most important refugia for stream macroinvertebrate communities, including the few Odonata species living in these habitats, such as *Cordulegaster* species. There is no information on the desiccation resistance strategies and methods for any members of the genus, including *Cordulegaster heros*. We hypothesized that the larvae use burrowing behaviour to survive droughts. In this study, beyond recording the survival rates of the larvae, we tested the effects of the sediment particle size and the body size of the larvae on burrowing behaviour in a three-week-long simulated drought experiment in an indoor artificial stream system. Eighty larvae were involved in the experiment from which sixty were treated with drought and twenty served as controls. Larvae were put into flowing water, into separate special compartments; one day later the flow was ceased and then the water level was gradually decreased for three weeks. Approximately 15% of larvae could survive the three weeks of drying. The survival probability of drought treated larvae was significantly increased if animals burrowed into the sediment. Also, the survival probability was higher in case of fine substrate material. Size of the larvae only affected the depth of the burrowing, but not the survival rate. However, two thirds of the larvae did not dig into the sediment, which implies that surviving via burrowing is not the only mechanism of the species for withstanding dry periods.

## Experimental flow intermittency affects alpine stream macroinvertebrates (Val Roseg, Switzerland)

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Changing weather patterns and receding glaciers are increasing flow intermittency in alpine streams globally, with strong effects on biodiversity and functional processes. We conducted a before-after-control-impact (BACI) flow experiment to examine the effects of increased summer intermittency on an alpine headwater stream. We monitored macroinvertebrates, periphyton and benthic organic matter over three years. Flow in one channel was manipulated to simulate the onset of increased summer intermittency (June-September) over two consecutive years, while an adjacent channel served as a control. Before manipulation, both channels had similar ecological properties. Multi-year flow manipulation caused a reduction in rheophilic macroinvertebrate density, macroinvertebrate density and taxa number. Periphyton and benthic organic matter did not differ between channels. Recovery of the macroinvertebrate community following the experimental flow intermittency took over a year, which is discussed in the context of macroinvertebrate life histories, dispersal limitation and biotic interactions. Climate change induced shifts in stream flow regimes may lead to a fundamental shift in macroinvertebrate assemblages with local extinctions of specialized rheophilic species.

## Characterization of the diatom distribution in a temporary, continental river through time

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Diatoms are photosynthetic organisms of both marine and freshwater habitats that are able to survive and resist desiccation following connectivity loss in temporary streams. The intensive studies in recent years have shown, that ecological and population disruption can have an effect on the ecological quality of the water. Most of the studies on temporary streams have focussed on tropical and subtropical climates, due to their immediate danger regarding climate change driven droughts. However, also continental (oceanic) climates have shown an increasing tendency for summer droughts, and studies are also starting to focus on the rivers of these climates. In this study we characterize a karstic and naturally occurring temporary stream in the Paderborn plateau as a proxy for climate dependent variation through two main seasons, spring and autumn. We found that diatom resistance to drought and survival was higher at the first part of the year. Diatom species and functional composition varied according to aquatic regime more than due to time. In comparison with neighbouring permanent rivers, diatom species diversity did not vary, as long as dampness sufficed. Our results point out that continental karstic rivers could be used as proxies to tropical/subtropical temporary rivers and could also be a base for the creation of a hydrology-independent water quality index.

## Every path has its puddle: conservation and management of isolated pools

**Dr Miguel Cañedo-argüelles<sup>1,3</sup>**, Pau Pau Fortuño<sup>2,3</sup>, Dr Francesc Gallart<sup>3,4</sup>, Dr Jérôme Latron<sup>3,4</sup>, Dr Pilar Llorens<sup>3,4</sup>, Dr Francesc Múrria<sup>2,3</sup>, Dr Maria Soria<sup>2,3</sup>, Dr Dolors Vinyoles<sup>2</sup>, Prof. Daniel von Schiller<sup>1</sup>, Dr Núria Cid<sup>3,5</sup>, Dr Núria Bonada<sup>2,3</sup>

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Temporary rivers are characterized by shifting habitats between flowing, isolated pools and dry phases. Despite the fact that they are currently receiving increasing attention by researchers and managers, the isolated pools phase has been largely disregarded. However, isolated pools in temporary rivers are transitional habitats of major ecological relevance as they support aquatic ecosystems during no-flow periods, and can act as refuges for maintaining local and regional freshwater biodiversity. Pool characteristics such as surface water permanence and size, presence of predators, local physicochemical conditions, time since disconnection from the river flow or distance to other freshwater habitats challenge a comprehensive understanding of the ecology of these habitats, and compromise ecological quality assessments and conservation practices in temporary rivers. In this presentation we will provide a characterization of isolated pools from a hydrological, geomorphological, physicochemical, biogeochemical and biological point of view as a framework to better conceptualize, conserve and manage these habitats.

### H-CSIA reveals LC-PUFA buffering capacity of zooplankton in eutrophic freshwater ecosystems

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1D\_SS02 Freshwater food webs in the Anthropocene, July 26, 2021, 10:30 - 12:00

Essential micronutrients, such as omega-3 polyunsaturated fatty acids (PUFA), are produced at the base of the food web and important drivers of food web dynamics. For many consumers, the conversion of the essential precursor alpha-linolenic acid to omega-3 long-chain (LC) PUFA is limited and they thus rely on the dietary provision of LC-PUFA. Climate change is predicted to induce a shift in phytoplankton communities towards species depleted in LC-PUFA. The aim of this study was to investigate how zooplankton contributes to the provision of LC-PUFA for higher consumers in eutrophic ponds with low LC-PUFA content in seston. We first performed lab experiments quantifying the changes in deuterium values based on food quality and changing water isotopic values. Zooplankton integrates hydrogen from environmental water into de novo synthesized or converted fatty acids, thus enabling a discrimination between dietary allocated and converted EPA. We then investigated nine eutrophic ponds used for carp farming and calculated models based on d2H values predicting the origin of EPA in consumers. At <0.5 mg EPA per g dry weight in seston, the conversion model correlated much better with zooplankton EPA d2H values than d2H values of seston EPA. Furthermore, the d2H values of EPA and DHA in carp, fed with terrestrial pellet feeds, matched those of zooplankton and not those of pellets or insects. We concluded that zooplankton act as an important buffer for LC-PUFA by increasing conversion activity upon decreasing LC-PUFA levels in seston and therefore increase the dietary quality for higher consumers.



## One step ahead: dietary tracers may help managers better adapt to invasions

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1D\_SS02 Freshwater food webs in the Anthropocene, July 26, 2021, 10:30 - 12:00

Invasive dreissenid mussels have substantially impacted food webs in large freshwater systems across North America and western Europe. Ecosystem impacts include a shift from pelagic to benthic production and, consequently, declines of ecologically important invertebrate and fish species. The predictability of these impacts can inform expectations of future system productivity – but only if the food web structure is well described. In Lake Champlain (Vermont, USA), a quagga mussel (*Dreissena bugensis*) invasion is imminent and expected to stress forage fish populations by reducing primary and secondary production. Further, a recent surge in wild lake trout (*Salvelinus namaycush*) recruitment, added to constant stocking of hatchery-produced lake trout, may increase top-down pressure on the forage fish community. We evaluated the risk quagga mussels pose to forage fishes alewife (*Alosa pseudoharengus*) and rainbow smelt (*Osmerus mordax*) using dietary tracers to map energy pathways (benthic vs pelagic) throughout the open-water season. We constructed MixSIAR models using bulk stable isotopes with stomach contents as priors, and analyzed fatty acid profiles and deuterium of fatty acids on a subset of samples. Preliminary results suggest the pelagic energy pathway is dominant for both species, leaving them vulnerable to the impacts of a quagga invasion. Alewife may be more at-risk than rainbow smelt, given their narrower diet breadth. Therefore, adjusting piscivore stocking rates may relieve pressure on forage fish after quagga mussels arrive in Lake Champlain. Using a variety of dietary tracers provides a robust approach to evaluating how food webs may respond to species invasion.

## Rapid evolution of Daphnia life history traits due to changing trophic states

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Due to human population growth, the anthropogenic pressure on many freshwater ecological systems increased significantly. In particular, numerous lakes worldwide increased in their trophic state. Anthropogenic eutrophication drives cascading ecological effects by changing the phytoplankton community structure with mass development of cyanobacteria being often triggered. These are considered to be a low quality food for zooplankton primary consumers by causing mechanical disruption, having nutritional deficits or by toxin production. Greifensee (Switzerland) is a lake that began to be eutrophicated around 1930 and peaked in 1974. This high trophic status promoted mass developments of the potentially toxic cyanobacterium *Microcystis*. After 1974, P and N concentrations from water decreased continuously until the present time so that the lake went through a so-called re-oligotrophication process. In the present study, we used a resurrection ecology approach to test the hypothesis that *Daphnia* clones, originating from high trophic periods, cope better with *Microcystis* compared to clones originating from periods of lower trophic periods. *Daphnia* hatched from recent and older sediment layers were fed 3 food types: toxic and non-toxic *Microcystis* strains and high quality food (*Acutodesmus*), during a full factorial life-history experiment. We found that “older” *Daphnia* clones have enhanced coping mechanisms to the presence of *Microcystis* and its toxin (presented a higher rate of population increase – i.e.  $r$ ). Nonetheless, “older” clones responded better on high quality food too. Our study suggests that some genotypes can adapt fast to shifting environments while others can be outcompeted and removed from the zooplankton community.

## Exploring the winter web - trophic ecology under lake ice

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1D\_SS02 Freshwater food webs in the Anthropocene, July 26, 2021, 10:30 - 12:00

Subarctic lakes are predominantly fuelled by benthic primary production, however seasonal phyto- and zoo-plankton blooms offer a temporary but highly nutritious additional food source to consumers within these lakes. Research in these systems is generally restricted to the summer 'ice-off' period, possibly biasing our interpretation of annual trends in consumer trophic ecology and overall ecosystem function. We combined stable isotopes of carbon and nitrogen with stomach content data to assess food web structure during the ice-off (September) and ice-on (March) phases in nine subarctic lakes in Finnish Lapland. We observed a seasonal change in resource use of most fishes from pelagic and generalist in summer to benthic specialist in winter, this was accompanied by a decrease in dietary and isotopic niche width in most species and an overall reduction in food web breadth. Characterisation of lake food web structure solely using data derived from summer sampling fails to account for the trophic dynamics within these systems during the winter 'ice-on' period.

## Ontogenetic scaling of the temperature and size dependence of functional responses

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1. Body size and temperature determine the strengths of trophic interaction and hence affect the structure and stability of freshwater food webs in the warming world.
2. Our understanding of the temperature and size scaling of trophic interaction strengths derives primarily from analyses across taxa. However, trophic interaction strengths also change during ontogeny as individuals of many freshwater taxa grow substantially in size during their development.
3. The relevance of the reported interspecific scaling patterns for ontogenetic scaling remains poorly understood. To fill this gap, we measured the ontogenetic scaling of the temperature and size dependence of functional responses in multiple dragonfly larval instars.
4. Our results indicate that the commonly used interspecific relationships linking temperature and body mass to trophic link strengths may not be fully applicable on the intraspecific level, which may lead to biased predictions of the effects of climate warming on individuals and populations.

## Dual use of compound-specific stable isotopes reveals dietary PUFA conversion in consumers

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Lake riparian spiders feeding at the aquatic-terrestrial ecosystem interface obtain a mixture of aquatic and terrestrial resources that vary in their nutritional composition. However, the relative significance of aquatic vs terrestrial diet sources remains to be explored. We investigated the trophic transfer of polyunsaturated fatty acids (PUFA) from emergent aquatic and terrestrial insects to spiders at varying distances from the shoreline of a subalpine lake, using fatty acid profiles and compound-specific stable carbon ( $\delta^{13}\text{C}$ ) and hydrogen ( $\delta^2\text{H}$ ) isotopes. The omega-3 PUFA content of emergent aquatic insects was higher than that of terrestrial insects (e.g., 6.6 X more eicosapentaenoic acid, EPA), whereas terrestrial insects had 2.6 X higher contents of the omega-6 PUFA linoleic acid. Spiders sampled directly on the lake and in upland habitats had similar EPA contents, but their EPA was derived from different diet sources, depending on habitat use and dietary availability. Our data suggest that spiders use two distinct pathways (trophic vs metabolic) to obtain EPA. In “lake spiders”, both  $\delta^{13}\text{C}$ -EPA and  $\delta^2\text{H}$ -EPA values revealed an aquatic diet pathway of EPA. In contrast, spiders from terrestrial habitats had lower isotopic values of EPA than any of their potential food sources and their precursor isotopic values, suggesting EPA bioconversion from dietary precursors. This study illustrates the ecologically added value of investigating multiple stable isotopes of PUFA to obtain more detailed understanding of how PUFA of consumers changed depending on their habitats and that PUFA bioconversion in spiders, and possibly other consumers, is triggered by dietary availability.

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### DOM properties across a lateral gradient in a semi-arid saline stream

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Litter of woody shrubs, typically remains distributed across the lateral gradient of semi-arid streams after floods. Their exposition to differing environmental conditions, including salinity, can alter their chemical composition, with potential implications for later use by organisms. We studied how different environmental conditions in stream channel, shoreline and floodplain, alter woody litter composition and quantity, composition, and biodegradation of dissolved organic matter (DOM) leached. To that, we performed a decomposition experiment where we deployed mesh bag containing small branches of *Sarcocornia fruticosa*, in these three habitats, during 9 months. Over the experiment we analyzed changes in woody litter chemical composition and we produced leachates for measurements of nutrients and dissolved organic carbon (DOC) concentration, DOM characterization by absorbance and fluorescence measurements and DOM biodegradation. Rate of woody litter decomposition was the lowest in the floodplain and their chemical composition differed among habitats. Woody litter from the stream channel and shoreline showed the lowest content in N and P and the highest salt concentration at the end of the experiment. According to that, we expect differences in DOM properties and biodegradation among habitats. For woody litter in floodplain, we expect a drop of DOM quality and biodegradation by its accelerated humification as result of solar radiation and associated heat. In this study we show for the first time, results on the effect of increased salt concentration in DOM quality and biodegradation. Our findings highlight the effect that not only drying but also salinity in stream, may have on carbon cycling.

## Carbon availability influences gross ammonium uptake in an intermittent Mediterranean stream.

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Headwater streams can process large amounts of dissolved inorganic nitrogen (DIN), yet the role of dissolved organic carbon (DOC) availability on driving the capacity of streams to take up DIN from the water column is still poorly understood. In this study, we explored the influence of two DOC sources, lignin (as recalcitrant DOC) and acetate (as labile DOC), on gross ammonium (NH<sub>4</sub><sup>+</sup>) uptake and metabolic activity in a headwater Mediterranean stream, and whether this response was related to seasonal changes in stream microbial composition. For each season over a year, we performed constant rate additions of three different treatments on three consecutive days: NH<sub>4</sub><sup>+</sup> alone, NH<sub>4</sub><sup>+</sup> + lignin, and NH<sub>4</sub><sup>+</sup> + acetate. Moreover, on each date, we added a metabolic tracer (resazurin) to assess changes in aerobic respiration under the different NH<sub>4</sub><sup>+</sup> and C treatments. In-stream gross NH<sub>4</sub><sup>+</sup> uptake estimated from the NH<sub>4</sub><sup>+</sup> and the NH<sub>4</sub><sup>+</sup> + lignin additions was similar across seasons, while it increased from 35% (summer) to 800% (winter) for the NH<sub>4</sub><sup>+</sup> + acetate addition. Further, resazurin transformation along the reach indicated that aerobic respiration varied across treatments and seasons. Together, these results suggest that both environmental factors and microbial community composition can influence in-stream NH<sub>4</sub><sup>+</sup> uptake and its response to DOC availability. Overall, our study shows that the potential of heterotrophs to take up NH<sub>4</sub><sup>+</sup> may be severely limited by the availability of labile DOC sources in this headwater Mediterranean stream, highlighting the interactions between carbon and nitrogen cycling in stream ecosystems.

## Mid-drought rain events alter sediment organic carbon partitioning between respiration and leaching

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With climate change, streams and rivers are at increased risk of droughts and flow intermittency. Yet, the full implications of these conditions for fluvial carbon (C) processing and stream-atmosphere CO<sub>2</sub> emissions are not well understood. We investigated how small mid-drought rain events that enhance sediment moisture content, but do not reinstate streamflow, affect streambed C dynamics, biofilm enzyme activity, and bacterial community composition. We conducted a controlled drying experiment in outdoor hyporheic flumes. During one month, the flumes filled with natural gravel and pre-conditioned with natural stream biofilms were subjected to intermediate rain events (weekly, 3 times per week, and dry as control). We found that more frequent intermediate rain events increased microbial respiration per unit sediment dry weight (DW) with a difference in surface averages of control vs. three times rain per week of  $-13.9 \pm 12.8$  g CO<sub>2</sub>/g DW h, (Kruskal-Wallis  $p < 0.05$ ). Also, intermediate rain events caused higher Glucosidase activity at the sediment surface (difference, control vs. three times rain per week, surface averages:  $-4.7 \pm 4.3$  nmol/g DW h, Kruskal-Wallis  $p < 0.05$ ). An additional leaching experiment was performed in the lab to simulate the initial flow resumption. We found that the net amount of leached DOC was lower with more frequent rain events than in the controls (difference, control vs. three times rain per week, surface average:  $0.813 \pm 0.62$  mg/L, Kruskal-Wallis,  $p < 0.05$ ). We propose that mid-drought rain events, even those of very small size, are highly relevant for the partitioning of C in intermittent stream sediments.



## Stream metabolism is an important source of carbon dioxide to the atmosphere

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Streams are important control points for CO<sub>2</sub> emissions to the atmosphere, with contributions to CO<sub>2</sub> evasion of lateral groundwater inputs widely assumed to overwhelm those from in-stream metabolism. We analyzed continuous measurements of dissolved CO<sub>2</sub> and O<sub>2</sub> concentrations during spring and early summer in two Mediterranean headwater streams from which we evaluated the contribution of in-stream net ecosystem production (NEP) to CO<sub>2</sub> evasion. The two streams exhibited contrasting hydrology: one was intermittent with relatively small groundwater inflows, while the other was perennial and received higher groundwater inputs. The intermittent stream showed strong inverse coupling between CO<sub>2</sub> and O<sub>2</sub> concentrations, and a strong negative correlation between aerobic ecosystem respiration (ER) and gross primary production (GPP) despite persistent negative NEP. At the perennial stream, the CO<sub>2</sub>-O<sub>2</sub> relationship was no consistent over time, ER and GPP were uncorrelated, and NEP was consistently more negative than in the intermittent stream. Despite large differences in the hydrological regime and magnitude of lateral inflows, both streams showed decreases in the magnitude of NEP with decreasing discharge, suggesting groundwater inputs were important for sustaining stream metabolic activity. In contrast to the idea that dissolved CO<sub>2</sub> evading from headwaters mostly comes from terrestrially-derived CO<sub>2</sub>, we found that NEP contributed substantially to CO<sub>2</sub> evasion at the two streams. Our study highlights that these streams are not just chimneys of soil-derived CO<sub>2</sub>, but rather important venues for mineralization of terrestrial organic carbon, and that hydrological conditions strongly influence temporal patterns of in-stream CO<sub>2</sub> production and their variability among streams.

## Dynamic streambed patches – ecological and biogeochemical consequences of fine sediment migration

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Bed sediments of streams and rivers are metabolic hotspots contributing significantly to global biogeochemical fluxes. Streambed morphodynamics is well recognized where sediment grains either move (migrating phase) or rest (resting phase). The frequency and the duration of these two alternating phases depend on the flow conditions and sediment grain size. The common perspective in stream ecology is binary and focuses on stable bed morphology that is infrequently disturbed by streambed migration during relatively short flood events. However, finer sediment fractions that make up large proportion to majority of sediment in some stream types migrate more frequently. Here, we extend the overly simplistic binary view by relating the frequency and duration of alternating resting and migrating phases to the temporal scale of biological processes. We expect sediment migration to act as a filter to the community depending on the temporal scale of sediment migration. The proposed concept enables to further the understanding of ecological and biogeochemical processes in streambeds with frequently rolling and saltating bedload as well as in sand-bed streams with migrating bedforms. We expect that worldwide increases in catchment erosion as a result of agricultural intensification and urban area expansion are substantially changing the spatiotemporal mosaic of migrating and resting streambed habitats shaping global biogeochemical cycles.

## Stream production and decomposition processes in contrasting environments in Argentina

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1E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system, July 26, 2021, 10:30 - 12:00

We estimated whole metabolism and leaf litter decomposition in two Argentina ecoregions, the Pampas and Patagonia. Pampean streams have mild weather, high irradiance, moderate temperatures, high nutrient concentrations and low slopes. Patagonian streams have lower irradiance, temperature and nutrient concentrations and higher slopes. Changes in dissolved oxygen were measured in twelve streams during austral spring at both ecoregions with the two station method along selected reaches. Using these values and those of re-aeration, whole stream metabolism was estimated. Decomposition was estimated by the litter bag method, in twelve stream reaches with coarse and fine mesh sizes (20 and 0.5mm diameter, respectively) filled with 5 g of *Populus nigra* leaf litter. Bags were fastened to stream bottoms and retrieved at different dates to estimate decay rates by a negative exponential model against cumulative degree days ( $dd^{-1}$ ) obtained from water temperature series. Both production and decomposition differed by one order of magnitude between the two ecoregions. Estimated production was  $1-8 \text{ g O}_2 \text{ m}^{-2} \text{ d}^{-1}$  in Pampean streams and  $0.027-0.397 \text{ g O}_2 \text{ m}^{-2} \text{ d}^{-1}$  in Patagonia streams. Decay rates in Pampean were  $0.00400 \text{ dd}^{-1}$  and  $0.00089 \text{ dd}^{-1}$  in Patagonian streams. Our findings suggest that Pampean streams function as autotrophic ecosystems while Patagonian streams behave as heterotrophic, mostly ruled by regional contrasts determining different carbon sources and the capability to process them. Such differences in stream functioning were diminished in high nutrient and less dense riparian plant canopy environments.

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### Sampling protocol to study benthic invertebrate community in a restored braided river

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1F\_RS10 Freshwater restoration: challenges, innovation and achievements, July 26, 2021, 10:30 - 12:00

Braided rivers are characterised by a multichannel pattern maintained by a dynamic hydrologic regime with alternance of floods and low water periods. In this context, the aquatic habitat mosaic displays high turnover rates. Nevertheless, benthic invertebrate communities present in these systems are adapted to these dynamic conditions and have recently shown a high diversity due to the spatial pattern of habitats mosaic. In Europe, benthic invertebrates are used to evaluate and monitor the effects of hydromorphological restoration on the ecological status (sensu WFD), but to date, there is not any protocol adapted to the specificities of braided rivers. The question is then : does hydromorphological restoration allow to recover a diverse spatial pattern in the benthic invertebrate community ? This work is based on the study of two reaches located on the Drac river (France), where one was restored in 2014 and the other displays a functional braided morphology. A new sampling methodology based on the national protocol (IBG-DCE) has been tested and relies on the identification of different types of channels and hydromorphological units. Three samples are taken from each identified unit, selected to represent the diversity of the braided reach, in the limit of 10 units. First results show a spatial pattern in the repartition of the community, especially between channel types. These results show the importance to consider the spatial morphological pattern of braided rivers in the sampling distribution. This study allowed us to better understand the structure and functioning of benthic invertebrate community within braided rivers.

## Bio-indicators of ecological responses of headwater stream restoration

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1F\_RS10 Freshwater restoration: challenges, innovation and achievements, July 26, 2021, 10:30 - 12:00

The assessment of restoration activities in streams has mostly relied on biodiversity with results riddled with many uncertainties. Consequently, there has been a growing call for more robust bio-assessment protocol that integrates ecosystem functioning with biodiversity for the assessment of the ecological status of restored streams. In addition to macroinvertebrate biodiversity, we proposed a suite of complementary bio-indicators for the assessment of the ecological status of restored headwater streams. These include an integrative ecosystem-level process – leaf litter decomposition, sediment oxygenation and lastly, macroinvertebrates species functional traits. These were monitored on three restored streams in Brittany, Northwest France. The restoration works involved the removal of artificial obstruction to flow. Sites were monitored both pre- and post-project using a BACI design. We observed increased depths of sediment oxygenation in restored stream sections comparable to the depths in reference sites. The depth also increases upstream with increasing distance from the site of restoration suggestive of improved sediment transport downstream. Also, the rate of litter breakdown was higher post restoration than before restoration even though values at reference sites remain higher than values in impacted sections both pre- and post- restoration. The trend in litter composition was strongly correlated to the functional composition of macroinvertebrate shredders rather than the structural assemblages. While the classical biodiversity metrics have historically proved useful in assessing the ecological status of streams, incorporating ecological processes and functional traits of biota into the assessment protocols of restored streams will provide a more integrative and mechanistic assessment of ecological responses.

## complexified Artificial Floating Islands (cAFI): solution to sustain macroinvertebrates in regulated lakes?

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1F\_RS10 Freshwater restoration: challenges, innovation and achievements, July 26, 2021, 10:30 - 12:00

The artificial water-level fluctuations (WLF) seriously threaten the biodiversity and functioning of littoral zones of lake ecosystems. The use of artificial floating islands (AFI) to compensate their deleterious effects on littoral habitats has been received a growing interest by European environmental managers. Artificial floating islands (AFI) are traditionally designed as simple vegetated floating mats. In this study, we designed an original and complexified AFI (cAFI) to mimic a natural littoral zone with a terrestrial vegetated part with helophytes and several underwater stages containing soil and hydrophytes. We aimed to assess the effectiveness of this newly-designed AFI to support macroinvertebrate communities. For this, three cAFI were anchored into three bays in a French hydroelectric reservoir exhibiting high WLF. Their colonization by macroinvertebrates has been compared with control littoral sites on seven seasonal samplings. The cumulated abundance and taxon richness were significantly higher in the cAFI than in the control littoral stations, notably when the water level increased the most (spring) and during post-drawdown (summer). Functional profiles of macroinvertebrates communities also significantly differed between cAFI and control littoral sites. These findings show that cAFI were successfully colonized by an original, diversified and abundant macroinvertebrates communities compared to littoral control sites. This suggests that the newly-designed AFI provide suitable and biogenic habitats for macroinvertebrates and might support macroinvertebrates communities in reservoirs.

## Further downstream where natural and regulated communities meet

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1F\_RS10 Freshwater restoration: challenges, innovation and achievements, July 26, 2021, 10:30 - 12:00

Dam-induced disruption of the natural continuum of rivers has manifold consequences in fluvial ecosystems, and in the structure and functioning of plant communities. We focused on understanding how different plant groups - vascular macrophytes, bryophytes, riparian vegetation - respond to disturbance along the longitudinal river gradient downstream of dams. We specifically aimed at establishing a 'passive' degree-of-regulation (DOR) or a distance from the dam (DFD), where river regulation does no longer significantly affect plant communities. We also aimed to understand differences/similarities within and between these communities. Since diverse dam types alter differently the streamflow components, we addressed two case studies – a run-of-river dam and a reservoir in Portugal, SW Europe. After inventorying the cover of plant species in free-flowing and downstream of dams conditions, we performed a cluster analysis and ordination to derive plant guilds for each plant group, using abundance data and flow-responsive traits, and general linear modelling to explore the effect of hydrological alterations on plant guilds. We obtained 3 macrophyte guilds, 5 riparian guilds, and 6 bryophyte guilds. We found that: i) responses downstream from dams were guild- and plant group-dependent; ii) it is possible to define a passive DOR/DFD for some macrophyte and riparian guilds; iii) for bryophytes only 'hygrophilous-lentic' guild was responsive in the reservoir river; iv) it is noticeable that 'flow-adapted hydrophyte' guild had lower passive DFD on the reservoir case study. Understanding recovery downstream from dams for diverse plant communities can guide river restoration projects, as well as environmental flow design

## Reintroduction of brown trout (*Salmo trutta*) in Belgium: past and future challenges

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1F\_RS10 Freshwater restoration: challenges, innovation and achievements, July 26, 2021, 10:30 - 12:00

Due to environmental degradation the water quality in European rivers was low at the beginning of the 1990's. Thanks to the EU Water Framework Directive (WFD), the installation of wastewater treatment plants, the efforts to restore fish migration and actual river restoration, good progress has been made towards the ecological state of waterbodies across Europe. To support ecological restoration and protect threatened species, the Belgian government has set up species reintroduction programs. One of these species is brown trout, which is being successfully bred under controlled conditions. After determining the habitat suitability and selecting suitable locations for survival of the species, it was decided to start (re)introduction of brown trout in the Zwalm River basin (Belgium). Although the physicochemical water quality is sufficient for the species to survive, the program can only be considered successful if natural reproduction is taking place. Spawning grounds were restored and the survival of fertilized brown trout eggs was tested with in situ experiments. Our results show that reintroduced juvenile fish have a high survival and grow well, but that the dry and hot summers of the past 4 years presumably have had an impact on the population size. In addition, pollution events and storm water discharge negatively influence the effect of restoration. The main bottleneck seems erosion as it not only negatively affects water quality but also hampers the development of brown trout eggs. More efforts are needed with regard to diffuse pollution and erosion to reach the targets set by the EU WFD.



## From sewer to nature: impacts of restoration on CES and biodiversity.

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1F\_RS10 Freshwater restoration: challenges, innovation and achievements, July 26, 2021, 10:30 - 12:00

We use social media photo posts to investigate the effects of river restoration on the provision of cultural ecosystem services (CES) and associated values along a degradation-restoration gradient in the Emscher river catchment in Germany, the largest river restoration project in the world. We want to answer the question, which environmental and biological properties of river restoration are responsible for the provision of CES and associated values and (where) do trade-offs between biodiversity and CES occur? The actual flow of CES is evaluated with > 25 000 georeferenced social media photo posts regarding photo density and photo content analysis (Flickr, Instagram). Statistical analysis of biological data, environmental parameters, and social media identifies which environmental structure and biological function contribute to the provision of CES and perceived values. The study area had been used as an open sewer system for the Ruhrgebiet agglomeration area in Germany with 5 Mio inhabitants. Since the 1990ies, the river catchment is restored with great effort. This catchment with still heavily degraded and already restored sections and with comprehensive hydromorphological and biological monitoring schemes implemented is ideal for testing which properties restoration must have to achieve a sustainable rehabilitation of biodiversity and the provision of CES, or where trade-offs between biodiversity and CES occur. With our research, we highlight the hidden contributions of river restoration to society. We underline the added value of taking CES and relational values into account when evaluating river restoration but also for the planning of future projects.

## 2A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions

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### Microalgae-based biodiversity and biomonitoring: Strengths and gaps of high-throughput sequencing applications

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2A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 13:15 - 14:45

The development of culture-independent high throughput sequencing (HTS) has opened new horizons in the study of aquatic biodiversity for fundamental and applied research. The limitations in the use of traditional approaches to the identification of organisms, which are based on the identification of morphological traits, have promoted several studies that aimed to integrate new HTS technologies in regulatory biomonitoring, such as WFD (CE) and WPO (CH). In the Alpine region, one of the main objectives of the Interreg Alpine Space Eco-AlpsWater project is to develop and apply HTS methods for monitoring cyanobacteria and bacteria, microalgae, and fish, integrating and harmonizing conventional approaches. Here, we will focus on the results obtained for "algal" assemblages, i.e. cyanobacteria and microalgae in plankton and biofilms, analysed using 16S and 18S rRNA marker genes. The survey was conducted in 37 lakes and 23 river sites. The specific points discussed in this investigation include the overall diversity recovered by HTS and light microscopy (LM); the taxonomic coverage of 16S and 18S rDNA sequences in NCBI taxonomic databases; the fraction of species identified by LM that are represented with at least one corresponding molecular marker (16S-18S) in the NCBI databases; the definition of methods to evaluate the reliability of LM classifications based on their correspondence with HTS sequences; the definition of phylogenetic approaches to fine-tune the taxonomic classifications obtained from the bioinformatic pipelines. The results are building a solid knowledge base for evaluating the range of applications and complementarities of HTS in the next generation biomonitoring systems.

## Aquatic biofilms as macroinvertebrate and fish eDNA samplers

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2A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 13:15 - 14:45

Recent studies, suggest that aquatic biofilms can entrap environmental DNA (eDNA). Thus, we propose a new metabarcoding approach to study macroinvertebrates and fish communities from this matrix.

The capacity of aquatic biofilms to catch macroinvertebrate eDNA was explored by collecting macroinvertebrate specimens and biofilms samples from several rivers in parallel. First, macroinvertebrate specimens were identified based on their morphology. Second, DNA was extracted from biofilms, and macroinvertebrate communities were targeted using a standard COI barcode. The resulting morphological and molecular inventories were compared. Both methods provided comparable structures and diversities for macroinvertebrate communities when using unassigned OTUs. However, after taxonomic assignment of OTUs, diversity and richness were no longer correlated. This results were encouraging but highlighted the need to use more specific primers targeting shorter barcodes and a well-adapted reference database.

Based on this, a second study looking for fish eDNA signal in aquatic biofilms was performed. Environmental biofilm and water samples were collected in parallel at littoral sites at Lake Geneva. DNA was extracted from these samples, and fish communities were targeted using a standard 12S barcode. The molecular inventories derived from the biofilm and the water samples were compared. Both methods provided comparable floristic lists, providing a novel approach for ecological studies related to fish phenology using eDNA in biofilms.

Our results showed the possibility to study macroinvertebrates and fish communities through metabarcoding from the same matrix reducing sampling efforts and costs.

## An eDNA metabarcoding time series reveals high macroinvertebrate diversity and seasonal patterns

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2A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 13:15 - 14:45

Environmental DNA (eDNA) metabarcoding is a promising and non-invasive method to detect biodiversity in aquatic environments. For animal communities, DNA metabarcoding typically relies on PCR amplification of a fragment of the mitochondrial cytochrome c oxidase I (COI) gene with degenerate primers. When using such 'universal primers' on eDNA isolated from water, the number of sequence reads for macroinvertebrate target taxa is "watered down", meaning that macroinvertebrates are underrepresented in comparison to other nontarget taxa, due to the overrepresentation of these compared to target DNA molecules. However, a recently proposed primer overcomes this problem. The aim of this project was to assess the potential of eDNA metabarcoding with a universal compared to a specific primer pair to assess macroinvertebrate diversity from eDNA filtered from a stream. Therefore, we performed a time series at the River Kinzig (Rhine-Main-Observatory, LTER site). We sampled a near-natural sampling location for 15 months every second week at three different sites within the stream: 1. surface; 2. riverbed; 3. riverbank. With the universal primer pair, we detected 4069 OTUs, but the majority were of diatom and bacterial origin, only 6.7 % were assigned to metazoans. With the specific primer, 4135 OTUs were found and 99.7 % were of metazoan origin. We found a strong seasonal pattern for all taxa detected: diatoms (spring/summer), bacteria (summer/autumn) and macroinvertebrates (February/May). This study shows that time series data can be obtained relatively quickly with a great resolution by analysing eDNA collected from the water to inform about community processes through time.

## A large-scale DNA-metabarcoding study for implementing molecular routine ecological status assessments

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2A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 13:15 - 14:45

The aim of biomonitoring mandatory under regulations such as the European Water Framework Directive (WFD; Directive 2000/60/EC), is to assess the ecological status of European water bodies ensuring early corrective measures. It is a common view that DNA metabarcoding can complement and even overcome the limitations of conventional methods and be used to establish molecular metrics and indices. However, important issues are yet to be solved especially in the case of Iberian freshwater macroinvertebrates, which have been selected as key Biological Quality Elements for rivers. These limitations mainly include problems related to the lack of a complete COI macroinvertebrate barcode database available for the Iberian Peninsula, as well as the scarce recovery of specific taxa due to DNA extraction and/or PCR amplification biases. In our study, benthic macroinvertebrates were collected in spring 2020 at 79 sites across Ebro Basin (Spain) as part of an official national stream monitoring program. The mitochondrial gene for cytochrome c oxidase subunit I (COI) was used as a DNA Barcode. Taxonomic coverage, taxonomic composition metrics (IBMWP), Ecological Quality Rates (EQR) and ecological status obtained from traditional and molecular approaches were analysed. Physical and chemical variables obtained during the routine biomonitoring, as well as other ecological parameters including biodiversity indexes, were also assessed and used, together with the macroinvertebrate data, in multivariate analyses. Results seem to support that the DNA-metabarcoding approach might deliver similar quality assessments results to the morphological approach, but increasing the cost-benefit balance.

## Applying a molecular toolbox for studying cryptic species coexistence

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2A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 13:15 - 14:45

The global emergence of DNA-based biodiversity assessments validated that species diversity is drastically underestimated due to the presence of cryptic species. Despite being regarded as ‘ecological clones’, more and more evidence in support of cryptic species coexistence emerges across a wide range of phylogenetically distinct taxa and from all types of habitats. To better understand dynamics and eco-evolutionary drivers underlying this ecological paradox, a multitude of tools is needed. Here we showcase a novel approach for studying cryptic species coexistence by investigating communities of freshwater amphipods with at least three cryptic species that belong to *Echinogammarus sicilianus* species complex co-occurring with *Echinogammarus adipatus* in a single river system on Sicily. By applying a combination of DNA-based methods and seasonal fine-scale sampling, we aim to investigate their microhabitat preferences, dietary habits and the potential influence of parasites, and by that, identify potential drivers of species coexistence. First results revealed the complexity of observed diversity, where ddRAD data supported a different number of lineages compared to DNA barcoding, highlighting the importance of using genome-wide data for species validation in highly diverse species complexes. Further results showed significant differences in microhabitat preference and parasite diversity between *E. sicilianus* and *E. adipatus*, but little or no differences between the cryptic species. On the other hand, stable isotope analyses suggested high flexibility of dietary habits indicating possible niche partitioning via food resources. The results show that a highly integrative framework is needed to disentangle drivers of cryptic species coexistence, supporting its use for studying similar cases.

## Invasive-on-native fish predation uncovered by gut content DNA analyses opens management avenues

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2A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 13:15 - 14:45

The restoration of longitudinal connectivity to improve access to spawning grounds involves substantial investments. These investments also enable the upstream migration of non-native predators into spawning areas, which potentially adversely affects the recruitment of threatened native fish. Whether or not such a scenario applies is however often challenging to determine because visual inspections of gut contents may underestimate the extent of egg and fry predation. We developed and applied several species-specific DNA-based detection assays for six valuable native fish species, including endangered salmonid and cyprinid river spawners. The applicability of the assays was confirmed in a series of laboratory and field feeding experiments involving eggs and fish tissue. A subsequent field study at a spawning area confirmed that invasive round goby (*Neogobius melanostomus*) prey on the eggs or fry of the threatened common nase (*Chondrostoma nasus*) in Switzerland. The results of this study could inform local conservation measures – such as temporary reductions in the density of round goby at spawning sites prior to spawning – and demonstrate how targeted application of species-specific molecular markers may advance freshwater fish management. Also, we provide a general guiding framework for conservation managers regarding the use and applicability of different DNA-based detection approaches for gut content analysis.

## 2B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges

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### Ecological impacts of hydropower plants in Southeast Europe

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2B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges, July 26, 2021, 13:15 - 14:45

Currently Southeast Europe face a boom of hydropower plants (HPP), which are even built in national parks and other protected areas. It is assumed that the ecological impacts of these dam constructions will be even more harmful than in other regions, as Southeast Europe represents a global hotspot of aquatic biodiversity. We analysed impacts on the macroinvertebrates induced by various types of HPPs (diversion run-of-the-river, storage with and without hydropeaking) in Southeast Europe (Bosnia and Herzegovina, Serbia, Montenegro). We sampled nine HPPs at upstream control and downstream impacted sites. Results show that all HPP types strongly affect benthic invertebrate communities downstream of them. Impacts are best visible in terms of total taxa number, overall colonization density and EPT density (Ephemeroptera-Plecoptera-Trichoptera). In addition, HPPs may cause the extinction of sensitive species protected by the EU Habitat Directive, and their replacement by more tolerant species or even invasive species. Diversion run-of-the-river HPPs seem to have slightly less serious impacts, while storage HPPs with hydropeaking exert the strongest impacts. However, the impacts of small diversion run-of-the-river HPPs are disproportionately high when compared with their low contribution to electricity production. As most HPPs (92%) planned to be constructed in southeast Europe are small, the current boom of hydropower plants causes much environmental damage for little benefit, and thus also contradicts the EU Water Framework Directive.



## Seasonal drivers of the aquatic invertebrate assemblages of a naturalised pond network.

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2B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges, July 26, 2021, 13:15 - 14:45

Temporary ponds are widespread across the world harbouring a high aquatic biodiversity, including singular species that have developed strategies to survive pond desiccation. However, these waterbodies are highly vulnerable to external perturbations and have been destroyed or seriously damaged in the last decades. We selected a pond network that have been restored from an old granite quarry to assess its recovery for biodiversity conservation, Los Camorchos ponds, located in the Cuenca Alta del Manzanares Regional Park (Madrid, central Spain). Across autumn, winter and spring, we sampled the macro- and micro-invertebrate assemblages and the physicochemical characteristics of six temporary ponds of different depths and surface areas, separated at different distances, and one permanent pond, trying to cover the entire hydroperiod and surface of the wetland. At the spatial scale we analysed differences in taxonomic compositions across seasons, over the 2020-2021 hydroperiod, in order to observe variations from pond flooding to the approach of pond desiccation. We hypothesised that the contribution of environmental and biological drivers in the organisation of these invertebrate assemblages would change throughout the seasons. We considered macroinvertebrate predators as proxy of biological interactions, such as some larvae and adults of coleopterans and notonectids, or larvae of odonates. We would expect that after pond flooding (autumn) and before desiccation (late spring), environmental drivers for species emergence and colonisation would be determinant in the structure of the macroinvertebrate assemblages; biotic drivers would be key in late winter, when macroinvertebrates have had time to construct complex assemblages after pond inundation.

## Modelled vs. observed changes of invertebrate communities in warming Alpine streams

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2B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges, July 26, 2021, 13:15 - 14:45

Global warming intensifies environmental change in high-altitude ecosystems worldwide, with retreating glaciers as best indicator. While past research in Alpine river ecology has primarily focused on how retreating glaciers might affect the ecology of glacier-fed streams on the long-run and used space-for-time substituted study designs, observations at habitat level and real-time alterations in such pristine environments are scarce. Further, the actual vulnerability of mountain stream communities to climatic changes – and differences among taxonomic groups – has not been evaluated. Besides reporting a rapid warming of summer temperatures in multiple high-altitude rivers in the European Alps, we demonstrate general shifts to be expected for aquatic primary producers or benthic invertebrates (based on space-for-time substitutions). In the same habitats we observed real-time changes at community level and group-specific shifts within the invertebrates over years, so that we can report about partial discrepancies between results derived from space-for-time substitutions and real-time observations of these communities. As an example, we demonstrate that cold-adapted invertebrates unexpectedly expand their dominance over the observed years despite the warming, while other taxa (e.g., EPT) remained stable or increased only marginally. Further, we explain why Alpine invertebrates might be disproportionately more vulnerable than invertebrate pools from other ecoregions and point out trait-based differences between invertebrate groups in their potential reaction to climate change effects.

## Littoral macroinvertebrate community structure change in Lough Feeagh - 48 year period.

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2B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges, July 26, 2021, 13:15 - 14:45

Lough Feeagh, located within the Burrishoole catchment Co. Mayo is a dystrophic lake which has been the subject of numerous long-term studies with a network of in-situ sensors deployed across the catchment measuring a range of variables in near real time since 2003. However, despite this monitoring network within the Burrishoole system, the shallower waters along the littoral zone of Lough Feeagh have received less focus. The littoral zone is structurally and functionally an important part of most lakes as it influences the movement and processing of material as it flows from terrestrial ecosystems into the lake, this can impact both physical and biological processes through the pelagic zone. This study aims to investigate changes in macroinvertebrate community structure in the littoral zone of Lough Feeagh through the analysis of historical data from three surveys carried out over a 48-year period. A decline in species diversity indices was observed between 1971 and 1994, with a subsequent increase in 2019, however, a reduction in species evenness and spatial diversity indicates a shift in community structure from the 1970s to the present day. Examining changes in macroinvertebrate community structure over time will provide information on impacts of catchment changes to the littoral zone with potential implications for ecosystem function.

## Contrasting host-symbiont interactions among fish and larvae in sympatric freshwater mussels (Hyriidae)

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To complete their life-cycle, larvae (glochidia) of Unionida mussels must form obligate relationships with fish that closely-related species may compete for. Partitioning host fish species may be a mechanism by which multiple species of sympatrically-occurring unionids facilitate co-existence. To determine host resource partitioning in two threatened sympatric New Zealand unionids, field surveys were used to quantify glochidia infestation on fish by the Hyriidae *Echyridella aucklandica* and *E. menziesii* throughout their reproductive periods in two Waikato streams. Additionally, laboratory host trials were conducted to validate field results, determine location of glochidia attachment, and compare encystment duration. Combined results showed evidence of host-partitioning, with broadcast-released *E. menziesii* glochidia most prevalent on benthic *Gobiomorphus* species and *E. aucklandica* released in conglutinates (lures) confirmed (for the first time) to attach and encyst on only the gills of pelagic-feeding *Retropinna retropinna*. Although few *R. retropinna* were captured in these streams, glochidia infestation levels were similar at the two sites (6.3 and 6.5 glochidia fish<sup>-1</sup>) and higher than infestation levels achieved in laboratory trials. Peak metamorphosis of *Echyridella aucklandica* glochidia occurred at 34 days post-infestation, and larvae grew on *R. retropinna* gills from  $\bar{x} = 99.5 \pm 4.7 \mu\text{m}$  to  $\bar{x} = 449.2 \pm 28.2$ . In contrast, *E. menziesii* peak metamorphosis ranged from 16 to 18 days during which larvae did not grow on host fish. These results improve the understanding of host-glochidia interactions in sympatric unionid species (Hyriidae), and support integrated conservation strategies for unionid communities and host fish populations.

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### Predicting invertebrate assemblage characteristics in seasonally inundated terrestrial riverine habitats

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Temporal fluctuations in water levels cause the spatial extent of terrestrial habitats to vary in river channels, especially in temporary streams. These changing water levels - as well as the advanced skills needed to identify terrestrial invertebrates - can hamper habitat quality assessments in aquatic–terrestrial riverine ecosystems. However, habitat characteristics may enable estimates of terrestrial invertebrate assemblage characteristics, such as taxonomic richness, to be made regardless of in-channel conditions and without invertebrate identification. We investigated whether indicators summarising standardised habitat survey data can predict metrics representing terrestrial invertebrate assemblages, and thus aid identification of priority sites for conservation in aquatic–terrestrial riverine habitats. Invertebrate samples collected from exposed riverine sediments (ERS) were divided into training and verification subsets, and training subsets used to predict richness and an index of conservation status. Across 500 randomly selected subsets, >80% of predictions were correlated with their verification subsets. Values predicted by an ERS training model were >65% correlated with those recorded in dry temporary stream channels with comparable riparian land use, suggesting that predictions may be transferable to other aquatic–terrestrial riverine habitats. The performance of the predictive model could be improved by analysis of data from standardised biotic surveys of aquatic–terrestrial habitats, and by developing habitat indicators that better reflect the abiotic drivers of invertebrate communities. By providing an initial indication of terrestrial assemblage characteristics regardless of instream conditions, modelled predictions could aid identification of conservation priority sites within aquatic–terrestrial riverine ecosystems.

## How affect flow intermittency and agricultural land-uses to decay rate Mediterranean basin?

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Intermittent rivers are characterized by periods of flow cessation, which can be natural and/or induced by human impacts. Intermittent rivers are the most common fluvial ecosystem in Mediterranean regions, where freshwater demand specially increases in summer when the water flow is the lowest. The most important water use in river basin is usually agriculture, producing water nutrient enrichment and exacerbating water scarcity. The aim of this study was to assess at basin scale how flow intermittence and agricultural land-uses affect OM decomposition rates and fungal biomass, as a proxy of ecosystem functioning. We calculated the decomposition rates of wood sticks installed in 16 sites along the Algars basin (NE Iberian Peninsula) during a year. Fungal biomass was measured at 90 and 365 days of incubation. In addition, water flow conditions and temperature were measured continuously during the period of this study, while water nutrient concentrations and environmental parameters were measured seasonally. The results showed that decomposition rates were mainly affected by water flow intermittence and land-uses. Concretely, an increase of DIN concentration associated with agriculture land-uses, and percentage of canopy were related with higher decomposition rates and fungal biomass. Whereas, an increase of non-flow days was associated with a decrease on decay rates and fungal biomass. Overall, our study revealed that flow variability and diffuse pollution from human activities in the basin influenced litter decomposition, the former changing stability conditions of the ecosystem (alternating terrestrial and aquatic conditions), the later favouring microbial growth, and both affecting ecosystem functioning.

## Dry-phase plant community responses to human impacts in cool, wet temporary streams

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Temporary streams are widespread and, are expanding in spatial extent and drying duration even in cool, wet regions. Our understanding and capacity to monitor the dry phase is increasing, but dry-phase terrestrial communities typically remain overlooked despite their potential as biomonitors. We investigated how dry-phase plant communities, including aquatic and terrestrial species, respond to changing habitat conditions in 'winterbourne' English streams, which are impacted by water demands and modifications in channel morphology. We characterised in-channel, bank and bank-top communities at 14 sites across four streams reflecting a scale of human impact, between April and September. Sites varied in their morphology, land use, shading, sediment composition, sediment moisture content, nutrient concentrations, and livestock poaching. As ponded habitats contracted, plant communities were largely influenced by sediment moisture, and sites with a short dry phase were often dominated by persisting aquatic macrophytes. From late spring to early autumn, and for those sites with longer dry phases, land use and fine sediment became increasing influences on communities. Sites dominated by fine sediments and with grazed pasture or recreational grassland land uses often supported communities dominated by competitive terrestrial generalists. Those with more heterogeneous sediments and more natural land uses (e.g. woodland) supported more diverse aquatic-terrestrial communities. Our results demonstrate the potential of dry-phase plant communities to act as effective biomonitors in temporary stream ecological status assessments.

## Fungal biodiversity mediates the effects of drying on freshwater ecosystem functioning

Dr Cayetano Gutiérrez-Cánovas<sup>2</sup>, Dr Isabel Muñoz<sup>1</sup>, Dr Cláudia Pascoal<sup>3</sup>, PhD Margarita Menéndez<sup>1</sup>

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Investigating the influence of biodiversity on ecosystem functioning over environmental gradients is needed to anticipate ecosystem responses to global change. However, our understanding of the functional role of freshwater biodiversity, especially for microbes, is mainly based on manipulative experiments, where biodiversity and environmental variability are minimized. Here, we combined observational and manipulative experiments to analyse how fungal biodiversity responds to and mediates the impacts of drying on two key ecosystem processes: organic matter decomposition and fungal biomass accrual. Our observational dataset consists of fungal biodiversity and ecosystem processes from 15 streams spanning a natural gradient of flow intermittence. Our manipulative design evaluates the responses of ecosystem processes to two fungal richness levels crossed with three levels of drying. For the observational experiment, we found that increasing the duration of drying reduced fungal species richness and caused compositional changes. Changes in species composition were driven by species turnover, suggesting resistance mechanisms to cope with drying. We also found that fungal richness had a positive effect on organic matter decomposition and fungal biomass accrual. Positive effects of fungal biodiversity were consistent when controlling for the effects of drying duration on richness by means of structural equation modelling. Our results for the manipulative experiment showed that the positive effects of higher richness on both ecosystem processes were evident even when exposed to short or long simulated drying. Overall, our study suggests that maintaining high levels of biodiversity is crucial for maintaining functional freshwater ecosystems in response to ongoing and future environmental changes.



## Diversity mediates responses of invertebrate abundance to annual drying duration and frequency

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Although all intermittent streams have in common their complete flow disruption, the complexity of the drying process can give rise to different annual and antecedent hydrological conditions. However, it remains unclear how these drying aspects (duration, frequency, antecedent conditions) influence aquatic communities. Here, using aquatic invertebrates from 33 streams along a wide flow-intermittence gradient, we assessed how annual (duration, frequency) and antecedent drying aspects (duration, flowing time since the last rewetting) affect abundance and diversity metrics of communities and trophic groups, while controlling for other key abiotic factors (dissolved oxygen, altitude). To do this, we characterized invertebrate communities through taxonomy and functional traits representing how organisms cope with environmental change and utilize resources (life-histories, trophic strategies). Using Structural Equation Modelling (SEM), we evaluated pathways by which drying aspects directly impact on abundance and whether diversity indirectly mediates such relationships. We show that drying duration drove reductions in abundance at community level and within trophic groups, while both drying duration and frequency had a negative influence on diversity metrics. Our models revealed that filterer, predator and shredder trophic groups exhibited the strongest negative responses to drying. Antecedent drying aspects had a minor effect on abundance and diversity metrics. Our SEM results demonstrated that diversity mediates negative impacts of annual drying duration and frequency on invertebrate abundance through reductions in their taxonomic richness and functional diversity. Our results underscore the importance of considering multiple drying aspects and the interdependence of abundance and diversity to better anticipate drying responses in freshwater ecosystems.

## Shading can buffer short- and long-term effects of drying on benthic processes

**Dr Gabriele Weigelhofer<sup>1,2</sup>**, Matthias Pucher<sup>1,2</sup>

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Headwater streams play an important role in the retention of nutrients and dissolved organic matter (DOM) imported from terrestrial sources. However, prolonged droughts during both summer and winter cause more and more perennial headwater streams to shift to intermittency even in temperate climate regions. Drying affects the biofilm community and transport patterns, which are both key factors for nutrient retention and organic matter mineralization in streams. Our project aimed at investigating the medium- and long-term effects of drying on biofilm structures and functions determining the self-purification capacity and the water quality of intermittent streams in Austria. We sampled water and benthic sediments of 10 intermittent and 10 perennial streams along a land use and pollution gradient in 2018 and 2019 and analysed them for biofilm structures (e.g. bacterial abundances, enzyme activities, EPS) and processes (e.g. respiration, nutrient uptake capacity). Resistance to drying was mainly driven by the remaining sediment moisture content during the no-flow period. Shaded intermittent reaches showed similar bacterial abundances, enzyme activities, and respiration rates in the benthic zone as perennial reaches. However, removal of riparian forests or artificial air-drying resulted in reduced respiration rates and enzymatic activities, while EPS increased. Sediments of intermittent and perennial streams showed similar responses to air-drying and re-wetting. The maximum net nutrient and DOC uptake capacity of the sediments was reduced after re-wetting, but recovered in most sediments within a few days to 2 weeks. We observed no long-term effects of drying on either the structures or the functions.

## 2D\_SS02 Freshwater food webs in the Anthropocene & SS03 The role of small water bodies in the landscape

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### The influence of sampling effort on assessing small pond biodiversity

**Dr Jan-Robert Baars<sup>1</sup>**, Nefeli Kassari<sup>1</sup>, Martina Caplice<sup>1</sup>

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Ponds are usually highly heterogenous and can support a rich diversity of aquatic invertebrates. Studies often use standard sampling techniques to assess the diversity of ponds but typically these methods have been variably applied making comparative assessments difficult. Horizontal activity traps (HATs) are a popular way of sampling ponds as they are effective at recruiting certain taxa and samples post-collection are relatively clean and easy to sort. In an assessment of the literature there was no standard way that HATs were used to sample beetles and bugs. This study assessed how the number of horizontal activity traps used per sample and the time left out influenced the recruitment of species and their abundance. The study took place in two shallow motorway attenuation ponds. The HATs were placed as either 1, 3 or 6 bottles per sample and left to collect individuals for 48, 96 and 144hrs. The results show that both the number of HATs used per sample (i.e. area) and soak time had a significant influence on the species and abundances recorded. The use of 1 HAT as a sample underestimated the species present and lead to an overestimation of predicted species presence (Chao1). The results show that a cluster of 3 HATs recruited a similar number to double this number and that 96hrs was similar to 144hrs. The results highlight that the way HATs are used to sample ponds has a significant affect on the species and abundances recruited and ultimately the conclusions drawn on the expected diversity.

## Dietary nutrient export from hypereutrophic fish ponds via emerging insects

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The importance of emerging insects from ponds to support biodiversity and dietary provision of essential nutrients for terrestrial consumers has so far gained little attention. The objective of this field study was to investigate the taxonomic composition of emerging insects, their biomass and dietary quality, as measured by lipids and their fatty acid contents, in 9 fish ponds of northern Austria from June to September 2020. During this study period, a total of 1068 kg dry weight of insects were exported from these fish ponds, of which 10 kg were omega-3 polyunsaturated fatty acids (n-3 PUFA). Diptera, mainly chironomids and Chaoborus, were the most abundant taxa of emerged insects followed by Trichoptera, Ephemeroptera and Odonata (mainly Coenagrionidae and Aeshnidae). The release of total biomass of chironomids was decreasing with increasing trophic pond status, and, the n-3 and omega-6 PUFA export via chironomids was not significantly decreasing with increasing eutrophication. Emerged insects had considerably higher n-3 PUFA and a significantly different fatty acid composition than pelagic primary producers, suggesting that emerging insects are able to selectively retain their fatty acids. This study highlights the potential ecological value of fish ponds as sources of essential dietary nutrients via emerging insects for terrestrial and avian consumers.

## Trophic and non-trophic impacts of wastewater pollution on stream food webs

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Impacts of environmental stressors on food webs are often difficult to predict because trophic levels may respond in divergent ways, and biotic interactions can dampen or amplify responses. Here we studied food-web level impacts of urban wastewater pollution, a widespread source of degradation that can alter stream food webs via top down and bottom-up processes. We propose that wastewater may (i) subsidize primary producers by decreasing nutrient limitation, inducing a bottom-wide trophic pyramid; however, abundant but poorly diversified resources will (ii) decrease energy transfer efficiency by reducing consumer fitness, leading to predator starvation; and/or (iii) pollution might have greater toxicity to higher trophic levels, releasing consumers from predation pressure. We tested these predictions in 10 pairs of stream sites located upstream and downstream of urban wastewater effluents with different pollutant levels. We found that wastewater pollution reduced predator richness by ~34%. Community Size Spectra (CSS) slopes were steeper downstream than upstream of wastewater effluents. Further, variation in downstream CSS slopes generally correlated with pollution loads: the more polluted the stream, the steeper the CSS. We estimate that wastewater pollution decreased energy transfer efficiencies to primary consumers by ~72%, limiting energy supply to predators. Additionally, predators presented traits that increase their vulnerability to chemical pollution, and had their  $\delta^{15}\text{N}$  -  $\delta^{13}\text{C}$  trophic niche compressed downstream of effluents. Our results show that wastewater pollution can impact stream food webs via a combination of energy limitation to consumers and extirpation of pollution sensitive predators.

## Pond ecosystems for resilient future landscapes in a changing climate: PONDERFUL project

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PONDERFUL (POND Ecosystems for Resilient Future Landscapes in a changing climate) is a multipartner EU Horizon 2020 project running from 2021-24 investigating the role of ponds and pondscapes in mitigating and adapting to climate change, protecting biodiversity and delivering ecosystem services. Ponds are numerous, with estimates ranging from around 100 million to 3 billion globally, and biologically rich, supporting up to 70% of the freshwater species pool in European landscapes, with more rare, endemic and threatened species than rivers or lakes. They are geochemical hotspots and are increasingly created, managed, and restored in the landscape to provide contributions to people (i.e. ecosystem services). Despite their evident importance and popularity with practitioners, ponds are still widely overlooked in nature and water-management policy. They are, for example, excluded from the European Water Framework Directive and remain poorly understood compared to other freshwaters, epitomising the bias toward larger rivers and lakes which has dominated freshwater science for 100 years. There is an urgent need for significantly increased knowledge on ponds to support the growing realisation of the major contribution they could make to solving many currently unresolved water management problems (e.g. continued loss of freshwater biodiversity, provision of high value freshwater ecosystem services, mitigation of climate change impacts). In this presentation we will introduce the aims of PONDERFUL project, briefly update current knowledge on the role of ponds in European landscapes, describe the contributions they make to delivering ecosystem services and summarise the main areas of uncertainty that the PONDERFUL project is investigating.

## Temperate ponds and their potential importance in the carbon cycle

**Dr Michael Jeffries**<sup>1</sup>, Dr Peter Gilbert<sup>2</sup>, Dr Scott Taylor<sup>1</sup>, Dr David Cooke<sup>1</sup>, Dr Michael Deary<sup>1</sup>

<sup>1</sup>*Northumbria University*, <sup>2</sup>*University of the Highlands and Islands*

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Ponds and small wetlands are missing from global carbon budgets. This is despite the fact that ponds are ubiquitous across the Earth's landscapes, found on every continent, from oceanic islands and to the heart of continents, in amongst intensive agriculture and in our cities. Ponds are overlooked perhaps because of their small size, familiarity and difficulties estimating their number. Their potential role in carbon budgets has been suggested because of their sheer numbers coupled with the intensity of geochemical processes found in many ponds. However, the initial evidence for the importance of ponds, for example measurements of carbon in sediments, drew largely on data from agricultural impoundments, which may be unusually nutrient rich and productive. Evidence from typical, temperate ponds, widely distributed across the temperate biomes is lacking. This talk will summarise recent data from typical lowland ponds in England to give estimates of organic carbon stocks in the sediment, and for carbon burial rates and also evidence that ponds can rapidly switch between being sinks or sources. The importance, or otherwise, of surrounding land-use, pond vegetation and whether the ponds were permanent or dried out as factors driving variation in carbon stocks will be examined. There are also significant gaps in our knowledge and evidence of ponds as green house gas sources which will be spotlighted too. The talk will pull together the recent and complex evidence of the major role these small habitats may play in global carbon dynamics.

## Analysis of aquatic food web responses to global warming using flow microscopy

**Dr Dania Albini<sup>1</sup>**, Dr Michelle Jackson<sup>1</sup>, Professor Guy Woodward<sup>2</sup>, Dr Emma Ransom<sup>2</sup>

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2D\_SS02 Freshwater food webs in the Anthropocene & SS03 The role of small water bodies in the landscape, July 26, 2021, 13:15 - 14:45

The projected impacts of the fast-increasing global warming on aquatic food webs are primarily expected to manifest with a change in the organism's body size-spectra (the relationship between abundance and size) and in the food chain length (Woodward et al. 2010). Body size is the most influential trait in structuring interspecific variability in metabolic rates and is therefore a fundamental variable in food web ecology (Woodward et al. 2005). It has been suggested that rising temperatures might shift the size spectrum in aquatic communities towards a prevalence of smaller organisms as large individuals are lost (e.g., Petchey et al. 1999). However, very little is known about this, since the available techniques are either outdated and slow, or have not yet advanced to the level where they can give us important trait information (Jackson et al. 2016b). In this experiment, high-throughput flow microscopy is used to rapidly characterise food webs in freshwater ecosystems subject to experimentally manipulated temperature stressor scenarios (from +1C to +8C temperature increase). The large amount of data rapidly generated with the flow cytometry technique allow to make general predictions about how global warming will affect food webs in terms of shift in body size spectra and specie richness.



## 2E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system

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### Is the hyporheic zone a source or a sink of DOM?

Clara Mendoza-Lera<sup>1</sup>, Ada Pastor, Joan Pere Casas-Ruiz, Nuria Catalan, Thibault Datry  
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2E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system, July 26, 2021, 13:15 - 14:45

The potential of streams to alter dissolved organic matter fluxes is widely accepted, yet the contribution of the hyporheic zone (Hz) remains unclear. For inorganic species of nitrogen, the Hz has been reported to be a sink, thus similar dynamics could be expected for DOM. We propose that the contribution of the Hz to stream DOM dynamics is conditioned by the water connectivity between surface and Hz. As water connectivity increases, DOM will tend to be removed by the microbial activity associated to the sediments in the Hz. We tested this hypothesis in four reaches, combining measurements of water with Hz water sampling to determine DOM quantity and properties. We observed that at the reach scale, reaches with low water connectivity tended to be sources of DOM while those with high water connectivity were sinks of DOM. Within the hyporheic zone, the areas with low connectivity tended to have high production of DOM than those more connected. These results suggest that low connected areas of the Hz act as sources of DOM and high connected areas act as a potential sink, and thus reach-scale changes result from the interplay among hyporheic areas with different degree of connectivity.

## Mapping changes in carbon storage in riverine areas: historical and future alterations

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Riverine areas are considered large carbon reserves because they support long-term woody communities, which in their natural state are dense and diverse. In this study, we analysed the carbon storage alterations across 20.5 km of riverine Sampling Units (SUs) downstream Touvedo (a run-of-river dam) and Fronhas (a storage reservoir), by adopting a Land-use Land-cover (LULC) change approach. We used pre-dam (1965) and post-dam (2013) high-resolution airborne imagery, to produce riverine LULC maps, in the area occupied by a 100-year flood, and assigned values of carbon stored to the distinct LULC classes. Carbon values for the riparian classes were derived from an earlier study combined with field surveys, while the carbon values for agricultural and forest classes were obtained from literature using local information on existing vegetation (e.g. crops, shrubby species). Hydrological data were modelled for all the SUs, in the pre-dam and post-dam periods, using information from gauging stations and related to carbon storage alterations by Regression Analysis. Distinct hydrological and LULC scenarios were applied to forecast riverine carbon storage for 2046-2065. The results showed that hydrological and LULC changes strongly influence the potential of carbon stored in riverine areas. We observed a significant increase in the carbon stored, in both case studies, between the pre-dam and the post-dam periods, mainly related to the riparian enlargement resulting from agricultural land abandonment and alteration of the magnitude of streamflows. Differences on carbon stock accumulations were observed within case studies and related to the effects of respective dam operation types.

## Land cover-mediated biodiversity as fundamental control of carbon cycling in river networks

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2E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system, July 26, 2021, 13:15 - 14:45

Rivers are important contributors to the global carbon cycle as they actively cycle terrestrial organic matter (OM) during transport to the oceans. The OM properties that maximize its efficient processing are poorly understood, particularly at the river network scale. The dendritic nature of a river network and the diversity of land cover types in its terrestrial matrix result in the formation of gradients of chemically and physically varied Particulate OM (POM) and, expectedly, of POM diversity. The efficient degradation of diverse POM likely requires an alignment between traits of POM and those of its consumers. However, at the river network scale, the diversity of both POM and its consumers can be controlled by different drivers and their distribution patterns may not spatially conform, with unresolved consequences for POM degradation. Therefore, to understand how land cover shapes diversity of both POM and its consumers and the ensuing implications for carbon cycling at the regional scale of river networks, we first need to identify factors and processes that shape patterns of POM diversity. We measured POM quantity, particle-specific size and chemical composition in two river networks differing in topology and land cover (Kamp and Ybbs, Austria). Preliminary results show that land cover shapes the local transfer of terrestrial POM to the river corridor, while river network topology constrains its transport, physical fragmentation and mixing. As a result, we observed larger and less degraded POM in headwaters than main stems, and in river sections draining forested sub-catchments compare to those draining agriculture-dominated sub-catchments.

## Rolling over: Bedform migration modulates activity of river and incoming bank sediments

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Climate change associated hydrological extremes increase bank and catchment erosion, input of sandy soils into lowland rivers, and in-stream sediment transport in migrating bedforms (ripples and dunes). In these bedforms that can cover 20-100% of the riverbed benthic microbial communities are exposed to high frequent periodic migrating-resting cycles and light regimes. We aimed to clarify the effect of sediment migrating-resting cycle on the microbial activity and structural assembly (bacteria and phototrophs) of i) aquatic sediment and ii) a bank-sediment mixture containing 80% freshly eroded bank soil and 20% aquatic sediment. Sediment and bank soil were sampled from a lowland sand-bed river. Pure aquatic and mixed sediments were exposed in microcosms to migrating and stationary conditions at 11°C, 14 h dark and 10 h light for 12 days. Aquatic sediments had initially higher rates of net community production (NCP) and increased continuously to highest rates during the incubation period at stationary conditions. NCP rates of bank-sediment mixture show a lag-period of 5 days, and increase during the incubation is much lower than aquatic sediments. Sediment migration equally limited rates of NCP of aquatic and mixed sediments to 25% of that of the stationary aquatic sediments. In comparison, community respiration in bank-sediment mixture was half as that of stationary aquatic sediments. Interestingly, the colonization dynamics of bank-sediment mixture remained unaffected by sediment migration. Our results indicate that high frequent sediment migration restricted benthic phototrophic and heterotrophic activities of aquatic sediments, which causes implications on the carbon transformation of lowland sand-bed rivers.

## Higher day versus night ecosystem respiration in rivers across the globe

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Assessment of carbon flux requires understanding processes that control primary production and respiration. Researchers typically derive river ecosystem metabolism from diel changes in dissolved molecular oxygen ( $O_2$ ) concentrations with the assumption that estimates of nighttime and daytime ecosystem respiration are equal. We coupled measures of high-frequency  $O_2$  from logging sensors with analyses of  $\delta^{18}O_{O_2}$  during 24-hour time periods in 14 sites globally (subarctic Patagonian Chile, tropical Cambodia, and temperate dryland, grassland, and mountain areas of the United States and Mongolia). We also measured the oxygen isotopic fractionation factor during respiration ( $\alpha_R$ ) at each site using sealed recirculating chambers containing natural biofilms. We used Bayesian inverse modeling of  $O_2$  and  $\delta^{18}O_{O_2}$  to estimate diel changes in ER and compare diel ER with estimates of daily ER from traditional  $O_2$  metabolism models. ER estimates from  $\delta^{18}O_{O_2}$  and  $O_2$  were 2 to 32-fold higher during the day than at night and GPP was 3 to 210-fold higher. Multiple regression analysis showed that the magnitude of daytime ER was explained 88.5% by GPP and 3.3% by land use. Our results indicate metabolic flux in rivers not accounting for variation in ER can ultimately misrepresent local to global freshwater carbon budgets.

## Stronger response in riverbed methane production to organic matter than to warming

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Rivers are an important global source of methane that could be amplified through a combination of climate warming and ingress of organic matter associated with fine sediments from intensive agriculture. Direct comparison between these two controls is, however, lacking. Here we show for 236 UK rivers that delivery of excess fine sediment is widespread and, for 14 other rivers, that while the response of riverbed methane production to warming is relatively modest, the increase in production in relation to organic matter can be ten-thousand fold. While the strongest warming scenario for the end of the century results in a predicted 1.8-fold increase in riverbed methane production, the widespread excess fine sediment delivery to rivers since the 1940s is likely to have already resulted in a 3 to 7-fold increase in methane emissions. We suggest that ingress of organic matter to rivers will continue to have a far stronger influence on riverbed methane production compared with forecast increases in temperature and that reducing the excess fine sediment delivery should be targeted for mitigating future emissions of methane from rivers.

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### Influence of temperature and pH on Phosphorus removal of selected P sorbents

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Phosphorus sorbents (PS) have been recognized as a powerful tool to manage eutrophication and cyanobacterial blooms. Here, we tested three commercially available PS (i.e. lanthanum-modified bentonite (LMB), aluminum-modified zeolite (AMZ) and Aluminium salt on their capacity to adsorb soluble reactive phosphorus (SRP) at six different temperatures (10 to 35 °C) and five pH values (6 to 10). Also, we evaluated if the SRP adsorbed at neutral pH would be released if pH increases to 10. We showed that temperature affected the PS behaviour differently. For instance, the highest SRP adsorption capacities of LMB and AMZ were 13.99 and 29.86 mg P g<sup>-1</sup> at 30°C and 35°C, respectively; and the lowest was at temperature 35°C for LMB and 25°C for AMZ (6.29 and 3.96 mg P g<sup>-1</sup>, respectively). pH values also affected the P-sorbents differently. LMB decreased its adsorption capacity when pH increased, from 8.47 mg P g<sup>-1</sup> at pH 6 to 3.19 mg P g<sup>-1</sup> at pH 10. In contrast, AMZ adsorption capacity was similar at pH 7 and 10 (6.26 and 6.20 mg P g<sup>-1</sup>). Aluminum's data did not fit well into the isotherm, and its adsorption capacity could not be calculated from our experiment design. We observed that in high pH, LMB did not desorb the SRP adsorbed; contrary AMZ desorbed around 40.9% of the SRP adsorbed when pH changed from 7 to 10. Abiotic factors such as pH should be considered while selecting the most promising material able to manage eutrophication.

## Modelling rewilding potential in a large Atlantic watershed: An ecosystem function-based approach

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2F\_RS10 Freshwater restoration: challenges, innovation and achievements, July 26, 2021, 13:15 - 14:45

Thoreau once said, “all good things are wild and free”, and indeed, despite their current status in our anthropogenically-dominated era, our rivers, too, deserve to be wild and free. Rewilding differs from traditional ecosystem restoration in that it favours a passive approach, focusing on helping humans to “get out of the way”, allowing nature to heal itself. Rewilding is based on ecological principles, yet can be applied without a predefined anthropocentric outcome. We explore the concept of rewilding as a holistic, science-driven approach to river restoration and present a framework to assess the ‘rewilding potential’ of a river, with a focus on ecosystem functions and structures. Because application of restoration tactics at the reach scale rarely affects the broader riverscape, this framework operates at a watershed scale. Alongside this framework, we present results from an ongoing case-study in the Wolastoq | Saint John River watershed in Atlantic Canada, assessing rewilding potential through spatial prioritization of threat mitigation and promotion of restorative ecosystem functions. Our goal is to stimulate new thinking on the restoration of our damaged rivers, promoting regenerative, resilient ecological networks.



## Using Bayesian Belief Networks to diagnose the stressors of riverine ecosystems

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2F\_RS10 Freshwater restoration: challenges, innovation and achievements, July 26, 2021, 13:15 - 14:45

Since the adoption of the Water Framework Directive (WFD) in 2000, biological components are being used to integrate the ecological status of riverine ecosystems into a single assessment value. Given the diverse range of stressors, it is often virtually impossible to reverse the assessment and prioritise individual stressors according to their individual impact on the biology. This complicates the identification of specific and targeted restoration and management measures. To bridge the gap between assessment and programmes of measures, we propose the use of Bayesian Belief Networks (BBNs). BBNs represent cause-and-effect relationships as directed acyclic graphs and allow for reasoning under uncertainty. We developed diagnostic BBNs for three different river-types in Southern Germany: pre-alpine streams and rivers, mountain streams and mountain rivers. BBNs were trained with WFD monitoring data and additional environmental variables from 783 sites using random forest and conditional inference tree analyses. Subsequently, BBNs were subjected to expert opinion during a workshop. Knowing the outcome for selected diagnostic metrics for macroinvertebrates and diatoms, the BBNs allow to estimate the probability of individual stressors causing biological deterioration. Regardless of the river type, several metrics show similarly high diagnostic potential: Rheoindex and % Littoral preferences (flow modification) as well as German Faunaindex and number sensitive taxa (morphological deficits). Our results suggest that the consideration of both river type-specific assessment metrics and additional diagnostic metrics can improve the models' diagnostic capabilities. Further tests of the developed diagnostic BBNs will examine these findings and help practitioners to choose appropriate restoration and management measures.

## Preliminary assessment of river floodplain condition in Europe

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River floodplains as an important link between rivers and their catchments hold a central role in supporting the status of water, nature and biodiversity conservation, climate change mitigation, and ecosystem services. Today, Europe's floodplains are environmentally degraded due to many human activities existing for centuries which mostly cut off natural processes. European strategies support the protection and sustainable development of floodplains by restoration measures. However, a consistent European-wide assessment of the floodplain condition was needed for strategic planning of restoration. Therefore, we performed an assessment based on available data using a methodological approach similar to the Water Framework Directive (WFD). The basis for the assessment was the development of an ecological floodplain typology that classifies seven floodplains according to natural abiotic factors. We identified their reference conditions from a set of least-disturbed floodplain sections across Europe. The assessment was performed for a set of indicators describing floodplain extent, structures and processes. The preliminary assessment results reveal clear signals of degraded floodplain condition and reduced lateral connectivity between river and floodplain. E.g., almost 75 % of Europe's floodplain area shows a severe reduction of floodplain extent. Today, in line with the European Green Deal recently adopted by the EU, the EU Biodiversity 2030 Strategy has set a target to create free-flowing rivers along at least 25 000 km of rivers in Europe. Restoration objectives aim on re-establishing lateral connectivity and restoration of floodplains. Restoration is expected to be based on re-establishing floodplain extent, structures and the integrity of natural processes.

## Simulating lake restoration: Benefits and challenges of applying lake ecosystem models

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Restoration of shallow lakes are undertaken worldwide to restore the deteriorating impacts of among others eutrophication, but lake restoration projects frequently fail due to complex, lake-specific problems. By incorporating lake-specific characteristics, process-based lake ecosystem models can reproduce several levels of lake ecosystem dynamics during and after restoration measures, and thereby explore potential restoration strategies and guide lake management and policy actions. In this presentation, we illustrate the benefits and challenges of applying complex, lake ecosystem models in a management and restoration context with a focus on shallow lakes that have undergone external or internal restoration. The lake ecosystem models were set-up, calibrated and validated on a +10 years comprehensive dataset covering temperature, nutrients and plankton dynamics from Danish lakes. To support management of catchment areas, scenario simulations with lake models can estimate nutrient loading thresholds for when a specific lake will achieve good ecological condition. Furthermore, lake ecosystem models can simulate a range of restoration strategies and methods (e.g. fish harvest and oxygenation of hypolimnion) to explore and assess impact of measures for a specific lake. Challenges remain when trying to simulate frequent shifts between turbid and clear water states. A model-ensemble approach may to some extent address this. To conclude, lake ecosystem models can serve as a powerful support tool for lake managers and water authorities in guiding restoration strategies and protection policies.

## Assessing major threats to European freshwater fishes using the IUCN red list

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Comprising 25% of vertebrates and 40% of all fish diversity, freshwater fish species are among the most threatened animal groups. The International Union for Conservation of Nature (IUCN) Red List of Threatened Species is the most comprehensive system for evaluating species risk of extinction and provides information on the species' populations, distribution, ecology and threats. Using this database, this work aims to identify the main threats to European freshwater fishes and on displaying the relationship between European geographical patterns of threat incidence, the spatial distribution of species richness and the threatened status of freshwater fish communities. The analysis focused on 434 European freshwater fish species and identified 837 related-threats. Overall, "Dams & water management/Use" was the most frequent (>50%) threat type and "Resident" the migratory phenology with the highest percentage of threatened species (46.3%). Central Europe encompasses the areas of higher species richness along with high threat incidence, while Iberia presents the same degree of threat incidence with lower richness resulting in the most threatened fish communities. Overall, there is a high level of imperilment in European freshwater fishes, especially in basins along the coastlines of the Black and Mediterranean seas, with a specific incidence in Iberia, an area of high endemism and species constricted distribution ranges. This study shows that the existing level of imperilment of European freshwater fish fauna is very high, particularly in southern regions, where the fragmentation of river networks by instream barriers stands out as the most important challenge for future river restoration efforts.

## 3A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions

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### Competition between microbial species: an endless question renewed with diatom metabarcoding

Dr Frederic Rimet<sup>1</sup>, Dr Teofana Chonova<sup>1</sup>, Alexis Canino<sup>1</sup>, Dr Agnès Bouchez<sup>1</sup>

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3A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 15:30 - 17:00

Ecologists have long sought to understand distribution patterns of biological communities. In the microbial world, and in particular for microalgae, environmental filtering plays a major role. Diatoms are highly diverse microalgae found in aquatic environments. In a review, Soninen & Teittinen (2019) state that diatoms are subject to strong environmental stress gradients that prevent the observation of interspecific competition phenomena. Until now, most studies were carried out come with microscopy analyses and we wanted to see if DNA information could enable to observe competition between diatom taxa. To reduce the environmental stress gradient, we sampled benthic diatom around the littoral zone of a large lake (Lake Geneva, 73 km long) that presents a relative environmental homogeneity. We used DNA information of communities to assess distribution patterns of taxa. Samples were sequenced by metabarcoding (rbcL). We constructed a phylogeny of diatoms using Diat.barcode reference library (Rimet et al. 2019); then environmental sequences were placed in it. This phylogeny was used to calculate NRI (Net relatedness Index) and NTI (Nearest Taxon Index) indices. These indices showed at different phylogenetic levels (whole community, intraspecific level) that environmental filtering dominates. We completed these analyses by multivariate analyses to assess dispersal limitation and environmental filtering.

This study was made possible thanks to <https://www6.inrae.fr/synaqua/>

Diat.barcode reference library: <https://www6.inrae.fr/carrtel-collection/Barcoding-database>

## Temporal variation of bacterial diversity inshore of bird paradise national park

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Bacterial communities have a crucial role in ecosystem well-being such as regulation of carbon and inorganic nutrient fluxes, fixation, and remineralization. The stressors like increasing nutrient inputs, organic matter runoffs are major factors affecting the freshwater ecosystems, bacteria show a rapid reaction to these environmental changes. The main goal of this study was to evaluate the bacterial community dynamics during a year on the shore of Bird Paradise National Park located in Manyas Lake. Within this scope, the samples were collected monthly intervals from March 2019 - February 2020, and the third generation sequencing technology, Oxford Nanopore, was used to determine the bacterial community structures. According to Carlson Trophic Index, Manyas Lake had a hypertrophic character for the study period. The results highlighted diverse bacterial communities during the study period which was represented by 22 phyla. Cyanobacteria, Bacteroidetes, Proteobacteria, and Planctomycetes were determined as the predominant phyla and the abundances varied significantly according to the season. Cyanobacteria species proliferated in the late winter and the abundance reached the highest level in March representing 91% of the all bacterial community. Bacteroidetes was the second dominant phylum in the bacterial community whereas the maximum abundance was detected in December (62%), the minimum was recorded in March. In May the bacterial community showed a different profile that Proteobacteria (43%) and Firmicutes reached their highest abundance for the study period. Overall, the findings of this research provide insights for detailed bacterial diversity in this freshwater lake and a database for further studies.

## Revisiting global biogeography of freshwater diatoms: new insights from molecular data

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3A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 15:30 - 17:00

Due to their high dispersal rates, microorganisms are often expected to be cosmopolitan. However, recent studies have demonstrated that microorganisms indeed may show biogeographical patterns. Diatoms have for a long time been used as models to study microbial biogeography. They are unicellular eukaryotic microalgae that are taxonomically diverse, and different species have marked species-specific ecological preferences. Most studies on diatoms dispersion and endemism are based on microscopy data and therefore suffer from drawbacks associated with the optical identification at large scale. Metabarcoding technologies provide higher resolution data and enable analyzing genetic diversity. Recent bioinformatics tools allow reliable comparison of large datasets, overcoming biases in species identification. In this study, we assembled a large metabarcoding dataset of benthic diatom samples collected from rivers in seven geographic regions (four continental areas and three tropical islands) covering the subpolar (Fennoscandia), temperate (France Mainland) and tropical (West Africa, French Guyana, New Caledonia, Tahiti island and Mayotte island) climate zones. We analysed diatom diversity patterns to address two main questions: 1) the presence of a latitudinal gradient in diversity and 2) the cosmopolitanism of diatoms. Our data showed a decrease in diatom richness with a decrease in latitude. However, testing the effect of land type (island vs. mainland) showed that this factor explains the actual variability of richness along the climatic gradient. Differences in community structure between regions and climate zones were significant. The proportion of endemic diatoms varied strongly depending on the selected level of genetic similarity.

## DNA-metabarcoding reveals differences in ecological preferences within key diatom species for biomonitoring

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We applied DNA metabarcoding to evaluate the ecology of genetic variants within several diatom species that are important for Water Framework Directive monitoring of European rivers: *Fistulifera saprophila* (FSAP), regarded as a marker for organic pollution and hence poor ecological status; *Achnanthes minutissimum* (ADMI), which usually indicates good ecological status; and *Nitzschia inconspicua* (NINC) and *N. soratensis* (NSTS), two species separated phylogenetically but almost impossible to distinguish in the light microscope. Our dataset was based on high-throughput sequencing using a 312-bp *rbcL* marker. We used the denoising pipeline DADA2 to infer amplicon sequence variants (ASVs) from 554 environmental samples from river biomonitoring campaigns in Catalonia (NE Spain) and France. Based on the environmental responses given by Threshold Indicator Taxa Analysis we could distinguish three ecological groupings of ASVs in both ADMI and FSAP. Two of these, in each species, were clearly separated by their opposite responses to calcium and conductivity. In addition, a third grouping in FSAP was characterized by a negative response to total organic carbon and hence, it was better represented in less organically polluted waters and higher ecological status than is generally assumed for the species. Our analyses did not identify ecological groupings of ASVs within NINC and NSTS but confirmed earlier studies: NINC prefers higher levels of calcium and conductivity than NSTS. Our results, coupled with previous knowledge generated by morphological identifications, help reveal and understand biogeographical distributions of these species complexes and could facilitate the development of more accurate biological indexes for biomonitoring programmes.



## Functional assessment of prokaryotes in constructed wetlands predicted from 16S rRNA data

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Polishing constructed wetlands (CWs) are conceived to improve the quality of wastewater treatment plants (WWTP) effluents. They are built mimicking natural wetlands and may serve as transitional ecosystems to approach the water ecological features to those of the receiving environment, including the assembling of microbial communities more functionally similar. Some CWs located at east Spain are managed by the company Global Omnium and have been thoroughly studied by the Limnology group of the University of Valencia. Part of this research has consisted in outlining the composition of their prokaryotic communities by sequencing the V4 region of the 16S rRNA. A prediction of the metabolic capabilities of these communities was made with bioinformatic packages PICRUSt2 and FAPROTAX, and the information gathered was used to assess the previously mentioned functional annotation. When the CWs performed optimally, predictions indicated a decline in the effluents of microbial functions typical from the wastewater treatment in favour of those more suited for the receiving environment. An increase of the aerobic chemoheterotrophs, photoautotrophs, and a general shift towards redox reactions with higher potentials prevailed. Accordingly, the denitrification and the dissimilatory sulphate reduction potentials, that are predominant in the anaerobic environments, decreased to levels comparable to those observed in natural environments. Additionally, enzymatic skills for degrading plant material were enhanced. We propose these metagenomic functional predictions advancing from the widely used 16S rRNA gene sequencing methods as being useful for routine biomonitoring applications, thereby resulting in an alternative to less affordable MAG metagenomic analyses.

## Effects of agricultural run-off on cryptic genetic diversity of stream benthic diatoms

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3A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions, July 26, 2021, 15:30 - 17:00

Small streams are very common components in agricultural landscapes and are consequently polluted by agricultural runoff, a mixture of pesticides and fertilisers. However, the combined effects of these mixtures on 1/ the biodiversity of the microphytobenthic community and 2/ the associated selection processes have rarely been studied in agricultural streams. We analysed the structure of benthic diatom assemblages sampled in 2018 and/or 2019 at 65 sampling sites across Germany reflecting different exposure scenarios (from reference sites to heavily polluted sites). Furthermore, the concentrations of 101 pesticides from 16 different chemical modes of action as well as local abiotic factors (e.g. nutrients) were analysed. Amplicon sequence variants (ASV) were determined by using an *rbcl* barcode primer for PCR, subsequent Illumina sequencing and data analysis applying the DADA2 workflow. Good agreement was observed between the parallel microscopy-based taxonomic analysis and the metabarcoding approach. A total of 4008 ASVs (identified as 208 species) were found at the 65 sampled sites. Multivariate statistics based on ASVs discriminated clusters for sites characterised by high toxicity or nutrients. These results correlated with higher phylogenetic clustering at reference sites compared to impacted sites. Accordingly, ASV richness and species diversity were lower at the reference sites. These results are discussed in terms of the adaptability of species with high cryptic genetic variation to environmental stress. We conclude that diatom communities in agricultural landscapes are sharpened by environmental filtering and reflect the effects of pesticides and/or nutrients.

## 3B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges & RS13 Hydromorphology: integration with ecology

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### Cryptic survival of *Palingenia longicauda* (Ephemeroptera: Palingeniidae) in South-eastern Europe

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3B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges & RS13 Hydromorphology: integration with ecology, July 26, 2021, 15:30 - 17:00

*Palingenia longicauda* was once generally distributed all over Europe, but suffered a drastic range contraction, due to intense pollution and hydromorphological interventions. For the last decades it was known to persist only in small enclaves, with high genetic diversity, in the Tisza River catchment and in the Rába River. However, new reports indicated its presence in the Danube River in Hungary, in the Danube Delta in Romania and Ukraine, and in the Prut River in Republic of Moldova. During 2018 and 2020 the species was collected from 14 locations corresponding to 4 rivers (Danube Delta, Mureş, Bega and Prut) from Romania, and 4 locations corresponding to 2 rivers, Sty and Horyn' from Ukraine, both tributaries of Pripyat River. We generated 196 combined mitochondrial COI (472 bp) and 16S (464 bp) sequences from these locations, and downloaded an additional 245 publicly available ones, representing the Tisza catchment populations, to analyze the phylogeographic pattern of the species. Our results show a high haplotype diversity and low genetic differentiation, and indicate that the analyzed populations from the South-eastern Europe represent cryptic local lineages. We therefore confirm the presence of viable populations in the Danube Delta and on the Prut River in Romania, and show additional presence on the Mureş and Bega rivers from Romania, and on the Styr and Horyn' rivers in Northern Ukraine. This work was supported by two grants of the Romanian Ministry of Education and Research, CNCS - UEFISCDI, project numbers PN-III-P1<sup>-1</sup>.1-PD-2019-0829; nr. PD91/2020 and PN-III-P2-2.1-PED-2019-0214; nr. 476PED/2020.

## Integrative taxonomy, biogeography and biodiversity conservation of the Plecoptera fauna in Croatia

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3B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges & RS13 Hydromorphology: integration with ecology, July 26, 2021, 15:30 - 17:00

Plecoptera are used as a biological indicator for pollution and climate change and since their populations are shrinking, it is necessary to give special attention to the conservation importance of their habitats. Project CroBarFauna (DNA barcoding of biodiversity of Croatian fauna, funded by Croatian Science Foundation: IP-06-2016-988) has contributed to the better understanding of geographic distribution of fauna and has positively impacted the research in systematics, phylogenetics and phylogeography. DNA barcoding of stoneflies (Plecoptera), with a more than 350 analysed specimens, collected at 100 different localities (in 3 biogeographical regions: Mediterranean, mountainous and continental), and comprising 70 species (90% of the species with recent finding in Croatia) revealed several deeply divergent genetic lineages. Given the high genetic diversity accompanied by distinctiveness of the morphological characteristics and ecological features they were identified as new species. The use of integrative taxonomy and rigorous delimitation in describing new species will inevitably yield better biodiversity inventory. The two newly described species have clearly marked morphological differences from related species (in males, females and larvae) and are associated with specific habitats in Dinaric karst. The species belong to the genera *Isoperla* and *Taeniopteryx*, characterised by high interspecific genetic diversity. The monophyly of two new species is supported by phylogenetic analysis and for establishing taxonomic relationships, several species delimitation methods were applied. Analysis of more mitochondrial and nuclear markers (in addition to already used cytochrome oxidase subunit I (COI) barcode region) contributed to a better understanding of the phylogenetic relationship between species.

## Habitat preferences of endangered diving beetle *Graphoderus bilineatus*: implications for conservation management

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3B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges & RS13 Hydromorphology: integration with ecology, July 26, 2021, 15:30 - 17:00

Populations of the endangered diving beetle *Graphoderus bilineatus* are decreasing across Europe. Evidence-based conservation of its local populations requires good knowledge of its habitat requirements, but data from different countries are often incomplete or contradictory. *Graphoderus bilineatus* was common until 1950s but then almost disappeared in the Czech Republic. Using data from a recent field survey in its core distributional area in the Czech Republic, we evaluate its habitat preferences at the habitat and microhabitat scale. We found that extensively managed fishponds can provide similarly suitable habitats for *G. bilineatus* as do more natural habitats including floodplain and sandpit pools, while the species is typically absent in intensively managed fishponds. All else being equal, the species is more likely found in larger water bodies surrounded by other wetlands and is more often absent at sites in agricultural landscape. We detected only weak preferences on the microhabitat scale. They suggested that *G. bilineatus* tends to occur in deeper water but closer to the shore and in microhabitats dominated by *Glyceria* or *Typha*. These microhabitat associations partly differ from those reported from other countries. Moreover, *G. bilineatus* was found at localities with higher species richness of large-bodied aquatic beetles, both common and threatened, supporting the species status as an umbrella species for other beetles. Our findings provide guidelines for conservation management of currently known localities and other potentially suitable sites, including the creation of new ones. Finally, our study reinforces Annex II species status of *G. bilineatus* in Habitats and Species Directive.

## Towards no-net-loss biodiversity in EU rivers: Planning offsets due to barriers implementation

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Biodiversity offsetting is a common conservation tool to reduce the impact of development projects on biodiversity. This tool is now especially relevant under the EU Biodiversity Strategy, which aims to reconnect 25,000 km of rivers by 2030 while assuring freshwater storage and energy production. Spatial optimisation methods can help inform decision by accounting offsets for barriers implementation regarding a no-net-loss in connectivity of the river network and the further alterations of structure and functioning of those systems. To demonstrate how to plan offset of longitudinal connectivity loss in rivers from the construction of new barriers, we used as case study the Tagus River, the largest in the Iberian Peninsula. We mapped the distribution of >900 barriers in the basin and 29 freshwater fish species with different movement abilities and needs. We simulate the construction of new additional barriers, measure the impact they would have on connectivity for each species, and identify an optimal set of existing barriers that should be removed to counterbalance the loss of connectivity caused for all species collectively. We found that loss in connectivity could be offset for most of species when a single new barrier was simulated at a time, by removing a small number of existing barriers. However, there was a group of species with very restricted ranges that could undergo irreversible connectivity loss. Non offsetable impacts increased when multiple new barriers were simulated simultaneously. The approach presented here could be used to plan offset actions for other impacts in freshwater systems or elsewhere.

## Assessment of hydromorphological potential of heavily modified/artificial water bodies in Croatia

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Latest Water Framework Directive (WFD) guidance documents provide a comprehensive review of methods and guidelines in order to improve comparability of heavily modified water bodies (HMWB) in the European Union. However, currently there is still no common single methodology neither for monitoring of HMWB and artificial water bodies (AWB) nor for determining maximum (MEP) and good ecological potential (GEP). In Croatia, the first assessment of hydromorphological potential of HMWB and AWB started in 2020 and it was based on a type-specific score scale. The typology of HMWB was developed according to ecoregion type, basin size, flow intermittency and the dominantly modified hydromorphological feature: hydrology, longitudinal continuity or morphology. AWB were typified considering their most distinct features: large changes in daily flow, disturbed groundwater-surface water interactions, and large seasonal changes in flow. The typologies can be easily related to uses of water bodies since each use is characterized by distinct hydromorphological modifications. The classes of hydromorphological potential were graded from the theoretical MEP, which was determined by the score scale as the tolerated deviation from natural reference conditions, considering the use of the water body and / or the wider environment according to the WFD. The hydromorphological parameters included in monitoring and assessment were type-specific and not directly related to the use of the water body and / or the wider environment. In the case of AWB, the parameters dependent on natural reference conditions, which are non-existent, were also omitted from the assessment.

## The role of ditches in supporting a temporary stream specialist, *Paraleptophlebia weneri*

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3B\_SS11 Freshwater invertebrate biodiversity - threats, assessments, knowledge needs and conservation challenges & RS13 Hydromorphology: integration with ecology, July 26, 2021, 15:30 - 17:00

In agricultural landscapes, ditches are artificial watercourses which are typically slow-flowing, and many sometimes stop flowing and dry out. Despite their artificial nature and exposure to pollution, ditches support high biodiversity, including rare species. For example, larvae of the mayfly *Paraleptophlebia weneri*, considered a temporary-stream specialist, inhabit ditches. Our previous research has suggested that *Paraleptophlebia weneri* occurs more frequently in headwater temporary reaches surrounded by agricultural land, leading us to formulate three hypotheses (H) to test how ditches support *P. weneri* populations in agricultural catchments: (H1) ditches with temporary flow in the lower catchment provide suitable habitat for the aquatic larvae of *P. weneri*, allowing populations to extend beyond headwater temporary stream reaches; (H2) if in-channel habitat conditions are comparable, *P. weneri* abundance will be similar in ditches and headwater temporary streams; (H3) if ditches have lower densities of their competitors, *P. weneri* abundance will be higher in ditches than temporary streams. Testing these hypotheses in spring/summer 2021 will allow us to evaluate the role of ditches in supporting a temporary stream specialist species, and thus to propose catchment-scale management strategies to enhance the resilience of such rare species.



## 3C\_SS14 Securing and managing biodiversity, functional integrity and ecosystem services in drying river networks

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### After the drought: effects of flow intermittence on macroinvertebrates in temperate streams

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3C\_SS14 Securing and managing biodiversity, functional integrity and ecosystem services in drying river networks, July 26, 2021, 15:30 - 17:00

The disruption of natural flow regimes by the combined effects of extensive anthropogenic pressures and climate change is transforming biodiversity patterns worldwide, due to the increasing spatial and temporal extent of drying events. Thus, characterizing changes in lotic communities as a consequence of flow intermittence is vital for their conservation. In this framework, we studied the distribution of aquatic macroinvertebrates in 24 perennial (P) and 21 intermittent (I) stream sites from northern Apennines (Po River basin, Northern Italy), aiming to evaluate changes in macroinvertebrate metrics and community structure as a consequence of flow intermittence. Macroinvertebrates were sampled before the summer dry phase in the P and I-sites for two following years (2017 and 2018), and several environmental variables (at patch, reach and basin scales) were recorded for each site. A flow permanence score (FPS) was computed using all environmental variables. Taxa richness and abundance were significantly lower in I-sites and also decreased during the second sampling year, as a consequence of an extremely dry summer. Beta-diversity was higher in I-sites but generally decreased after 2017 summer drought, with many taxa showing a decline with decreasing FPS. Conversely, few taxa increased with decreasing FPS, highlighting weak adaptation of macroinvertebrate communities to flow intermittence. Furthermore, we found that communities of I-sites were mainly affected by reach-scale environmental variables, whereas communities of P-site were driven by patch-scale variables. These findings represent valuable insight in the effects of flow alterations in the perspective of best-strategy planning to face the flow intermittence phenomenon.

## Physico-chemical and biological indicators of river health during the dry phase

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3C\_SS14 Securing and managing biodiversity, functional integrity and ecosystem services in drying river networks, July 26, 2021, 15:30 - 17:00

Intermittent rivers and ephemeral streams, characterized by the presence of a dry phase, are widespread and abundant ecosystems worldwide. When rivers are dry, traditional indicators of river health cannot be measured, however indicators to determine their ecological quality during the dry phase are barely starting to be developed. Here, we analyzed both physico-chemical parameters of sediment and terrestrial invertebrates present in dry channels to evaluate their potential as indicators of river health. To this end, we monitored 47 intermittent and ephemeral streams located at Segura River Basin (SE Spain) during the dry phase. We analyzed the sensitivity of different physico-chemical parameters (extractable nitrate, ammonium, pH, conductivity and dissolved organic carbon) and invertebrate metrics (Total richness and abundance, Araneae richness and abundance, Coleoptera richness and abundance, and Formicidae richness and abundance) to a multiple stressor gradient reflecting main pressures in the study area. Nitrate and ammonium were the parameters which significantly discriminated among different levels of quality classes, showing higher levels in most disturbed sites. Similarly, several invertebrate metrics discriminated among levels of degradation. Our findings support the incorporation of dry riverbeds into ecosystem monitoring and assessment works through government policy and legislation.

## Fish carcasses in intermittent rivers: phosphorus sources or sink?

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Animals are important in nutrient cycling. Fish represents steady pools of nutrients in aquatic ecosystem recognized as nutrient sinks, accumulating over time more nutrients than is recycled by releasing. Nevertheless, considering fish as nutrient sink or source depends on emigration and immigration, biomass changes, and fate of post mortem nutrients. Annual cease of flow in Intermittent rivers can promotes fish kills that potentially causes sources of nutrients. The goal of this study is to investigate if fish carcasses represents a Phosphorus source in intermittent rivers. We quantified phosphorus composition of the most abundant fish species in a intermittent river and temporal biomass change of these species to estimate P potentially released by fish mortality. Furthermore, we test whether fish carcasses were predated or not and identified fish scavengers in artificial river pools. The results shows a fish biomass temporal decrease in the middle reach of the river only in the dry season very end. On the other hand, in the low river reaches the overall fish biomass increase over time. Moreover, fish carcasses were highly predated in artificial river pools. River intermittence can enhance the fish role as sink of nutrients by different mechanisms that depends on the presence or absence of remanent pools. On the basis of these results, it can be concluded that fish carcasses in intermittent rivers are nutrient subsidies to terrestrial ecosystem in sites where total flow cease, whereas fish are steady pool of Phosphorus capable to accumulate nutrients during dry season remanent river pools sites.

## Modelling fish passability across a weir (Tagus River) under climate change scenarios

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Climate change represents a major challenge for the management of native fish communities in Mediterranean rivers, as reductions in discharge may lead to a change in habitat availability, both in temporary and large rivers. Moreover, the efficacy of small barriers such as weirs to fish passage may also be affected, as it will depend on the incoming flows upstream. Through physical habitat modelling, we investigated how the flows released from a large hydropower plant in the Tagus River are expected to affect the passability of native freshwater fish species through a rock weir equipped with a fish ramp. We considered not only mean daily flow data retrieved from nearby gauging stations (1991–2005), but also predicted flows supported on climatic projections (RCP 4.5 and RCP 8.5) for the Tagus River Basin. Results showed that a minimum flow of 3 m<sup>3</sup>/s may be required to ensure the passability of all species through the fish ramp of the weir and that, overall, passability is likely to occur exclusively through the fish ramp for flows lower than 30 m<sup>3</sup>/s. The habitat suitability index for each species was significantly different between the reference and climate change scenarios, with lower values in the latter ones. This study suggests that climate change may reduce the passability of native freshwater fish species in weirs, meaning that the construction of small barriers in rivers should consider the decreases in discharge that are likely to occur in global change scenarios for a suitable management of fish populations.

## Terrestrial and aquatic invertebrate communities along drying in semi-arid naturally saline streams

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As saline streams are geographically widespread in arid and semiarid regions, flow intermittence frequently occurs as a stressor factor in addition to salinity. Both salinity and flow intermittence are natural stressors that shape biological communities. However, we know little about the effect of drying on aquatic invertebrates and even less on terrestrial invertebrates, especially in saline streams. In this study, we analyzed structural and compositional responses of aquatic and terrestrial invertebrate communities along drying in two intermittent saline streams (SE Spain), distinguishing among the wet, contraction and dry phases. Aquatic invertebrates were sampled during the aquatic phases (wet and contraction) with hand nets and terrestrial invertebrates were sampled with pitfall traps in the channels and their shoreline during the three phases. The highest abundance and richness values were significantly higher in contraction than in wet in both streams for both communities in the two study streams. Aquatic and terrestrial composition differed significantly among phases in both streams. For the aquatic community, Coleoptera, Ephemeroptera, Heteroptera and Odonata were the most important taxa that explained the differences, with their highest abundances in the contraction phase. For the terrestrial community, Formicidae, Araneae and Hemiptera were responsible for the detected differences, with greater abundance in the contraction and dry phases than in the wet phase. These findings evidence the significant effect of drying in both aquatic and terrestrial invertebrate communities in saline streams, with the contraction phase particularly contributing to the diversity of the communities.

## Disentangling responses to natural stressor and human impact gradients in river ecosystems

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3C\_SS14 Securing and managing biodiversity, functional integrity and ecosystem services in drying river networks, July 26, 2021, 15:30 - 17:00

Rivers are highly dynamic ecosystems, in which both human impacts and climate-driven drying events are increasingly common. Disentangling ecological responses to these interacting stressors is crucial to guide effective monitoring and management. We analysed the independent and interactive effects of human impacts and river drying on taxonomic richness, functional diversity and biomonitoring indices representing aquatic invertebrate assemblages in nine European countries. We calculated response metrics for the whole community and for an assemblage of drying-resistant and resilient ('high RR') taxa. Most community metrics decreased independently in response to impacts and drying. Biomonitoring index totals and 'ASPTs' showed the strongest responses, indicating their potential for adaption and use in biomonitoring. High RR taxonomic richness responded only to impacts, but little variance in high RR metrics was explained. The responsiveness of high RR metrics could be enhanced by recognizing region-specific environmental conditions and high RR taxa, to inform the development of richness metrics that respond to ecological status. To enable effective ecological status assessments in dynamic river ecosystems, including those that dry, we thus recommend the consideration of richness-independent biomonitoring indices alongside new metrics that characterize the richness of region-specific groups of resistant and resilient taxa. We also observed interactions between aridity, human impacts and drying, evidencing the need for new metrics to be flexible, to enable their ongoing adaptation to protect river ecosystems as they respond to climate change.

## 3D\_SS03 The role of small water bodies in the landscape

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### Not all fish are bad – in ponds containing great crested newts

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3D\_SS03 The role of small water bodies in the landscape, July 26, 2021, 15:30 - 17:00

Impacts on amphibians by certain fish species have resulted in ecologists broadly labelling all fishes as 'bad for ponds'. Current conservation strategies for many amphibians such as Great Crested Newt (*Triturus cristatus*) consequently propose indiscriminate fish eradications through draining-down, making ponds ephemeral, or the use of broad-spectrum biocide rotenone. Some fish species however are characteristic of favourable ponds, and local knowledge suggests they can co-exist with amphibians, including the protected Great Crested Newt (GCN). This study presents previously unpublished field data from surveys of 53 ponds in North Norfolk (England) in which fish, GCN presence and aquatic macrophytes were assessed. Consistent with previous studies, GCN recruitment (confirmed by oviposition [egg-laying] and the presence of large efts) was statistically higher in ponds containing macrophytes than in those devoid of macrophytes but containing fish. Contrary to most published studies, GCN recruited in ponds containing certain fish species (including crucian carp *Carassius carassius*, ninespine stickleback *Pungitius pungitius*, and rudd *Scardinius erythrophthalmus*) but not other fish species (i.e. visual predators, including northern pike *Esox lucius*, Eurasian perch *Perca fluviatilis*, and European eel *Anguilla Anguilla*). Limited macrophyte cover may explain why GCN were not found in any ponds containing omnivorous fishes such as roach *Rutilus rutilus* and threespine stickleback *Gasterosteus aculeatus*. These results emphasise the need for more detailed examination of amphibian-macrophyte-fish interactions in ponds and the practice of indiscriminate fish removal as a conservation measure, particularly in light of declining population of native species such as crucian carp.

## Preliminary results of EUROPONDS: early researchers shedding light on overlooked water bodies

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3D\_SS03 The role of small water bodies in the landscape, July 26, 2021, 15:30 - 17:00

Whilst being generally small and shallow lentic water bodies, ponds provide valuable habitats for a multitude of groups and contribute to habitat connectivity. Semi-aquatic insects emerging from such ponds act as one of the most important vectors of dietary energy to the adjacent terrestrial environment. By providing essential fatty acids, emerging insects constitute an important nutritional food resource for terrestrial (e.g. spiders, lizards, ants) and aerial (e.g. bats, birds) consumers. Broad-scale studies are needed to explore differences in dietary exports encompassing diverse pond types and different landscapes or regions, with the final aim of



drawing general patterns. Herein we present the first results of "EUROPONDS". In this ongoing project we quantify the seasonal and spatial variation in insect emergence. In a total of 55 ponds distributed across Europe we installed emergence traps for one week per season over a full year. This broad scale set-up allows us to quantify differences in biomass export between different geographical regions, between rural and urban systems as well as between natural and artificial ponds. The project brings together the knowledge of 80 early-career limnologists from all over Europe and therefore not only provides important insight in the aquatic-terrestrial linkages of ponds, but also provides an important exchange among the future generation of European limnologists.

## Blue roofs as nature-based solutions: A characterization of rooftop ponds in Switzerland

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3D\_SS03 The role of small water bodies in the landscape, July 26, 2021, 15:30 - 17:00

Urbanization leads to a loss of natural areas, altering our environment and quality of life. Buildings offer, however, rooftop surfaces that can be valued as natural habitats. Ponds built on roofs can provide several ecosystem services, such as water retention or thermic regulation. We suggest that they also provide habitats for aquatic biodiversity. Furthermore, their location on roofs makes them novel ecosystems, characterized for example by well-oxygenated water and low content in nutrients. We undertook an inventory of existing roof ponds in Switzerland with the aim of characterizing them. We described their morphometry, hydrology, productivity, nutrient status, water oxygenation, elevation, exposure to wind, and shade. We also undertook a diagnosis of aquatic biodiversity with a focus on aquatic vegetation, dragonfly, and mosquitoes. Finally, we compared 40 roof ponds, with urban and rural ponds. Our investigations confirmed our preliminary assumption: rooftop ponds constitute a novel ecosystem, with several characteristics distinguishing them from rural or urban ponds. First, their morphometry is limited to shallow, mostly small, and temporary systems. Nevertheless, large permanent systems also exist. The water quality differs with a low conductivity related to rainfall water source and low nutrient content. The biodiversity is represented but less diversified compared to other pond types. A selection of best practices highlighted a high potential for ponds having an appropriate design and management. We, therefore, encourage the creation of such well-designed ponds on rooftops, as a nature-based solution. As they are relatively small, they can be easily replicated at a moderate cost.

## Motorway attenuation ponds as new habitats for mobile aquatic insects in Ireland

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3D\_SS03 The role of small water bodies in the landscape, July 26, 2021, 15:30 - 17:00

Ponds are biodiversity hot spots and support a greater diversity than rivers or streams relative to their size. However, many of Ireland's natural ponds have been lost or impacted by agriculture and land-use change. During the construction of motorways in Ireland, stormwater run-off ponds were built every few kilometers to meet EU regulations. These ponds are providing a new man-made habitat in the landscape but despite being an EU requirement, minimal research has been done on the biodiversity supported by these ponds. This study assessed the overall biodiversity of the coleopteran communities using horizontal activity traps in five motorway run-off ponds in the midlands of Ireland. Temporal changes were investigated by sampling three times over a year in March, June and September. Results show that these ponds support a large number of species, some of which are red-listed. Most of the ponds supported statistically unique communities, even those in close proximity to each other. No strong environmental gradients were detected but the vegetation type present and water chemistry had a significant influence on the beetle communities. The results show that these ponds support a high diversity of mobile aquatic insect groups and highlights the importance of these new habitats for the conservation of these insects in a landscape dominated by agriculture.

## Differential effect of organic and conventional agriculture on pond biodiversity

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3D\_SS03 The role of small water bodies in the landscape, July 26, 2021, 15:30 - 17:00

Agriculture is a key driver of global land use change and profoundly affects communities in a variety of ecosystem. Although organic agriculture is increasingly promoted as a more environmentally friendly alternative to conventional agriculture, the extent of the differences of impacts of both farming systems is still debated. Comparative studies focus mainly on terrestrial systems or on rivers, whereas small lentic waterbodies, such as ponds, are ignored, despite these being abundant ecosystems in agricultural landscapes and largely contribute to regional biodiversity. Additionally, ponds are excellent sentinels to study the impact of land use since they are highly sensitive to local environmental change. Here we compare the impact of conventional and organic agriculture on biodiversity of multiple aquatic organism groups in farmland ponds, at  $\alpha$ -,  $\beta$ -, and  $\gamma$ -scale. We sampled 48 ponds (26 in organic and 22 in conventional agricultural land), for which we assessed local environmental variables, species composition and relative abundances of macrophytes, zooplankton and macroinvertebrates communities. Our results show that effects of organic agriculture differ among organism groups and spatial scales. Shoreline vegetation and zooplankton are the taxonomic groups for which organic agriculture has a (moderate) positive effect on biodiversity compared to conventional agriculture. These differences were more evident for  $\beta$ - and  $\gamma$ - than for  $\alpha$ -diversity. Our results suggest a moderately positive effect of organic farming on aquatic biodiversity, but the wide variety in biodiversity among ponds irrespective of agricultural type also emphasizes that other factors such as land use intensity might be more important for biodiversity.

## Demonstrating the role of ponds in increasing freshwater biodiversity

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3D\_SS03 The role of small water bodies in the landscape, July 26, 2021, 15:30 - 17:00

Freshwater Habitats Trust research over the last 30 years has shown the important role that ponds play in supporting landscape-scale biodiversity. Worryingly, our resurveys of reference condition ponds suggest that many of the UK's best sites, in semi-natural landscapes are declining. Evidence from the wider countryside shows a similar trend. The Water Friendly Farming project (WFF) is a long-running demonstration project in the English Midlands that evaluates the role played by nature-based solutions (NBS) in protecting freshwater biodiversity. It is also a demonstration site for the EU-funded PONDERFUL project. In WFF's three headwater catchments we measured freshwater plant alpha and gamma richness annually over nine years in all waterbodies to test whether freshwater biodiversity could be increased by adding: (i) multi-functional NBS intended to intercept pollutants, store water and promote biodiversity (dammed streams and ditches, runoff ponds, flood storage ponds) and, (ii) biodiversity-only clean-water ponds. Without the addition of any measures, we saw a background 1% pa species loss (rare species 2% loss pa) across all catchments. Five years after introducing measures, colonisation of multi-functional NBS waterbodies largely cancelled-out the background loss of plant species but, importantly, did not reverse losses of rare plants. Adding clean water ponds as a biodiversity-only enhancement brought substantial benefits: increasing catchment richness by 26%, and rare plant species richness by 181%. The findings suggest that 'multifunctional' NBS could bring some biodiversity benefits to agricultural catchments. However, creating clean-water ponds specifically targeted for biodiversity could substantially help stem ongoing catchment declines in freshwater plant biodiversity.

## 3E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system

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### Floodplain pools are emitters of CO<sub>2</sub> and CH<sub>4</sub> to atmosphere

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3E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system, July 26, 2021, 15:30 - 17:00

Very small water bodies like ponds and pools are considered to represent an important inland water carbon flux. However, direct estimates of emission fluxes from alluvial floodplain pools are still scarce. Here we present results from a set of 26 pools located in the Morava river floodplain, Czech Republic. CO<sub>2</sub> and CH<sub>4</sub> concentrations in a water and fluxes at the water-air interface from pools were directly measured with floating chambers and Los Gatos ultraportable GHG analyser during spring-summer period 2020. The pools varied in their nature (man-made and natural), size, depth, sediment organic matter content, water duration period, and macrophyte growth. Generally, all pools were found to be a net source of CO<sub>2</sub> and except two also the source of CH<sub>4</sub>. No significant relationship between pool size and emission fluxes of both gases was found. In average, the pools emit more CO<sub>2</sub> during a night (0,15 mol m<sup>-2</sup> day<sup>-1</sup>) compared to day (0,08 mol m<sup>-2</sup> day<sup>-1</sup>) Average CO<sub>2</sub> fluxes amounted to 0,15 and 0,08 mol m<sup>-2</sup> day<sup>-1</sup> at night and day, respectively, with night fluxes exceeding those during the day by 47%. No significant differences were found for the methane. Dissolved organic carbon (DOC) concentrations, water pH and temperature significantly correlated with CO<sub>2</sub> emissions, CH<sub>4</sub> flux variability was attributed mainly to changes in pH and dissolved oxygen content. In respect to their numbers, our results highly supported opinion that floodplain pools should not be omitted in the global carbon cycles.

## Environmental gradients shape the structure and function of Ebro delta prokaryotic communities.

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In this work, we have studied the prokaryotic communities that inhabit three different types of wetlands located in Ebro river delta (Spain), through the analysis of V4 region of the 16S rDNA. We observed the effect of the environmental factors on the structure and potential metabolism of the prokaryotic communities, analyzing the influence of these drivers on the main carbon-related metabolisms such as aerobic photosynthesis, aerobic respiration, methanogenesis and aerobic methanotrophy. These wetlands present strong seasonal variations in their salinity, which strongly affects prokaryotic communities from both water and sediments. Metabolic rates are also affected by environmental factors and show a correlation with the predicted metabolisms. The methane emissions of the wetlands result from a balance between methanogenesis and (mostly) aerobic methanotrophy, whereas the relative contribution of dissimilatory sulphate reduction and methanogenesis to overall anaerobic respiratory processes depends on a sort of factors. The analysis of the relationships between prokaryotic groups and potential metabolisms can help to understand the factors that influence this balance. Our results show the main taxonomic and metabolic differences of the prokaryotic communities of deltaic wetlands and the strong effect of the environmental variables in the structuration of these communities and their metabolic capacities, determining their patterns of carbon balances and methane emissions. The complexity of the structure and metabolic function of the prokaryotic communities involved in the net balance of emissions of the main greenhouse gases makes this kind of studies relevant to understand and therefore efficiently manage the diversity of wetlands in deltaic systems.

## Effects of carbon source, temperature and oxygen on methane/CO<sub>2</sub> emissions from lakes

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3E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system, July 26, 2021, 15:30 - 17:00

Sedimentary organic matter degradation leads to the production of CO<sub>2</sub> and CH<sub>4</sub>. Both are greenhouse gasses, but the warming potential of CH<sub>4</sub> exceeds that of CO<sub>2</sub> over 28 times. What determines which of these greenhouse gasses is released from lake systems, and in which quantities? To examine these questions, we set up incubation experiments with sediments from Lake Lucerne, a large oligotrophic lake in central Switzerland. To assess the effect of carbon source material and temperature on total and relative rates of CO<sub>2</sub> and CH<sub>4</sub> production, we supplied autochthonous (algal) material and allochthonous (leaves) material at in situ and elevated temperatures. Furthermore, we tested the effect of oxic versus anoxic degradation, mimicking the conditions in lakes with either oxic or anoxic water columns. For this, experiments were performed either completely anoxic, or initially oxic, to be turned anoxic afterwards, supporting both oxic degraders and anoxic fermenters and methanogens. Besides gas concentration and isotope analysis, reaction intermediates were examined, to follow the breakdown of large organic matter molecules to smaller volatile fatty acids, which are partly the precursors of methane or CO<sub>2</sub>. The microbial community was assessed by 16S rRNA sequencing and marker gene specific qPCR analysis, allowing for an assessment of both the initial degraders and specific methane-producing organisms.



## Carbon balance of Mediterranean wetlands: role of ecological types and human impacts

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Mediterranean wetlands are generally shallow, but differences in salinity, alkalinity, hydroperiod length, or origin, lead to a great ecological diversity. Carbon balances, estimated from a metabolic approach, may differ according to these features, as well as to the conservation status. The aim of this work was to understand the differences in the carbon balance between the main wetland types within different ecological features and differently impacted. For that purpose, inland and coastal, freshwater and saline, permanent and temporary, and alkaline and low alkaline wetlands from the Iberian Peninsula were surveyed, by estimating the metabolic rates involved in the carbon exchange. Results showed a clear influence of the ecological type, though the conservation status altered the trends observed among the groups. Salinity was found to be one of the main drivers of the carbon metabolic activity, inhibiting the metabolic rates and reducing the carbon balance (20 g C m<sup>-2</sup> y<sup>-1</sup> on average for the most saline well-conserved inland wetlands). Freshwater coastal wetlands were the most productive wetlands among the studied types (up to 950 g C m<sup>-2</sup> y<sup>-1</sup> in restored sites), with increases in the carbon-greenhouse gases emissions when the conservation status worsened. The hydroperiod length was also a key in the regulation of the methane emissions. Inland freshwater wetlands may release high methane amounts, especially when they kept artificially flooded during the warmer months (reaching up to 40 g C-CH<sub>4</sub> m<sup>-2</sup> y<sup>-1</sup> in altered sites). Hence, the importance of these aquatic ecosystems in the carbon exchange with the atmosphere.

## Forecasting carbon retention and GHG-emissions in Mediterranean wetlands within climate change scenarios

**Prof. Dr Antonio Camacho<sup>1</sup>**, Daniel Morant<sup>1</sup>, Alba Camacho-Santamans<sup>1</sup>, Dr Carlos Rochera<sup>1</sup>, Dr Antonio Picazo<sup>1</sup>, Javier Miralles-Lorenzo<sup>1</sup>

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3E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system, July 26, 2021, 15:30 - 17:00

Mediterranean wetlands are especially vulnerable, and alterations in their ecological features are worsened by climate change impacts. Despite they currently keep their carbon retention capacity when they preserve their ecological health, changes in the environment can alter the functioning of the mechanisms regulating the carbon balance. Projections of the carbon balances in these wetlands to future climatic scenarios are essential to know the trend of its C-sequestering capacity. The objective of this work was to determine the response of the main metabolisms involved in the carbon balance to environmental factors, and forecasting its behaviour on future climate scenarios. From the experimentation, the response of each metabolism involved in the carbon balance was estimated according to its response to different environmental parameters (such as salinity, temperature or hydroperiod length). A mathematical model was created to forecast the carbon balance under different future climate scenarios (RCPs). Expected increase in temperature would activate metabolisms, both C-sequestering primary production, as well as C-releasing respiration. Aerobic respiration would increase linearly, while anaerobic respirations, especially methanogenesis, would increase exponentially. Although generally the carbon retention capacity would increase in both freshwater and saline wetlands, increases of methane emissions would reduce the mitigating capacity, especially when the wetlands are hydro-morphologically altered. Increases in methanogenesis would be more relevant in the more negative RCP scenarios if the maximum temperature response slope is reached. From our results, some conservation measures were suggested in order to improve the carbon retention and to reduce GHG emissions while protecting their natural ecological features.

## Modelling the carbon balance of inland shallow lakes under different management scenarios

Alba Camacho Santamans<sup>1</sup>, Daniel Morant<sup>1</sup>, Dr Carlos Rochera<sup>1</sup>, Dr Antonio Picazo<sup>1</sup>, Javier Miralles-Lorenzo<sup>1</sup>, Prof. Dr Antonio Camacho<sup>1</sup>

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Management of aquatic ecosystems can drive or modify the structure and functioning of wetlands. Although the objective is usually focused on the conservation, sometimes certain measures can weaken some factors or services in favour of others. Climate change mitigation is not usually considered, and some management actions can increase greenhouse gases emissions from shallow lakes and wetlands, such as CH<sub>4</sub> and CO<sub>2</sub>, to the atmosphere. However, other activities can strengthen its sink capacity and carbon sequestration. In this work, the carbon balances of three differently managed inland Mediterranean saline shallow lakes located in La Mancha Húmeda Biosphere Reserve (Spain) were studied. Through the modelling of the different metabolic rates, the carbon exchange of the lakes was evaluated against different management scenarios. The aim was to observe the effect of the management on their mitigation capacity and carbon sequestration. The chosen scenarios were related to the modification of the water regime and the marginal vegetation coverages. Under current scenarios, results showed a carbon sequestration capacity of these lakes, mainly determined by the marginal vegetation productivity. The extension of the flooding period and decreasing salinity level mediated by freshwater pouring caused increases of greenhouse gases emissions. Contrarily, the carbon sink capacity increased when the natural conditions of these shallow temporary saline lakes were restored. From the interpretation of the modelling results, some recommendations were defined for each of the three studied lakes, considering their current condition and management, in order to maintain or even increase its climate change mitigation service.

## 3F\_SS07 The Burrishoole Ecosystem Observatory: 65 years at the cutting edge of lake and catchment studies

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### Marine growth of salmon (*Salmo salar* L.) from North-East Atlantic populations.

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3F\_SS07 The Burrishoole Ecosystem Observatory: 65 years at the cutting edge of lake and catchment studies, July 26, 2021, 15:30 - 17:00

Atlantic salmon (*Salmo salar* L.) have been declining across the species range over the past four decades. Due to its anadromous life history involving marine migrations from multiple locations across long distances, determining the causes of the decline in abundance is difficult. In this study, post-smolt growth of salmon from six rivers in broadly contrasting geographic areas (Ireland, Norway, Finland, and Iceland) were analysed to identify changes in growth at key periods from 1970 to present. Dynamic factor analysis (DFA) was employed to identify synchrony between populations. Both the Repparfjord and Teno rivers showed strong synchrony with each other which was attributed to their geographical closeness. Little synchrony was evident between the remaining rivers. Post-smolt growth (PSG) was compared to prevailing oceanographic conditions (Sea surface temperature (SST), North Atlantic Oscillation (NAO), Atlantic Multidecadal Oscillation (AMO)), and to biological indicators (plankton indices and fish spawning stock biomass estimates). Correlations and general additive models demonstrated different responses from the six salmon populations to potential drivers of growth with only the northern stocks demonstrating PSG responses to local SST and NAO. The lack of consistency between salmon stocks is likely partially due to different migration routes and ultimately to different nursery and feeding areas at sea.

## Autumn peak of pCO<sub>2</sub> and import of DOC in a humic lake

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3F\_SS07 The Burrishoole Ecosystem Observatory: 65 years at the cutting edge of lake and catchment studies, July 26, 2021, 15:30 - 17:00

Lakes in humic systems play a key role in the processing and fate of organic carbon (OC) mobilised from their catchments. At present, knowledge of lake OC dynamics in temperate lakes, especially those with maritime climates, is limited. The generally wet and cloudy conditions coupled with the relatively benign temperatures exert a significant influence on mechanisms of OC capture, storage and processing on the west coast of Ireland. Here, we examine a high-frequency dataset of partial pressure of CO<sub>2</sub> (pCO<sub>2</sub>) in the surface waters of Lough Feeagh along with an allied set of environmental explanatory variables. The annual pattern in pCO<sub>2</sub> ranged between 491 and 1169  $\mu\text{atm}$ , and was found to be strongly related to allochthonous OC inputs from the incoming rivers. In contrast to observations from lakes in colder climates where snowmelt often drives pCO<sub>2</sub> seasonality, a single peak in pCO<sub>2</sub> occurred in Lough Feeagh in early September. Generalised additive mixed modelling revealed that two variables, inflow water colour concentration (a reliable proxy for DOC concentrations) and lake Schmidt stability together explained 68% of pCO<sub>2</sub> variability. The analysis strongly suggested that catchment carbon export drove pCO<sub>2</sub> supersaturation in the lake, and hence CO<sub>2</sub> emission. We estimated that between 217 and 370 t CO<sub>2</sub>-C (0.55 – 0.94 t CO<sub>2</sub>-C / ha) as CO<sub>2</sub> was emitted from the lake during the study period. These results highlight the interplay that exists between catchment OC fluxes and climate in determining pCO<sub>2</sub> dynamics in maritime temperate lakes.

## Effects of consecutive extreme weather events on a temperate dystrophic lake

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Between May and July 2018, Ireland experienced an exceptional heat wave, which broke long-term temperature and drought records. These calm, stable conditions were abruptly interrupted by a second extreme weather event, Atlantic Storm Hector, in late June. Using high-frequency monitoring data, coupled with fortnightly biological sampling, we show that the storm directly affected the stratification pattern of Lough Feeagh, resulting in an intense mixing event. The lake restabilised quickly after the storm as the heatwave continued. During the storm there was a three-fold reduction in Schmidt stability, with a mixed layer deepening of 9.5 m coinciding with a two-fold reduction in chlorophyll a but a three-fold increase in total zooplankton biomass. Epilimnetic respiration increased and net ecosystem productivity decreased. The ratio of total nitrogen:total phosphorus from in-lake versus inflow rivers was decoupled, leading to a cascade effect on higher trophic levels. A step change in nitrogen:phosphorus imbalances suggested that the zooplankton community shifted from phosphorus to nitrogen nutrient constraints. Such characterisations of both lake thermal and ecological responses to extreme weather events are relatively rare but are crucial to our understanding of how lakes are changing as the impacts of global climate change accelerate.

## Hindcasting nutrient export for 100 years to an oligotrophic lake.

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Understanding the balance between nutrient sources has relevance not only for lakes that are nutrient enriched, but also for those that are less eutrophic. Moreover, daily nutrient export data are needed when running lake biogeochemical models in hindcast mode to assess changes over time. Lough Feeagh, a humic lake in the Burrishoole catchment, is classed as oligotrophic based on phytoplankton data, but has experienced increases in nutrient concentrations in recent decades. The Generalized Watershed Loading Functions (GWLF) model can be used to simulate daily nutrient export. It includes a dynamic hydrological model and a sediment loss module based on the Universal Soil Loss Equation; however, the original model used an export coefficient approach with static land use categories for dissolved nutrients. It was adapted to use timeseries for human and livestock populations and land use, and a module to allow for changes in farming practice and afforestation was added. We describe the model and its application to the Black River catchment, the largest sub-catchment of Lough Feeagh and the changes in nutrient sources over time from 1920-2020. While human and cattle populations have remained low over this period, nutrients related to forestry and sheep numbers increased up to the 1990s. Further simulations of in-lake changes will allow exploration of the effects of such changes in nutrients on lake biota and chemistry.

## Temporal changes in fish migration in and out of the Burrishoole catchment

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The fish traps in Burrishoole are an internationally valuable monitoring infrastructure, allowing a full census of migrating fish in and out of the catchment. The three native diadromous fishes in Burrishoole, Atlantic salmon (*Salmo salar*), trout (*Salmo trutta*) and European eel (*Anguilla anguilla*), are routinely counted and examined as they migrate through the upstream and/or downstream traps. This almost complete census began in 1970, and here we present and describe some of the metrics which we can extract from this rich data archive. We describe the migration timing of juvenile salmon and trout smolts from freshwater to the sea, adults returning to freshwater to spawn, and the migration of silver eel to the sea. In addition, we describe the changes in size at age and fecundity of these migrating fish, ascertain whether temporal changes are significant, and if so, discuss whether they are likely to impact on lifecycle productivity.



## Application of CRISPR-Cas to *Salmo salar* eDNA detection in the Burrishoole Catchment

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3F\_SS07 The Burrishoole Ecosystem Observatory: 65 years at the cutting edge of lake and catchment studies, July 26, 2021, 15:30 - 17:00

In Europe, *Salmo salar* represents the primary farmed fish in terms of biomass and economic value since aquaculture production was established in the 1960s. However, although under a high level of protection, numbers continue to fall. In 2020, the Standing Scientific Committee on Salmon reported that only 45 % of Ireland's salmon rivers are meeting biologically based conservation limits, highlighting a need for simple and rapid species monitoring systems. Management and conservation of *S. salar* requires knowledge of distribution, traditionally gained through visual detection and counting, methods that are expensive, time consuming and potentially harmful. Environmental DNA offers a solution to this through detection of DNA shed into the environment. We have developed a novel CRISPR-Cas based assay for *S. salar* detection as a route to a simple, cost-effective biosensor device. The assay combines isothermal Recombinase Polymerase Amplification with a CRISPR-Cas system consisting of two main elements; a guide RNA specific to the target and an effector Cas12a nuclease. The Cas12a nuclease is unique in that it can only recognise DNA downstream from a specific protospacer adjacent motif (PAM), it has cleavage activity that facilitates easy detection and it has optimal function in isothermal conditions. These features support a highly specific sequence recognition system and simplify the move towards in field monitoring of eDNA. As a proof-of-concept, this assay has proven effective in monitoring *S. salar* in a limited number of sites across the Burrishoole Catchment.

## 4A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions & RS06 Emerging contaminants in freshwater systems

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### Diversity of bacteria in microbial mats – are they really cyanobacterial mats?

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4A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions & RS06 Emerging contaminants in freshwater systems, July 27, 2021, 10:30 - 12:00

Microbial mats are communities which occur at the sediment/water interface in various water bodies and often have complex structures. In so-called "autotrophic mats" Cyanobacteria play a dominant role, though in all of them other bacterial phyla co-dominate depending on the microenvironmental factors and gradients. Here we present results of next-generation sequencing (NGS) based studies of 51 mats collected from various water bodies in the cold desert of Eastern Pamir Mountains. Based on macroscopic features, we divided the mats into 8 types, ranging from simple, biofilm-like mats (Phormidium-like, Phormidium beneath soil, Nostoc-like, Epiphytes) to complex and multilayered structures (Amorphous, Jelly-like, Multilayer soft and Multilayer hard). The NGS examination of mats was based on the V3-V4 hypervariable region of 16S rDNA and analysis of reads in QIIME2 using Silva classifier. The amplicon sequence variants (ASV) approach was applied to study microbial communities and analyze their associations. Cyanobacteria contributed, on average, to 32% of the total ASV and their mean contribution varied from 22% in Nostoc-type mat to 67% in Jelly-like mat. Proteobacteria were the second prevailing phylum, with an average percentage of 29% (between 6 and 58%). Bacteroidetes and Firmicutes were the next two large phyla, with the mean contribution of 12 and 10%. The analysis of co-occurrence performed at phylum level revealed that the ASVs belonging to Cyanobacteria were often associated with those classified as Proteobacteria. The most dominant bacterial phyla correlated positively with N-NH<sub>3</sub> except for Cyanobacteria and Chloroflexi. Salinity was the second parameter correlating positively with many bacterial phyla.

## Taxon specific bioaccumulation and transfer of contaminants from aquatic to terrestrial ecosystems

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Considering a large number of different chemicals that are detected in freshwaters worldwide, as well as complexity of predicting individual impact of these chemicals on aquatic biota, current knowledge is insufficient to fully understand the fate and behavior of emerging contaminants in aquatic ecosystems. Certain pharmaceuticals and endocrine disrupting compounds can be transferred from aquatic to terrestrial ecosystems through food webs and emergence of aquatic insects. Therefore, emerging contaminants potentially endanger not only aquatic, but also terrestrial organisms. Hence, in our research we compared concentrations of pharmaceuticals and endocrine disrupting compounds measured in aquatic nymphs and terrestrial adults of two Odonata suborders: Anisoptera and Zygoptera, sampled from a wastewater impacted river. We also calculated the bioaccumulation and bioamplification factors (BAFs & BAmFs) in order to determine accumulation potential of detected compounds as well as possible changes of compound concentrations between different insect life stages. Results show similar trends in total concentrations of emerging contaminants and individual compound concentrations for both observed taxa groups, being mostly higher in nymphs compared to adults. BAF values indicate the existence of notable differences on the suborder level, as values for six compounds are significantly higher in Zygoptera compared to Anisoptera. Furthermore, we confirmed bioamplification for two compounds in both Odonata suborders. Our results suggest that ecological traits like dispersal and feeding behavior of aquatic insects have an important contribution on bioaccumulation and bioamplification of emerging contaminants, but also highlight necessity for conducting further taxon- and trait-specific research.

## Spatiotemporal dynamics of bacteria communities in Lake Geneva by Next-Gen amplicon sequencing

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Bacteria communities play major roles in freshwater ecosystems such as contributing to the primary production of lakes and to the biogeochemical cycles of many key elements. Because of their fast life cycles, bacteria are readily responsive to environmental variations. However, predicting how prokaryotic communities may adapt to climate change and how their response may influence ecosystem functioning is currently difficult, partly because the ecology of many bacteria groups is largely unknown. Since August 2019, we are conducting a monitoring project in the experimental floating platform Léxplora, in Lake Geneva, in which to date we have collected more than 200 water samples at different depths, from the lake's surface to 100 meters deep, and analyzed them by 16S amplicon high throughput sequencing. Simultaneously, we compile a dataset of the environmental conditions using CTD sensors, and measure nutrient concentration in the water column. This project has allowed us to obtain about 25 million bacteria sequences, classified in more than 17,000 different species. Our results show interesting spatio-temporal patterns in the bacteria communities of Lake Geneva and their predicted functions, and allow us to deeply characterize cyanobacteria blooms caused by *Planktothrix rubescens*, a toxic cyanobacteria that is favored by global warming. In addition, combined with the environmental dataset our taxonomic data represent a unique opportunity to use ecological distribution modelling to predict community assemblage under future climate change scenarios.

## Impacts of low concentrations of nanoplastics on leaf litter decomposition in streams

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Hazards of nanoplastics in aquatic environments are unclear. Nanoplastics studies in freshwaters have focused on large rivers and lakes, and smaller streams have been overlooked. Small streams constitute 70-80% of river networks' total channel length; they are critical to the ecosystem and the community. Among plastics, polystyrenes (PS) are widely used worldwide, contributing mainly to waste. Leaf litter decomposition is a vital ecosystem process in streams, ensuring the transfer of energy from one trophic level to another; it is regarded as a proxy for assessing stream ecosystems' health. So far, no information is available on the impact of environmental realistic concentrations of nanoplastic particles (1 to 1000 nm; NPPs) on organic matter decomposition and nutritional (fatty acid and carbohydrates) profiles. Here leaf litter decomposition was used as a model; studies were conducted in microcosms using natural microbial communities exposed to PS NPPs of two sizes: small (100 nm) and large (1000 nm) with concentrations ranging from 0 to 25 µg/L. The leaf litter mass loss, fungal sporulation and community structure, leaf litter fatty acid, and carbohydrate profiles were assessed. Results indicated that leaf litter decomposition, fungal sporulation and community structure were significantly affected by both types and concentrations of nanoplastic particles. In contrast, fatty acids and carbohydrate profiles were impacted only by NPPs size. This study contributes to new insights on the potential dangers posed by environmentally relevant NPPs concentrations on freshwater health.

## Method development for the determination of Watch List chemicals in Irish waters.

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Micropollutants which do not have adequate data on occurrence in the environment are being added to the Watch List under the WFD. The WL contains multiple micropollutants with differing chemistries, making analysis of surface water samples increasingly complicated due to the multiple extraction and analysis methods needed. Reaching the detection and quantification limits needed to monitor these micropollutants presents a challenge. An analytical approach involving solid phase extraction and liquid chromatography tandem mass spectrometry was developed for monitoring 2nd Watch List substances in Irish surface waters. It was found that the pesticide metaflumizone was not compatible with the evaporation and solvent exchange step of SPE, and therefore analysis of the direct eluent was performed for this compound prior to blow down. Two LC-MS methods were used for detection of the full suite of analytes, in which estrogens were determined separately due to inefficient ionization of these analytes when used in the main method. Matrix-matched calibrations were used resulting in good linearities ( $R^2 < 0.99$ ) for the majority of compounds excluding the estrogens. All studied analytes aside from estrogens are below the EU stated target LODs. The methods were applied to 21 Irish field samples taken over a three-year period from 2018-2020. Frequently detected analytes, occurring in approximately 50% or more Irish samples, were the three estrogens, three macrolide antibiotics and four out of five studied neonicotinoid pesticides. The majority of these detections were below quantifiable levels. This work represents the first data on monitoring of all Watch List chemicals in Ireland.

## Effects of anthropogenic organic micropollutants on population genetic diversity of freshwater amphipods

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4A\_SS22 Genetic approaches to assess and monitor freshwater biodiversity and ecosystem functions & RS06 Emerging contaminants in freshwater systems, July 27, 2021, 10:30 - 12:00

Pollution is one of the main drivers of biodiversity decline in rivers worldwide. In particular, anthropogenic organic micropollutants, including pesticides and pharmaceuticals, contribute majorly to negative trends in freshwater species diversity. Of the manifold adverse effects of these pollutants, some can result in a shift of the population genetic structure in species living in rivers with a pollution gradient. Here, we present insights into the effects of anthropogenic organic micropollutants on genetic diversity indices of an amphipod species, *Gammarus pulex* (Linnaeus, 1758), living in polluted as well as pristine river sections. Levels of over 500 organic micropollutants and their potential for adverse effects were determined in *G. pulex* from 35 sites within six rivers in central Germany. Applying linear mixed effects models, the adverse effect potential of pollutants at different sites was compared to the genetic diversity indices of amphipods, acquired through genotyping 16 microsatellite loci. The results suggested that neonicotinoid insecticides, biocides, and common pharmaceuticals contributed the most to toxic potential at the analyzed sites. Although *G. pulex* genetic structure depended strongly on the river catchment at the regional scale, several population genetic diversity indices suggested effects of micropollutants on species genetic composition at the local scale. In fact, waste water effluents positively contributed to increased allelic richness and abundance of amphipods at moderate pollution levels. However, amphipods at sites with higher toxic potential showed reduced genetic diversity and high rates of inbreeding that can lead to an increase of the vulnerability of amphipods at seasonal pollution peaks.

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### Benthic invertebrate metrics reveal major impacts of physical habitat alteration in rivers

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4B\_RS13 Hydromorphology: integration with ecology, July 27, 2021, 10:30 - 12:00

Alteration in hydromorphology is considered a major stressor for riverine ecosystems in Europe. To univocally define hydromorphological impacts is a complex task and links with biological communities are considered weak or unclear by many authors. To identify the relationships between riverine biological metrics and physical habitat alteration is a key task for effective interpretation of ecological status. We investigated the responses of macroinvertebrates metrics along a gradient of habitat alteration in 95 Italian river sites in the absence of relevant water pollution. Emphasis was put on the STAR\_ICM index, legally required in Italy for ecological status assessment. The analysis revealed a major gradient of habitat alteration expressing a combination of bank and channel modifications opposed to features related to the presence of trees on river banks and channel. A set of descriptors were calculated based on a field habitat survey method including Habitat Modification Score (HMS). Significant correlations were observed between invertebrate metrics and indicators of morphological impairment. HMS and STAR\_ICMi relations were further tested through a linear mixed-effects regression approach, resulting in > 60% of STAR\_ICMi variability explained by HMS. Results demonstrated that morphological alteration identified with habitat survey methods is significant for the biological community and that HMS can support the interpretation of ecological status in a wide geographical context and in the absence of evident water pollution.



## Developing an ecologically informative hydromorphological classification of Irish small streams

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Hydromorphological setting and condition are increasingly recognised as crucial to the functioning of river ecosystems. Knowledge of the natural physical structure for a given geomorphic setting is an important tool for effective environmental management, particularly for small streams (first and second order rivers) which comprise approximately 75% by length of the Irish river network and a similar proportion in many other regions. However, scarce physical habitat scale information exists for these rivers in Ireland. In this study the hydromorphology of 42 minimally impacted headwaters across Ireland was assessed using the multi-scale Modular River Physical Survey (MoRPh) method developed for English rivers. Rivers were surveyed at three scales: module (length 10 m), sub-reach (50 m), reach (1+km). At the reach-scale, we established river gradient, planform and degree of confinement and at the sub-reach scale, we determined the average and coarsest bed material types. Using this information, we applied a pre-existing, simple hydromorphological classification. This assigned the surveyed streams into six indicative geomorphic types, with most streams classified as either 'confined bed-rock' or 'step-pool' types. While the streams assigned to five of the six types were associated with quite distinct combinations of bed material and gradient and, at the module scale, with coherent assemblages of physical and hydraulic habitats, the 'step-pool' rivers encompassed a wider range of substrate and geomorphic-habitat features than anticipated. Further analysis, particularly considering the streams assigned to this class, has allowed us to refine the classification to make it more ecologically informative when applied to Irish small streams.

## Damning the river - Pathways of anthropogenic influence on stream temperatures

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A variety of river system elements (e.g., hydrology, channel morphology, riparian land cover) affect stream temperature responses to temperature drivers (e.g. air temperature, solar radiation). Some natural elements help insulate against temperature flux by reducing the rate of heat or water flux into or out of the channel. These elements, for example, include the riparian vegetation which can intercept solar radiation before it reaches the channel. Other elements include bank seepages and surface-subsurface flow exchanges with the alluvial aquifer, which can act as buffers by removing heat/water from the channel when temperatures are high and releasing heat/water to the channel when temperatures or flows are low. Hydromorphological alterations in the form of impoundments, flow regulation, abstraction and channelization can disrupt these interactions by changing the timing or magnitude of the amount of, a) temperatures/flows delivered to the channel or, b) riparian cover which modifies the amount of heat energy delivered to the channel (heat load). This research focused on the synergistic effect of hydromorphological alterations including low head weirs, channelization and riparian degradation in disrupting stream temperatures. These outputs are then considered against commonly employed conservation strategies such as fish passage, impoundment mitigation, environmental flows and measures to improve instream and riparian habitat. Some conservation strategies may be increasingly limited against a backdrop of previous alterations and increasingly extreme meteorological events.

## Mitigation of hydropeaking in an Alpine stream: the Noce River case study

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The upper course of the Noce Stream (3rd order gravel-bed stream, 1200-950 m asl, NE Italy) had been regulated since the mid '30s by storage hydropower production (Cogolo HPP) and associated hydropeaking (1 to 7 m<sup>3</sup>/s). Within the recent boom in run-of-the-river (RoRPP) power plants in Alpine streams, in 2014-2015 three RoRPPs (total about 9 MW) were built in the hydropeaking reach. This has been taken as an opportunity to mitigate hydropeaking by the local Environment Agency (APPA Trento), because the three RoRPPs run in series, and the upstream intake is located in the release channel of the storage power plant. As a result, hydropeaking in an 8-km stretch was substantially eliminated. The ecological impacts of hydropeaking on the hyporheic zone had been assessed in 2006-2008, and were due to the deposition of fine sediment transported by the water released by the storage HPP, hardly removed within the regulated flow regime. The resulting clogging caused a reduction of the interstitial space available to invertebrates. We repeated the same hyporheic monitoring scheme in 2016, and recorded relevant changes in the hyporheic communities. Ecological data recorded by APPA allowed detecting the positive (reduced clogging) and negative (increased pollutants concentration) effects of these mitigation measures. Application of different sets of hydrological and hydrodynamic indicators allowed to quantify hydropeaking changes in the entire river reach. This work illustrates an interesting option for hydropeaking mitigation coupled with further hydropower production and highlights unexpected side effects that may suggest further environmental measures.

## A new index for the assessment of hydromorphological conditions of French lakes

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The decline of freshwater biodiversity is one of the main consequences of global change and it is important to know the causes to initiate effective conservation measure. Hydromorphology provides a physical framework for aquatic biocenoses. Its status influences the quality of organisms' habitats and its assessment is required in the implementation of the EU water framework directive. However, to our knowledge, no published method currently makes it possible to describe adequately both hydrology, morphology and their alterations. In this study, fifteen metrics reporting on six parameters, were developed. They were then combined in a Lake HYdroMOrphological condition index (LHYMO) to provide a quantitative assessment of the HYMO status of all the French natural and man made lakes. One of the originalities of the approach lies in the definition of the reference status of each metric: their degree of deterioration is measured with regard to the natural conditions linked to the environment specific to the lake evaluated, such as 'they would be expected in the absence of disturbances'. This index is compatible with WFD and CEN standards. It allows us to provide the first quantitative assessment of the hydromorphological conditions of French lakes classifying them into 5 classes from high to bad. Although very greedy in environmental data, this index is based on national reference datasets and is therefore applicable to all French water bodies; its principle is transferable over a wider scope. This index is currently being compared with biological data to improve the quality of bioindicators.

## Climate change effects on the biodiversity of a Mediterranean hydropower regulated river

**Dr Rui Rivaes<sup>1</sup>**, Maria João Feio<sup>2</sup>, Salomé F. P. Almeida<sup>3</sup>, Ana R. Calapez<sup>2</sup>, Andreia Mortágua<sup>3</sup>, Daniel Gebler<sup>4</sup>, Ivana Lozanovska<sup>1</sup>, Professor Francisca Aguiar<sup>1</sup>

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This work appraised the effects of expected climate change scenarios on the habitat availability of multiple biological elements downstream of a hydropower dam. Macrophytes, macroinvertebrates, diatoms and macroalgae, as well as physical-chemical parameters, were sampled in June-July 2019 in 31 mesohabitats along 17 sampling sites in the Lima River, Portugal. Mesohabitat characterization was explored via Principal Component Analysis, revealing major variables as hydraulic-related. Furthermore, a Linear Discriminant Analysis (LDA) performed on these variables achieved a very good mesohabitat classification capability. The biological assessment also enabled the setting of indicator taxa of every group for each mesohabitat considered. Expected flow regime scenarios were computed from hydrological predictions for the Lima River basin according to the latest IPCC scenarios, and adjusted by the expected hydropower production changes forecasted for Portugal. The flow regime scenarios were modelled in a representative 2 km river stretch of Lima River, to determine river hydraulics and assess the mesohabitat availability using LDA classification. Results show that the hydraulic conditions are significantly different between scenarios with a general reduction of riffles and pools while runs increase. Changes in river's indicator taxa metrics can go from mild to drastic, ranging from 3.8% up to 76% in abundance/coverage, being proportional to the severity of the climate change scenario. This reveals an increased threat of climate change on the fluvial ecosystem in regulated rivers already for 2050, despite the slight amelioration expected from the likely human energetic demand modifications, which expose a fluvial ecosystem risk that urges to be addressed.

## 4C\_SS14 Securing and managing biodiversity, functional integrity and ecosystem services in drying river networks & RS15 Lakes as sentinel sites

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### Unveiling pre-human diatom communities in Azorean lakes: are there common reference conditions?

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The assessment of reference conditions is a key requirement of Water Framework Directive (WFD). In the absence of long-term data, pre-human impact conditions can be assessed through paleoecological data. Diatoms, well-known for their high sensitivity to changes in the aquatic environment, are widely used to define those conditions in lakes and evaluate the degree of deviation to determine the ecological status. To assess the reference conditions of the lakes of the Azores we calculated the dissimilarity between diatom assemblages in sediment samples of six lakes from two types (shallow type: Caldeirão, Caveiro and Peixinho; deep type: Rasa, Lomba and Funda) dated before human arrival to the Archipelago (900-1000 y BP). We also compare diatom assemblages between pre-human and modern samples in each lake to determine the degree of change in ecological conditions. Our results revealed a high dissimilarity between diatom assemblages in pre-human samples and the absence of a common reference community for all lakes or in each lake type. Our results strongly support the existence of site-specific reference conditions, mainly determined by lakes morphology, hydrology and ontogeny. The differences in the lakes characteristics and ontogeny resulting in different reference conditions suggest that the baseline conditions for ecological status assessment should be considered individually (i.e., site-specific). Modern assemblages show significant deviation from pre-human states and don't fulfil the environmental goals of the WFD, requiring restoration measures.

## Use of fossil NPPs on the Azores to reconstruct past environmental changes

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Non-Pollen Palynomorphs (NPPs) includes a large group of fungi, algae and invertebrates remains. Their abundance, diversity and resistance to degradation allow their use in palaeoenvironmental reconstructions. Here we describe NPPs (45 taxa) from the sedimentary core of Lagoa do Caldeirão (Corvo Island, Azores). The successional NPPs assemblages track changes from a pristine ecosystem to an area severely altered by human activities over the last two millennia. The first assemblage includes an abundance of megascleres of *Racekiela* and a set of aquatic fungal species associated with littoral plant communities (*Clasterosporium*, *Vargamyces*). This is followed by an increase in *Hyphomycetes* conidia from decaying wood, *Kretzschmaria deusta* (forest pathogen) and *Glomus*, which is derived from a forested landscape that is disturbed by soil erosion and herbivore, this fungi assemblage points to the significant transformation of the landscape from a forest to open grass. This landscape transformation began before the arrival of the Portuguese (1450 AD) and was dramatically amplified in the following centuries. The most recent assemblage is dominated by coprophilous fungi (*Podospora*, *Cercophora*) from pasture-livestock faeces and a substantial increase in planktonic algae (*Lacunastrum*, *Desmodesmus* and *Closterium*) which are associated with nutrient enrichment. The use of NPPs will improve palaeoenvironmental reconstructions, although further studies of modern analogues are required to understand better the specific habitats related to different taxa.

## Differential responses of biofilms from perennial and intermittent streams to drying

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The frequency and spatial extent of non-flow periods in streams is growing in many regions worldwide. Consequently, many perennial streams are abruptly becoming intermittent, with unknown consequences for their structure and functioning. We conducted a laboratory mesocosm experiment to compare the resistance and resilience to drying of perennial and intermittent streams. Therefore, we collected stones from 10 perennial and 10 intermittent streams during the flowing phase, placed them in open recirculating mesocosms under standardized conditions, and exposed them to a complete flowing-drying-rewetting cycle. During the experiment, we followed changes in epilithic biofilm structure (bacteria and fungi composition, algal biomass, pigment composition) and functioning (community metabolism, nutrient uptake). Our results show generally higher resistance and resilience to drying in biofilms from intermittent streams. Nonetheless, the response was complex, with inconsistencies among the measured variables. Overall, our results indicate that biofilms from perennial streams are less adapted to drying-rewetting cycles than biofilms from intermittent streams, which has relevant implications for stream ecosystems in many temperate climate regions.



## Lentic-lotic habitat features influence macroinvertebrate metrics used to assess ecological status

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Ecological status classification based on benthic macroinvertebrates is performed through comparison between observed and reference conditions. To prevent major shortcomings deriving from natural biological variability, reference conditions are established in accordance to river typologies. However, river flow and local hydraulic features are changing over time and constantly modify the occurrence of lentic and lotic habitat features introducing influential natural variations which bypass river types definition. To reduce systematic bias in ecological assessments, site-specific tuning of reference conditions related to the ratio of lentic to lotic habitats might be required. We performed a piecewise spline regression analysis to investigate the response of macroinvertebrate metrics to the lentic-lotic character. Nineteen metrics from assessment systems of South European countries were tested on predominantly temporary river reaches in Sardinia, Italy. A significant response of most metrics to the ratio of lentic-lotic habitats was observed with a parabolic or a decreasing lotic to lentic trend. Best correlations were observed for richness, score-based metrics, ovoviviparous taxa and multi-metric indices. Potential impact on ecological status assessment was tested for the STAR\_ICM index, formally used in Italy for classification and in Europe for the Water Framework Directive intercalibration process. Better ecological status was obtained after adjusting the bias caused by the ratio of lentic to lotic habitat features. Results prove the importance of including lentic-lotic information in the definition of reference conditions. Failing to include this aspect might hamper the understanding of biological responses to pressures and/or provide a largely biased classification of ecological status in many circumstances.

## Structural Equation Modelling to Approach Biodiversity-Ecosystem Functioning Relationships in Temporary Streams

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Environmental conditions drive both the biodiversity and functioning of aquatic ecosystems. Change to these conditions may translate into biodiversity changes, affecting their associated ecosystem functions and, ultimately their relationship (BEF). In temporary streams, drying shapes community biodiversity and functioning of organisms including photoautotrophs, many of which are desiccation-sensitive and disappear during dry periods; others have adaptations to tolerate desiccation. Despite the close relationship between biodiversity and ecosystem functioning, the nature and strength of BEF relationships are poorly understood, especially in temporary streams. To address this knowledge gap, we selected 32 permanent and temporary streams across the NE Iberian Peninsula, characterised their hydrological regimes, and calculated metrics to summarise temporal components of the dry periods. Stream biofilms were analysed for their physiology (active chlorophyll), biodiversity (calculated from photoautotrophic composition) and functioning (primary production). Permanent and temporary stream biofilms showed differences at both functional and structural level. We then developed a structural equation model to characterise causal relationships between environmental conditions, biofilm composition and functioning. Photoautotrophic physiology and diversity changed in response to the dry duration, and both contributed equally to functional responses. Beyond the predictable positive contribution of active chlorophyll to primary production, the positive relationship between photoautotrophic diversity and its functioning highlights the key role of community diversity to maintain autochthonous production. Biodiversity has an intrinsic value but, understanding how key ecosystem processes are affected by changes in biodiversity will inform river ecosystem management in the face of ongoing climate change.

## First human impact and aquatic ecosystem responses on remote oceanic islands

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Remote oceanic islands are compared to natural laboratories of evolution, providing model systems for testing evolutionary, ecological, and biogeographic theories. Island ecosystems are usually hotspots of biodiversity, with legacies of recent human impact, offering an ideal scenario to trace the first human impacts and their fragile ecosystems' effects and resilience. Lake sediments constitute natural archives of past environmental changes. Their analysis allows access to various information indicating early human activities and their impacts on these ecosystems and their ecological shifts. Here we present the onset and evolution of human disturbance on Azores aquatic ecosystems revealed through multi-proxy characterization of lake sedimentary archives. Our results show that first human impacts on lake ecosystems and their watersheds on the Azores vary in time7space. They present clear evidence of initial human impact predating the official Portuguese colonization in 1432CE. These first impacts had few ecological repercussions and were extended over time. During this period, landscapes were modified by burning practices and prepared for agricultural purposes, leading to soil erosion. This initial human disturbance only affected lakes' catchment and often predates the first detectable response in aquatic systems by several decades. The most intense human impact phase started with the official Portuguese colonization. Human practices such as species introduction and increase of farming activities led to rapid shift state changes, such as acidification and eutrophication. Changes in ecosystem structure or function depend on lake characteristics and human activities conducted in the catchment. This research is funded by FCT (DL57/2016/ICETA/EEC2018/25; PTDC/CTA-AMB/28511/2017), and (CGL2010-15767, CGL2013-40608-R, CGL2016-75281-C2)

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### How hydrological and landscape features shape Odonata communities in man-made aquatic ecosystems

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4D\_SS03 The role of small water bodies in the landscape, July 27, 2021, 10:30 - 12:00

One of the major current ecological challenges is to understand how ecosystems cope with the impacts of a variety of human activities. This issue is particularly relevant in freshwater ecosystems where biodiversity is globally under severe threat. Artificial waterbodies, such as ditch networks, are part of the few remaining wetlands in agricultural landscapes and hence play a crucial role in maintaining aquatic biodiversity in these landscapes. We investigated the multiscale (local and landscape) responses of adult Odonata communities, in agricultural ditch networks, to a series of environmental drivers considering taxonomic and functional features. We highlighted that species richness increased with water depth and decreased with the duration of drying episodes, and that the latter was also a key driver of species turnover. Other local variables such as riparian and aquatic vegetation and water quality were less influential. Landscape variables, notably meadow cover and ditch network length, and geographical distances between local communities shaped the distribution of Odonata. Finally, we found evidence of trait syndromes in Odonata communities but without clear relationship with the environmental gradients observed. This study reveals the structuring role of water management for Odonata biodiversity in ditch networks and demonstrates the need to consider environmental variables at various scales. Lastly, we call for further large-scale investigations into the taxonomic and functional responses of Odonata in other landscapes to gather lessons for the conservation of man-made freshwater ecosystems.

## Biodiversity in a pondscape: relative roles of environmental filtering and network position

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4D\_SS03 The role of small water bodies in the landscape, July 27, 2021, 10:30 - 12:00

Disentangling the relative roles of processes that shape biodiversity and community composition is the central aim of metacommunity ecology. A better quantitative understanding is invaluable not only for advancing the field but it can help making informed decision about the protection and restoration of habitat networks. Pondsapes became popular objects for landscape-level community ecology studies due to their large numbers and environmental heterogeneity, which contribute to high regional biodiversity. Here, we study a well-delineated cluster of 54 bomb crater ponds on the Pannonian Plain (Hungary). The morphological similarity of the ponds and the strong environmental gradients they exhibit results in a very suitable model system for assessing the relative roles of spatial arrangement and environmental filtering for community assembly. Despite their man-made origin and small individual sizes, these bomb crater ponds harbour high regional diversity, comparable to that observed at much wider spatial scales. We specifically tested how local species richness and community composition is related to habitat position in the network (centrality) and local environmental characteristics. This was done for multiple organism groups, including prokaryotes (16S rRNA gene amplicon data), protists (18S), zooplankton and macroinvertebrates. According to our results, while environmental filtering in general played a predominant role in driving community dynamics, spatial signals related to network position were also evident, especially in species richness of passively dispersing groups. This highlights the importance of network thinking in pond conservation, instead of prioritising individual habitats.

## Environmental correlates of macroinvertebrate biodiversity in garden ponds: implications for pond management

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4D\_SS03 The role of small water bodies in the landscape, July 27, 2021, 10:30 - 12:00

Garden ponds are popular among the public and form significant component of the urban freshwater network. The potential for garden ponds to serve as important aquatic and terrestrial biodiversity resources in urban landscapes has been well documented, although currently their biodiversity is often lower than other pond habitats. Despite their potential to contribute substantially to biodiversity, evidence-based management strategies to increase aquatic biodiversity within garden ponds is missing. In this study, we examined the spatial and environmental variables driving macroinvertebrate richness and composition among garden ponds in the UK and provide several management recommendations to increase aquatic macroinvertebrate diversity within garden ponds at both a local and regional scale. For the ecological potential of garden ponds to be achieved there is a need to provide management guidance to home-owners on how this potentially valuable resource can help support freshwater biodiversity.

## Diatom diversity and community composition along an elevational gradient in subarctic ponds

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4D\_SS03 The role of small water bodies in the landscape, July 27, 2021, 10:30 - 12:00

Subarctic ponds are important ecosystems for many freshwater species. The increase in global temperatures have stressed on the study of the ponds as rising water temperatures may have severe consequences on such cold and harsh ecosystems. Microalgae such as benthic diatoms, are vital components of subarctic pond food-webs and well-known indicators for environmental quality. The aim of this research was to illustrate the variability in diatom species richness and community composition along an elevational gradient in northernmost Finland and Norway and reveal the most important drivers for diatom biodiversity. Water pH, aluminium concentration and air temperature best explained the variation in species richness and community composition, whereas elevation had a secondary, non-significant role. Nearby sites showed similar conditions for water chemistry and diatom communities, yet there were some differences in how taxa responded to environmental variables. Diatom species often occupied the entire elevational gradient, however the mean of the abundance of each species was lower than the mean of the elevational gradient. Most of the rare taxa appeared at the ends of the gradient. To summarize, our results showed that local abiotic variables rather than elevation drive diatom species richness and community composition in subarctic ponds. However, it seems that the lowest and highest elevations provide suitable habitats for rare diatom taxa that have unique environmental preferences. Such taxa may be valuable indicators for ongoing global change in the subarctic. More subarctic research is required to fully understand the diverse abiotic and biotic interactions of the benthic freshwater communities.

## Land use changes seasonal biomass patterns of aquatic emergent insects

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Stream ecosystems are affected by many anthropogenic stressors like toxicants, excessive nutrient input and habitat destructions. These stressors are often associated with agriculture. Furthermore, stream ecosystems and their adjacent terrestrial ecosystems are strongly linked via the flux of organic and inorganic material as well as organisms. For instance, aquatic emergent insects can serve as prey for riparian predators. Especially in agricultural areas, riparian predators can benefit from aquatic emergent insects, compensating for the loss of terrestrial prey. Little is known how agriculture affects the composition and biomass of aquatic emergent insects, though a recent meta-analysis (Van Klink et al. 2020) suggested an increase in biomass and abundance of aquatic emerging insects. Moreover, seasonal patterns may vary between land use types and insect order, which are important to understand the energy exchange between ecosystems. We studied ten streams in south-west Germany regarding the composition and biomass of aquatic emergent insects from March to September 2018 using a paired design with an upstream forested site and a downstream site, where viticultural land use dominated. The hydromorphological structure and water quality were monitored to identify potential drivers of emergence patterns. Although the biomass was similar across land use types, we identified seasonal patterns that differed between the forest and viticultural sites. We will discuss details and potential drivers in the presentation.



## Consequences of riparian deforestation on detritus-based food-webs in streams

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Detritus-based food-webs in streams are interconnected to crucial ecosystem functions and services. The most important processes include decomposition of allochthonous leaf litter, mainly carried out by aquatic hyphomycetes and invertebrate shredders. These food-webs and their biodiversity are increasingly under pressure from environmental change due to land use, e.g. agriculture, which alters water quantity and quality but also the riparian vegetation. These general concepts are true for streams on all continents. However, differences in resource quality and in the relative importance of decomposer groups have been documented and seem to be particularly marked between temperate and neotropical streams. In replicate field experiments in small streams in Switzerland (Prealps biomes) and Brazil (Atlantic Forest biome), we measure the processing of litter of different quality in mixtures and single-species treatments, as well as the activity, biomass and diversity of aquatic hyphomycetes and of invertebrate shredders, scrapers and predators. Stream sections impacted by similar reductions in density and diversity of the riparian vegetation are compared to nearby reference sections. Using structural equation modelling, our project will reveal how degradation of riparian vegetation alters the relative role of decomposer groups for litter decomposition in streams and explore the consequences of changes in biodiversity at different trophic levels on this key ecosystem process. Preliminary results indicate that the influence of landscape alteration on decomposition rates depends on local abiotic and biotic conditions. Such findings are crucial for the management of stream biodiversity and ecosystem functioning in both regions.

## 4E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system

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### Short-term effects of dam decommissioning on carbon fluxes in a temperate reservoir

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4E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system, July 27, 2021, 10:30 - 12:00

Decommissioning is a part of the life cycle of dams, but we ignore its impact on carbon dynamics in riverine ecosystems. To narrow the gap, we measured CO<sub>2</sub> and CH<sub>4</sub> fluxes in impounded water, running water, and exposed sediment before, during, and after the drawdown of Enobieta Reservoir, N Spain. The mean areal CO<sub>2</sub> flux for exposed sediment ( $188 \pm 12$  mmol m<sup>-2</sup> d<sup>-1</sup>; mean  $\pm$  SE) was higher than in impounded water ( $25.1 \pm 11$  mmol m<sup>-2</sup> d<sup>-1</sup>) and running water ( $41.5 \pm 8$  mmol m<sup>-2</sup> d<sup>-1</sup>). The mean areal CH<sub>4</sub> flux from impounded water ( $2 \pm 0.3$  mmol m<sup>-2</sup> d<sup>-1</sup>) was 4 times higher than in running water and two orders of magnitude higher than in exposed sediment. The mean CO<sub>2</sub> and CH<sub>4</sub> fluxes were, respectively, 2.7 and 4 times higher in shallow than in deep impounded water where CH<sub>4</sub> ebullition was 1.8 times greater than diffusion. Considering the average of all campaigns, exposed sediment emitted 94% of ecosystem CO<sub>2</sub> fluxes, and CO<sub>2</sub> contributed 99% of total ecosystem carbon fluxes. In CO<sub>2</sub> equivalents, exposed sediment emitted 87% (706.428 kg CO<sub>2</sub>e d<sup>-1</sup>), impounded water 12% (100.607 kg CO<sub>2</sub>e d<sup>-1</sup>) and running water 1% (7.400 kg CO<sub>2</sub>e d<sup>-1</sup>) of the total ecosystem carbon fluxes (814.435 kg CO<sub>2</sub>e d<sup>-1</sup>) over a 100-year timespan. Carbon fluxes were higher during and after than before reservoir drawdown and, hence, the stage of dam decommissioning should be included in assessments of fluvial carbon cycling.

## The organic carbon budget of an oligotrophic temperate peatland lake.

**Brian Doyle**<sup>1,2</sup>, Elvira de Eyto<sup>2</sup>, Valerie McCarthy<sup>1</sup>, Mary Dillane<sup>2</sup>, Eleanor Jennings<sup>1</sup>

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4E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system, July 27, 2021, 10:30 - 12:00

Lakes play a key role in the global carbon cycle, transporting, processing and storing organic carbon (OC) along the land-ocean aquatic continuum. There are, however, surprisingly few complete lake OC budgets, particularly for certain lake types and geographical areas. An OC budget for Lough Feeagh (Ireland), an oligotrophic, peatland lake in a temperate oceanic location, was estimated for one year using both direct measurements and elements calculated from literature. It was constructed as a simple mass balance model that constrained the key OC processing rates. The total OC input to the lake during 2017 was estimated to be 2544 t C, of which 51% was imported as dissolved OC (DOC) in surface water, 4% in ground water, 1% in rainwater, and 3% was fixed in the lake as net ecosystem production. The remaining 41% was carried into the lake as particulate OC (POC) in surface water. The total C exported was estimated to be 2689 t C, of which 49% and 12% were exported as DOC and POC in the surface water outflow respectively, 28% was deposited as sediment and 11% was mineralised and emitted as CO<sub>2</sub> to the atmosphere. The excess of estimated export over import was attributed to year to year carryover. The results highlight the substantial volume of OC turned over in the lake during the study period. Moreover, it emphasises how lakes in temperate, humic systems, common in the west of Ireland, are important to the processing and fate of OC mobilised from their catchments.

## The effect of flow velocity on methane production and oxidation in sediments

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4E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system, July 27, 2021, 10:30 - 12:00

Inland waters are a globally important source for the greenhouse gas methane, but the processes regulating these emissions are still poorly understood. Near-bed flow velocity has the potential to effect methane production and oxidation in the sediment and is controlling methane transport across the sediment-water interface. The effect of flow-velocity on methane emissions, however, has not been studied so far. To fill up this knowledge gap, a novel experimental mesocosm system was developed. In six annular flumes a gradient of flow was simulated and the production, consumption and transport of methane, carbon dioxide and oxygen were measured simultaneously in the pore space, surface water and headspace. In this paper, we will present and discuss the novel mesocosm system and provide first insights into the importance of flow velocity for methane emissions from aquatic sediments. In particular, we will discuss the flow regimes in which methane release is dominated by diffusion or bubble-mediated transport, respectively.

## DOM reactivity linked to connectivity and landscape position in Arctic lakes

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4E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system, July 27, 2021, 10:30 - 12:00

Dissolved organic matter (DOM) is exported from terrestrial to freshwater ecosystems where it may be degraded and eventually lost to the atmosphere. The flux from terrestrial to aquatic systems seems to be increasing associated with anthropogenic perturbations. Of paramount importance is the Arctic, as permafrost soils in the region hold a massive carbon (C) stock vulnerable to being mobilized towards freshwaters as DOM. However, despite the relevance of these fluxes for the global C cycle, Earth System Models (ESMs) are just starting to consider them and determining the in-situ degradation of that DOM flux is important. Here, we have determined the dissolved organic matter (DOM) chemical diversity and degradation, greenhouse gases (GHG) fluxes and water isotopes in 37 Arctic lakes and ponds of northern Canada (i.e. Cambridge Bay area in Victoria Island). We hypothesized that the homogeneous landscape of the area, with continuous permafrost, base-rich bedrock and dwarf shrubs as vegetation, will allow us to test for water bodies' size, connectivity and distance from the sea as main drivers of DOM reactivity. Our results include both the development and assessment of the indices describing DOM chemical diversity as well as the spatial distribution of such diversity across these water bodies, its link with connectivity and with the role of a system as C sink or source as determined from GHGs fluxes. Finally, we will discuss the potential for this information to be applied into the C cycling of a regional ESM using landscape descriptors.

## Carbon dioxide emissions from waterbodies along the land-ocean aquatic continuum

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4E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system, July 27, 2021, 10:30 - 12:00

The movement of carbon from long term terrestrial storage to the ocean is recognised as an important dynamic in the global carbon cycle. Catchment morphometry and estuarine connectivity are two important factors in the control of terrestrial carbon export to marine environments, and how much is either buried in lake and river sediments, or emitted as GHG to the atmosphere. Here, we report on a long term field campaign, the aim of which was to measure surface pCO<sub>2</sub> of a freshwater lake and a downstream connected coastal lagoon, in order to quantify GHG emissions along the LOAC (land ocean aquatic continuum). We describe the hydrological conditions that appear to be important drivers, and place our results in the context of overall aquatic carbon budgets of humic catchments.

## Carbon fluxes from water surface and dry sediments in a Mediterranean reservoir

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The significant role of reservoirs in the carbon cycling and the recent growth of dam building have increased the interest to evaluate carbon fluxes in these systems. In this work, we study the spatial and temporal variability in CO<sub>2</sub> (diffusive) and CH<sub>4</sub> (diffusive and ebullitive) fluxes from the water surface in a Mediterranean reservoir (El Gergal, Spain). During a whole year, CO<sub>2</sub> and CH<sub>4</sub> fluxes were measured monthly from the reservoir lacustrine and riverine zone. Additionally, we measured CO<sub>2</sub> flux from dry sediments of the reservoir drawdown area. CO<sub>2</sub> and CH<sub>4</sub> diffusive fluxes from the water surface were higher during mixing period, and the CO<sub>2</sub> flux was related to pH and Chl-a, suggesting primary production as a relevant driver. Conversely, CH<sub>4</sub> ebullitive flux was higher during thermal stratification. Dry exposed sediments constituted a net CO<sub>2</sub> source to the atmosphere showing higher CO<sub>2</sub> emissions in areas influenced by river or intermittent stream discharges. During the mixing period, the reservoir water surface was a net source of CO<sub>2</sub> to atmosphere whereas it was a CO<sub>2</sub> sink during the stratification period. However during the stratification period the reservoir drawdown zone increased due to lower water input and larger water demand, and consequently larger areas of previously submerged sediments became dry and exposed to the atmosphere. Therefore, ecosystem net CO<sub>2</sub> uptake during the thermally stratified period could be significantly diminished in Mediterranean reservoirs in future conditions, due to the predicted increase in the frequency and intensity of droughts expected for this region.

## 4F\_SS09 Aquatic fungi: bringing a key freshwater microbial group into the spotlight

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### Aquatic fungi: bringing a key freshwater microbial group into the spotlight

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Fungi display diverse lifestyles in freshwater ecosystems including decomposers, parasites, predators, endophytes, symbionts, and pathogens and yet are greatly understudied compared to other microbial groups. Unknown biodiversity of freshwater fungi also limits our understanding of their ecological roles. Disentangling ecological roles of individual species has been hampered by limitations to assess their biomass, but methodologies like quantitative PCR and DNA-based quantitative stable isotope probing (qSIP) are filling this gap. Also, -omics create new avenues to unravel aquatic fungal taxonomic and functional diversity, but they need to be supported by annotated whole-genome data. This will benefit fungal-trait databases which are becoming available and allow functional assignments and ecological interpretation of environmental studies. However, freshwater fungal representativeness in these databases is still low. The discovery of numerous dark matter fungi (i.e., uncultured and poorly known taxa) and the occurrence of intra-specific groups calls for reevaluation of aquatic fungal phylogeny. Other knowledge gaps center on spatial factors shaping fungal communities, namely the links between fungal communities in transitional ecosystems like lotic-lentic, freshwater-marine, aquatic-terrestrial and the general spatial and temporal variation in fungal diversity and function. Studies in this direction would inform on the extent of cosmopolitanism versus endemism in freshwater fungi. Large areas of the planet are still unexplored; it is unknown whether fungal biodiversity hotspots overlap with those of better-known organism groups. Addressing these knowledge gaps is pivotal if we are to protect aquatic fungal biodiversity and to provide scientific knowledge for policy making and conservation.



## Nutrient-induced changes in food web interactions of adaptive zooplankton and parasitic fungi

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Parasitic fungi are an integral, yet often overlooked part of the aquatic food web. Empirical studies show that they can play a critical role in controlling phytoplankton. Furthermore, the presence of parasitic fungi can create an additional energy pathway, named mycoloop, from inedible phytoplankton (host) to zooplankton. The fungi zoospores emerging from the infected hosts are rich in polyunsaturated fatty acids and thus form a highly nutritious food source for zooplankton. Specific zooplankton species might even prefer zoospores over phytoplankton. Consequently, the mycoloop affects the zooplankton-phytoplankton link and thus competition between phytoplankton species. We developed a mathematical model to investigate the influence of the mycoloop for community response patterns along a nutrient enrichment gradient and conducted experiments by semi-batch cultures. The modelled food web consists of two phytoplankton species competing for a shared resource, i.e. a parasitic fungus specialized on the inedible phytoplankton, and zooplankton with adaptive prey preference for feeding on the edible phytoplankton versus the parasitic fungus, while the experiments comprise different levels of complexity. The model predicts an increase of energy transport along the mycoloop pathway with nutrient enrichment. Accordingly, zooplankton preference shifts from exclusively feeding on phytoplankton at low nutrient levels to dominantly feeding on the fungus at high nutrient levels, even though the fungus never formed the dominant prey. These results highlight the importance of parasitic fungi for energy flow and system behavior in aquatic systems. We will compare the model predictions with the experimental results in the presentation and further discuss major outstanding questions.

## Responses of fungal communities and related ecosystem functions to agricultural stress

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In viticulture, fungicides are the dominant pesticide group applied for pest management. They are known to affect non-target aquatic fungi, keystone organisms in the ecosystem function of organic matter decomposition (OMD). To date, the ecological mechanisms of fungal community assembly (e.g., dispersal, environmental selection through fungicides) have rarely been studied under field conditions. We conducted a field experiment focusing on the fungal community composition, determined using DNA metabarcoding and spores, as well as OMD in an intensive viticulture region of South-West Germany. We compared three treatments: 1) undisturbed upstream area surrounded by forest, 2) downstream area with intensive viticulture exposed to multiple stressors including fungicides and 3) transplantation from undisturbed to disturbed stream section. This was conducted in ten streams at four timepoints over the course of one year, chosen to capture the time before, during and after fungicide application. OMD in the viticultural treatment was consistently lower than upstream, while the transplantation treatment showed different responses over the year. The fungal communities before fungicide application were similar across treatments and clearly separated from those of later time points. During and after the season of fungicide application, the fungal communities of undisturbed (control) and transplantation treatment became more similar and differed from the viticultural treatment. Based on our results, we discuss the relevance of environmental selection and dispersal for fungal community assembly.

## Aquatic fungi in the Anthropocene

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4F\_SS09 Aquatic fungi: bringing a key freshwater microbial group into the spotlight, July 27, 2021, 10:30 - 12:00

Fungi are increasingly gaining interest from aquatic microbial ecologists. The application of new molecular tools has revealed that they are a ubiquitous and highly diverse organismic group in aquatic environments with essential contributions to aquatic food web dynamics and biogeochemical cycles at the global scale. However, there remain many open questions and knowledge gaps about the consequences of urbanization for fungi in aquatic ecosystems. Urban development and anthropogenic pollution provide aquatic fungi with new habitats and substrates but also challenge their adaptive behaviour to withstand toxicity and frequent disturbances. In my talk, I will focus on fungal metabolic capabilities in the light of increasing urbanization. In particular, I investigate the multiple and yet largely unknown effects of microplastics, a steadily increasing anthropogenic pollutant, on aquatic fungal communities. I also highlight that by studying the multiple ecological roles of aquatic fungi, we will better understand the impacts of urban development and anthropogenic pollution on human and environmental health.

## Chytrids synthesize polyunsaturated fatty acids from an inedible alga available to Daphnia

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Chytrid fungal parasites can convert dietary energy and essential nutrients from large inedible algal hosts into smaller edible zoospores, and therefore, form a key intermediate-level trophic group at the phytoplankton-zooplankton interface. Here, we assess potential trophic upgrading of Planktothrix for the crustacean zooplankton Daphnia through a chytrid parasite in terms of fatty acids. We specifically question whether and how improved diet quality (i.e., long-chain PUFA) due to chytrids extend to the consumer via a positive food quality effect. Daphnia feeding on chytrid-infected Planktothrix grew significantly faster, produced more eggs, and had a higher survival rate compared to the only alga diet. While Daphnia ingested only slightly more C in the P-C system, they assimilated 4x more C, implying a much higher C-use efficiency on the chytrid diet. At the same time, FA analysis revealed that chytrids were enriched in stearidonic acid (SDA, 18:4n-3) relative to the non-infected Planktothrix. Daphnia feeding on the P-C system exhibited significantly higher SDA, underlining the effects in terms of diet quality. These results suggest the existence of a positive feedback loop between enhanced Daphnia growth and herbivory, pointing at the paramount importance of chytrids transferring essential dietary nutrients in pelagic food webs, even in very small quantities. (Austrian Science Fund, FWF Project, P 30419-B29)

## Chytrids and freshwater crayfish, a scary combination for amphibians?

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Chytridiomycosis, caused by *Batrachochytrium dendrobatidis* (Bd), is an emerging disease threatening amphibian populations worldwide. While mainly amphibian-based, non-amphibian hosts could play a relevant role in the dynamics of this disease. Freshwater crayfish, besides of preying on amphibians in co-occurring ecosystems, can act as alternative hosts of the diseases, but their ability to transmit Bd has gone unnoticed. In this ongoing project, we aim (1) to evaluate the susceptibility of diverse freshwater crayfish species to be infected by the Bd pathogen and (2), to analyse whether they are able to transmit Bd pathogen to amphibians. Previous results have showed a certain susceptibility of various crayfish species, and particularly, the red swamp crayfish *Procambarus clarkii* seems to increase the prevalence of Bd in amphibians but Bd-transmission remains unknown. Here, we will show the experiments conducted with the Australian redclaw crayfish *Cherax quadricarinatus*, a potentially invasive but pet-traded crayfish species often sold in diverse European countries, and the European, white-clawed crayfish *Austropotamobius italicus*, a species involved in actions of reintroduction and re-stocking in South European countries. In this talk, we will present the preliminary results of this project which expect to shed light on the transmission of Bd throughout introduced crayfish. Under this unprecedented globalization scenario, translocations of non-native crayfish might act as key drivers of Bd-transmission in aquatic environments, crucially affecting amphibian conservation.

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### Interactive effects of microplastics and ciprofloxacin on aquatic microbial decomposers

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5A\_RS06 Emerging contaminants in freshwater systems, July 27, 2021, 13:15 - 14:45

Environmental contamination by microplastics (MPs) of aquatic ecosystems is increasing worldwide, since the actual plastic production almost reached 370 million tonnes in 2019, making this thematic of global concern. Although the effects of MPs are still poor know, the possibility of other contaminants to bind MPs overwhelm this problem. Plant litter decomposition is a key ecological process in freshwaters, where microbial decomposers, play an important role by transferring nutrients and energy to higher trophic levels. The goal of this study was to evaluate the interactive effects between MPs and the antibiotic ciprofloxacin (CIP) on microbial communities associated with decomposing plant litter in streams. For this, leaves were immersed in a stream to allow natural microbial colonization and exposed in microcosms individually and in mixtures to MPs (5, 50 and 500 mg L<sup>-1</sup>) and CIP (0.01, 0.1, 1 and 10 mg L<sup>-1</sup>). Our results showed that leaf mass loss was stimulated by the presence of CIP, while the activity of the extracellular enzyme  $\beta$ -glucosidase was inhibited with increasing MP concentrations. The structure of fungal communities changed by the presence of CIP, and fungal reproduction was inhibited by increasing MP concentrations. These different effects between MP and CIP that were found, dependent on the parameter analysed and concentrations, highlight the importance to considerer the effects of mixtures of contaminants in further studies to better understand their impacts on ecosystem processes and associated communities.

## Determination of alkylphenols and plasticizers in a river in southern Germany

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Alkylphenols and plasticizers are compounds extensively used in the industry and are found in detergents, paintings, personal care products, pesticides, food cans, and products made of plastics. They are considered endocrine disruptors and some compounds are listed as priority pollutants according to the Directive 2013/39/EU. Domestic effluent and wastewater treatment plants (WWTP) are considered the main sources of these pollutants in urban areas. This study analyzed 4-n-nonylphenol (4-NP), 4-tert-octylphenol (4-OP), bisphenol A (BP-A), and di-2-ethylhexyl phthalate (DEHP) in a river in Germany in order to identify the main matrices of accumulation or transport. Biofilm, sediment, and water samples were analyzed in sampling sites upstream and downstream of a small WWTP. BP-A was the pollutant most frequently detected in the samples, reaching 0.1 µg/L in water samples and 300 µg/kg in biofilm samples. DEHP was not detected in all the samples, but the concentrations detected were higher than BP-A, reaching 0.3 µg/L in water samples and 2750 µg/kg in biofilm. The concentrations were usually higher downstream of the WWTP, suggesting that the effluent increased the concentrations in the different matrices, mainly biofilm and sediment. The high accumulation of these pollutants in biofilm causes concern since biofilm is a source of food to many species at bottom of the food chain.

## Alternative biomarkers in assessment of CeO<sub>2</sub> nanoparticle toxicity to *C. riparius*

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The toxicity of Cerium-oxide nanoparticles (nano-CeO<sub>2</sub>) on the freshwater midge *Chironomus riparius*, Meigen, was assessed by observing several standard and nonstandard biomarkers. Experiments were designed using measured concentrations of nano-CeO<sub>2</sub> in the sediment (2.5, 25, 250, and 2500 mg of nano-CeO<sub>2</sub> per kg of sediment), according to the OECD guidelines for testing of chemicals, in the laboratory setup. The following biomarkers were investigated: oxidative stress parameters, in vivo genotoxic effects, bioaccumulation (NP uptake by larvae); morphological variability, and life trait parameters. Full characterization of nano-CeO<sub>2</sub> revealed the tendency of agglomeration and sedimentation, as well as interaction with sediment constituents. Bioaccumulation of nano-CeO<sub>2</sub> by chironomid larvae was confirmed by ICP-MS analysis. Lethal toxicity was not detected, nevertheless, sublethal toxicity was detected through DNA and morphological variability analysis. At the subcellular level, toxicity was detected through significant DNA damage in the midges exposed to higher nano-CeO<sub>2</sub> levels. At the organismal level, subtle, but significant, changes in important morphological structures of larvae and adults were observed at low and very high concentrations of nano-CeO<sub>2</sub>, as well as a potential impact on the reduction of sexual dimorphism. There is a need for further investigation in order to understand causal relationships between molecular and higher-level responses of *C. riparius* to nano-CeO<sub>2</sub> exposure. Nevertheless, obtained results indicate that, beside standard biomarkers and methods, a set of sensitive alternative biomarkers, such as DNA damage, morphological variability and nanoparticle intake, should be tested in nano-CeO<sub>2</sub> risk assessment.

Keywords: aquatic midges; nanoparticles; OECD; sediment toxicity



## Microplastic abundances in freshwater rivers and the common cockle

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Microplastics are contaminants of emerging environmental concern and have been documented in a wide range of environmental matrices and species. To date, less microplastic pollution analysis has been conducted on freshwater environments than on marine environments. Dundalk Bay is classed as an SPA and SAC and is a designated Ramsar site. It is a commercially important bivalve (cockle and razor clam) fishery and houses up to 57,000 wintering waterfowl annually. In this study seven rivers flowing into Dundalk Bay were examined for the presence of microplastics using bulk water collection and on-site filtration with mesh sizes smaller than those typically used in surface water trawls. Two separate sampling regimes of each of the seven rivers were carried out (Sept-Jan 2019-2020 and Sept-Jan 2020-2021) and each river was sampled at two different points along its course in order to compare microplastic contamination between inland (headwater) sites and coastal (outflow) sites. Microplastics were recovered in a typically overlooked size category in surface water sampling (<300µm) and in each of the seven rivers and were typically fibrous in nature. Additionally, cockles found in the Bay area were digested and examined for the presence of microplastics.

## The curious case of methylparaben

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The widespread use of parabens has caused increased exposure to natural aquatic systems in recent decades. Methylparaben (MePB), one of the most commonly used preservatives in skin care products and food items, is considered to be highly accumulative and toxic for aquatic organisms. Recent studies have also suggested that exposure to MePB can result in endocrine-disrupting effects, raising much concern regarding its environmental impact. On the other hand, however, MePB has been found to be part of the metabolome of some organisms. The objective of this study was to therefore assess the natural presence of MePB in holometabolous caddisflies collected in situ, and to examine the movement of MePB across different life stages (larvae, prepupae, pupae, adults). We collected caddisflies from both contaminated and pristine freshwaters to measure levels of MePB present in their tissues. In addition, the impact of complete metamorphosis on the transfer of MePB was investigated by monitoring various life stages of holometabolous caddisflies collected from a pristine river in a 54-day mesocosm experiment. MePB was detected in all biota collected in situ from our sampling locations. In our mesocosm experiment, caddisflies measured increasing concentrations of MePB across all life stages, from larvae to adults. Our field and mesocosm results suggest that MePB may not in fact be an emerging contaminant. We therefore cannot be certain to which extent the MePB detected within the tissues of caddisflies is the result of contamination, and how much is naturally present within these aquatic invertebrates.

## Biofilms versus POCIS: assessing concentrations and effects of pharmaceuticals in freshwater environments

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5A\_RS06 Emerging contaminants in freshwater systems, July 27, 2021, 13:15 - 14:45

Pharmaceutical compounds (PhC) are an important environmental issue, because of their high variety, potentially toxic byproducts and bioactivity at low concentrations. PhC concentrations in WWTP effluents often exhibit large and rapid variations that are difficult to record. Passive samplers are helpful to detect spot pollution events and record PhC occurrence at low concentrations. In this study, we aim at (i) comparing PhC accumulation in two integrative samplers – polar organic chemical integrative samplers (POCIS) and environmental biofilms exposed to urban (U) and hospital (H) treated effluents and (ii) evaluating the capacity of these two sampling techniques to explain changes in biofilm microbiome over a defined time period. Moreover, we (iii) determine the enrichment of PhC in the recipient river to evaluate levels of environmental contamination and potential effects on microbial biofilms. Biofilms and POCIS were installed in treated effluents and in the recipient river to measure the accumulation of PhC. In parallel, microbial communities were studied using DNA metabarcoding. The performance of POCIS and biofilms to quantify PhC was compound specific, which demonstrated the complementary use of these techniques. However, POCIS appeared better adapted to reveal contamination trends similar to these in the water column and to identify key PhC drivers of microbial changes.

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### Piscivorous fishes as connectors in ecological networks of a neotropical floodplain

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5B\_RS11 Fundamental and applied freshwater ecology, July 27, 2021, 13:15 - 14:45

The compartmentalization of interactions in the ecological networks and the role of species connecting these compartments determine the stability and dynamic of the ecosystems. Species traits as body size or those related to environmental and trophic niche may determine species role in different ecological networks as food web and occurrence networks. In this work, we analyzed the topological roles of 16 piscivorous fishes of the Middle Paraná River in occurrence networks and food webs and the traits that determine them along different hydrologic and climatic conditions. We sampled 20 aquatic environments, during 20 samplings over five years analyzing the spatial distribution and trophic interactions of 3048 individuals. A modular structure was observed in both networks persistent over time, despite the species change their roles in the different hydro-seasonal situations. The body size and ecomorphology were determinants for the topological role in the occurrence networks and the food webs. Large-bodied species connected the modules of the food web, whereas the small-sized species connected spatial aggregations of occurrence networks. Morphologies associated with swimming and predation behaviours were consistently related to the connector role in both networks. Among the species with the highest degree of connection, there was a positive correlation in the intermodular connection in both networks, sustaining the idea of the large mobile predator as network integrators. The relationship between species traits and topological roles supports the idea of a no-neutral assembly of ecological networks, and the dynamic role of species may foster the stable modular structure along the time.

## Beta diversity of lowland river fish assemblages: examining responses to hydrological fluctuations

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A core theme in ecohydrology is understanding how hydrology affects spatial variation in the composition of multi-species assemblages (i.e. beta diversity) within river systems. However, most empirical evidence is from research done in upland rivers spanning small spatial extents. Relatively little is known of the consequences of hydrological variation for beta diversity across multiple spatial scales in lowland rivers. We sought to examine how spatial variation in hydrology and beta diversity of fish within and among rivers changed over time in response to intensification and cessation of hydrological drought. We used monitoring data of river fish assemblages, coupled with hydrological and biophysical data, to test how incidence- and abundance-based components of fish beta diversity in lowland rivers of the Murray – Darling Basin (Australia) varied across spatial scales in response to hydrological fluctuations. Spatial variation in hydrology among rivers declined with increasing duration of hydrological drought before increasing during a return to above-average flows. Longitudinal hydrological variability did not show consistent changes between hydrological phases among rivers. Fish beta diversity among and within rivers showed variable, river-specific changes among hydrological periods for all incidence- and abundance-based components of assemblage composition. Inconsistent hydrology – beta diversity patterns found here suggest that mechanisms and outcomes of drought and flooding for beta diversity are context-specific and not broadly generalisable. Overall, our findings indicate that hydrological fluctuations occurring in the Murray – Darling Basin in the period analysed here did not cause significant or consistent homogenisation or differentiation of freshwater fish assemblages.

## Phytoplankton geometric shapes along seasonal environmental variability in natural and artificial lakes

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The amazing variability in morphological traits and the relative trade-offs represent the best adaptive strategy of phytoplankton to cope with the strong variability of the pelagic environment.

In this work, phytoplankton species were grouped in geometric shapes. Field multiannual data on cell density, biomass, volume, surface and surface-to-volume ratio were analyzed to study the seasonal dynamic of phytoplankton geometric shapes in relation to environmental variability in two different Mediterranean lakes, a natural and an artificial lake. The affirmation of specific geometric shapes in precise seasonal environmental conditions was detected in both ecosystems, with the following common highlights: 1) Cone + Half Sphere was the only complex shape, and with a low surface-to-volume ratio contributed most to the total phytoplankton abundance in winter, when the mixing depth-to-euphotic depth ratio and the nutrient concentrations were the highest; 2) Cylinder represented the most elongated and the largest shape. Its contribution was higher in summer, when the mixing depth-to-euphotic depth ratio was the lowest and the water column was thermally stratified; 3) the geometric shape with the highest surface-to-volume ratio (Sphere in the natural lake, Cube in the artificial lake) contributed most to the total phytoplankton abundance in spring, when the lowest nutrient concentrations were observed. Our results will be important to understand how geometric shapes relate to the natural environment in lake ecosystems. Despite the well-known ecological value of phytoplankton morphology, phytoplankton shape structure has been only seldom considered in the literature compared to phytoplankton size structure.

## Species-area relationship of freshwater diatoms

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The species-area relationship (SAR), showing how the number of species increases with area, is one of the most prominent biogeographical patterns. The SAR has been largely studied in terrestrial systems but rarely in freshwaters, especially in algae. Here we used a global dataset, including eleven oceanic islands and six continental areas to compare SARs between islands and continents. For reliable comparisons, we developed an innovative approach to generate virtual islands on continents, which were then paired with real islands of similar size. We then examined the SARs of real islands (ISAR) and virtual continental islands (VSAR) in freshwater diatoms using both total richness and richness of different ecological guilds. In both cases, we found a significant VSAR, which was attributed to dispersal-related processes, but a non-significant ISAR. Species richness on oceanic islands was correlated with environmental productivity, and the richness of some ecological guilds with island isolation. These results suggest that ecological and evolutionary processes shaping diatom island biogeography do not depend on area but on productivity and island isolation. Our findings lead to new insights into diatom biogeography and the processes underlying diatom biodiversity on islands vs. continents.

## Flow intermittence and functional processes: are artificial flumes and field data comparable?

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Because of the effects of climate change and human pressures, streams of the Alpine area are increasingly facing flow intermittence and specifically riverbed drying. In this context, the high unpredictability of intermittent streams flow regimes and interactions among multiple environmental factors make the study of these systems extremely complex. Therefore, the use of laboratory and field-based mesocosms produces considerable advantages. Nevertheless, the results obtained with these simulations require evaluation and calibration with field data. We compared an intermittent condition (in which the channel or streambed dried) with a control treatment with perennial flow in (a) an artificial flume system fed by a mountain stream and (b) two mountain streams. In both experiments, we sampled the macroinvertebrate community and measured leaf decomposition rates at comparable time intervals, to assess the applicability of manipulative experiments to natural conditions. Consistent patterns in total  $\beta$ -diversity and leaf mass loss were observed between the two experimental conditions, despite differences in shredder abundance. Leaf litter decomposition was more efficient where water was present during the whole experiment, along with a more stable and diverse macroinvertebrates community, in both mesocosm and field studies. This result highlights the impact of drying events and the opportunity to study this phenomenon through flume simulations, which can provide an effective proxy for naturally occurring processes in stream ecosystems.



## Sea water intrusion in freshwaters: effects on litter decomposition

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The projections until the year 2100 foresee scenarios of sea level rise and extreme weather events, resulting in the intrusion of coastal ecosystems (including freshwaters) by seawater. We evaluated the effect of seawater intrusion on leaf litter decomposition, a major process for the functioning of freshwater ecosystems. The experiment was carried out under realistic scenarios in six outdoor freshwater mesocosms containing fauna and flora, to which increasing volumes of seawater were added to obtain salinity values of 0.28 (freshwater only, control), 2.0, 3.3, 5.5, 9.3 and 15.3 mS/cm. Leaf mass loss and invertebrate colonisation were studied on days 16 and 63 after the pulse of seawater using leaf packs. The effect of seawater on the response variables was assessed by computing the average proportion deviation of a treatment relatively to the control. There was a net negative effect of the two highest salinities on mass loss, which was 51-59% lower than in the control. Seawater intrusion tended to enhance macroinvertebrate abundance, with a net positive effect in the 2.0 and 3.3 mS/cm treatments, where abundance was 61-162% higher than in the control. Although a negative net effect was not found, total richness decreased with salinity. In conclusion, sea water intrusion resulting in salinities higher than 9 mS/cm may decrease the rate of litter decomposition in freshwaters. Invertebrates, probably some species more than others, seem to be resilient to sea water pulses even with salinity values of up to 15 mS/cm.

## 5C\_RS15 - Lakes as sentinel sites & SS5 Multidisciplinary perspectives on invasive alien species in freshwater ecosystems

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### Potential effects of invasive Dreissenid mussels on a pelagic freshwater ecosystem

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Dreissenid (zebra and quagga) mussels are spreading across North America and having an impact on freshwater ecosystems, through bottom-up impacts. Lakes in British Columbia are known to be at risk for mussel invasion due to favourable water chemistry and significant cross-border boat movements. This project uses Ecopath with Ecosim (EwE) to model a hypothetical mussel invasion into Shuswap Lake: one of the most popular lakes for recreation and one of the most productive sockeye lakes in the province. A model of the ecosystem was fit to available data and then projected forward to examine the effects from three different scenarios: no invasion, a base mussel invasion scenario, and a high-density invasion scenario. The greatest ecosystem impacts resulted in declines in large piscivorous rainbow trout and lake trout, followed by non-anadromous kokanee salmon, with little effect observed on anadromous sockeye salmon. Two mechanisms limit the predicted impact of mussels in the study system: (1) paucity of shallow water habitat, limiting the scope for invasion; and (2) movements by fish in and out of the system. This second mechanism includes some resident species that rear for up to three years upstream of the lake, as well as anadromous species, which spend most of their life in the marine environment. While most of the effects are observed on recreationally important species, there is also the possibility of mussels spreading from this system into others within the same watershed, reiterating the importance of preventing the invasion and spread of Dreissenid mussels.

## Freshwater macrophyte population resilience under the threat of saltwater intrusion

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Sea level rise resulting from climate change has the potential to be a significant driver in reshaping the composition of freshwater macrophytic communities. We evaluated the effect of saltwater intrusion into freshwater aquatic ecosystems by conducting a series of greenhouse-based mesocosm experiments at the University of Florida Fort Lauderdale Research and Education Center in Davie, Florida, USA. We induced different salinity levels by adding aquarium salt to site-sourced pond water and found that ecotypes (geographically discrete populations or “lake races”) of *Vallisneria americana*, a keystone submersed macrophyte native to North America, responded differently to induced salinity changes and some ecotypes were more tolerant of salinity than were others. We used similar protocols to evaluate an assortment of North American native and non-native invasive aquatic plants that represented a range of growth forms (e.g., submersed, emergent, floating-leaved, amphibious, and arborescent). We determined that several invasive taxa – including amphibious *Alternanthera philoxeroides*, emergent *Panicum repens*, and arborescent *Schinus terebinthifolius* – were considerably more tolerant of high salinity conditions than their native counterparts with similar growth forms (i.e., the amphibious *Bacopa caroliniana*, emergent *Pontederia cordata*, and arborescent *Annona glabra*). These findings highlight the impact that sea level rise and increased salinity are likely to have on freshwater ecosystems, and may be helpful for resource managers and others to ensure that ecosystem restoration and enhancement projects are designed with resilience in mind.

## Integrating climate impacts: discharge changes and warming effects on lake thermal structure

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Regional climate models predict changes in air temperature and precipitation, with some evidence that changes are already manifesting in lake systems. Lakes integrate these shifts in meteorology and catchment runoff into their characteristics and functioning. Climate warming is impacting lakes through increased water temperatures and stronger and longer periods of thermal stratification. However, there has been little work done to understand how the changes in precipitation, and therefore the throughflow, will interact with this warming trend. The effects of changing flow will be particularly relevant for small, short-residence time lakes, which make up a large number of global freshwaters. Therefore, it is crucial that the combined impact of flow and air temperature changes are considered when investigating the response of lakes, as sentinel sites, to climate change. Using the physical lake model GOTM (General Ocean Turbulence Model), we modelled the interacting effects of climate warming and changes to flows on the thermal structure of a small monomictic lake in the UK, Elterwater, based on the predicted impacts of climate in the region, including increased seasonality – warmer wetter winters and hotter drier summers. Results show that whether flow increases or decreases changes lake temperatures at a comparable level to the effect of climate warming. Overall, the results suggest that changes to flow will compound the effects of warming air temperatures, further increasing lake temperatures in both summer and winter. Additionally, discharge impacts are caused by a combination of changes to flow and inflow temperature.

## Riverine biodiversity response to the richness and abundance of multiple aquatic invaders

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**Abstract.** Worldwide freshwater ecosystems have experienced the colonisation and spread of multiple alien species and are suffering increasing levels of biocontamination. However, how the abundance (number of individuals) and richness (number of taxa) of co-occurrent invaders influence the recipient communities has not been widely considered in the riverine scientific literature. This study examines this research gap using long-term data (2006 – 2019) from rivers in England by: a) identifying the most common combination of co-occurrent macroinvertebrate invaders; b) exploring which biocontamination component exerts the greatest effect on measures of taxonomic and functional biodiversity at different spatial scales. Results based on the most common co-occurring aquatic invaders demonstrated that richness rather than the abundance of invading organisms was generally the most important factor influencing aquatic community measures at all spatial scales. However, the response of community functional redundancy was distinct at the river basin scale, demonstrating the need to consider the effects at different spatial scales using a range of community measures. The response of communities varied as invaders richness increased but was most marked following the initial colonisation of the first invaders. Results also indicate that multiple biological invasions influence distinct aspects of aquatic biodiversity. These findings increase our understanding of the effects of co-occurring macroinvertebrate invaders on recipient riverine communities, facilitate the testing of ecological theories and will help environmental and resource managers plan appropriate mitigation and management strategies.

## Shape and desiccation influence dispersal capabilities for airborne aquatic microorganisms

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The atmosphere plays an important role in the dispersal of microorganisms, as well as in the connectivity of most of the planet's ecosystems. In recent decades, interest in microbial diversity and dispersion in the atmosphere has increased due to its importance in various fields. For example, they are useful in ecology to establish and predict the level of risk against the arrival of invasive species into vulnerable ecosystems due to climate change. However, there are few studies on the abundance of airborne microorganisms. Likewise, the physical-mathematical models that attempt to reproduce their possible origins also require integrating some biological features. In this oral presentation we expose the results of the multidisciplinary research carried out on airborne microorganisms collected at a sampling station over 12-day period. Thanks to epifluorescence techniques, we have been able to observe in the air a high presence of large filamentous aquatic microorganisms, surprisingly up to 400  $\mu\text{m}$ , despite most of the captured particles were small spherical microorganisms (diameter < 20  $\mu\text{m}$ ). We demonstrate the possibility that these large microorganisms can have their origin at long distances, showing thus probability of surprisingly long dispersal, without ruling out a nearby origin, when their equivalent spherical diameter (ESD) and drying capacity are considered in the refined mathematical simulations models of the air masses back-trajectories. This increased dispersion capacity would explain the presence of invasive microbial species that are threatening biodiversity and represent a hazard risk for aquatic ecosystems in a context of climate change.

## Planktonic response to dissolved organic carbon and nutrients in a high-altitude lake

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High-altitude lakes are sentinels of change, sensitive to any events occurring within their waterbodies and their surrounding catchments. By increasing dissolved organic carbon concentration and availability in water, global changes are expected to favour mixotrophic phytoplankton and heterotrophic bacteria to the detriment of autotrophs in these ecosystems. However, the responses of plankton communities to added labile dissolved organic carbon interacting with nutrients during the summer season are still not well understood. Our work reports laboratory investigations revealing how the inputs of dissolved organic carbon and nutrients affect a plankton community in a high-altitude lake during the summer season. We performed dissolved organic carbon and inorganic nutrients (N and P) enrichment microcosm experiments under controlled conditions on plankton assemblages (heterotrophic prokaryotic plankton and phytoplankton) sampled during the summer 2019 in a French high-altitude lake. This study sheds light on alpine phytoplankton communities' sensitivity to short-term carbon supply by identifying potential biotic and abiotic drivers. Our work contributes to a better understanding of the ecological trajectories of mountain lakes under global change and provides tools for improving their management.

## 5D\_SS03 The role of small water bodies in the landscape

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### Hydrochemical characteristics of the small stream network in Ireland

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5D\_SS03 The role of small water bodies in the landscape, July 27, 2021, 13:15 - 14:45

Recent publications have drawn further attention to the need to refocus research and management on small headwater streams, to address catchment water-quality and biodiversity concerns together with the sustainable management of ecosystem services. The key contribution of this research is the characterisation of a portion of Ireland's small stream network (SSNet) based on current and historic water quality data coupled with an analysis of the influence of landscape factors. Using EPA datasets and recently collected data from 73 extensive sites, the nature and extent of nutrient water-quality status and impairment are evaluated for small streams across the major catchment typologies of Ireland. The dataset comprises 252 sites, with nutrient and geo-physical data spanning 13 years. A total of 73% of the sites were characterised according to their physical descriptors; geology, physiography and soil type. Nutrient conditions were analysed to identify the level of compliances and exceedances e.g. 57% of the sites were at/below the mean threshold of 0.035mgP/L (molybdate reactive phosphorus-MRP) for good status (SI 272(2009)). Individual sites from a selection of characteristic groupings were analysed to highlight changes in conditions over time and to investigate possible relationships with flow conditions/precipitation events thus gaining an improved understanding of the spatiotemporal variability of the chemical conditions of headwaters and factors that may influence these. Results from 16 sites across 7 types suggest a strong correlation between rainfall and MRP. However, the mechanisms contributing to this relationship needs further study. Possible relationships between concentrations and flow dynamics will be further explored.



## Diversity and structure of macroinvertebrate communities in permanent rivers in 7th Ecoregion

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Aquatic macroinvertebrates assemblages are typical for the different kind of water bodies and they are used as essential indicators of the aquatic ecosystem they prevailed, directly describing the health and further its water quality. Within this study we present data on the taxonomic composition, diversity and community structure of bottom macroinvertebrate communities in stream sections of R3 (mountainous) and R5 (semi-mountainous) river type from 3 watersheds all belonging to 7th Ecoregion Eastern Balkans. The aims of the present work were: to analyze the current state of diversity, abundance, structure of the macroinvertebrate communities of permanent watercourses and their seasonal alterations; to analyze the similarity of taxa composition within the proper watershed and between the studied river basins; and to reveal the characteristic elements of the macrozoobenthos communities in representative for this Ecoregion mountainous and semi-mountainous river sections. In total 69 samples from 38 sites were collected - in autumn 2017 and spring 2018. For the analyses we used the following metrics/indices: taxa number (S), total abundance (N), relative percentage of taxa and abundance (%), species diversity (H) and richness (d), evenness (e) and index of dominance (c). During the survey 280 taxa belonging to 18 systematic groups of bottom macroinvertebrates were listed. Nevertheless, within this survey we contribute to the specific  $\beta$ -community representatives and further to the unique macroinvertebrates assemblages from mountainous and semi-mountainous rivers from this Ecoregion, that characterize the Balkan Peninsula as a "unique hotspot".

## The importance of freshwater connectivity on total phosphorus and chlorophyll-a in lakes

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Lakes across landscapes are connected through flows of nutrients along the hydrological network, but also through nutrient transfer across land. Particularly important may be transformations in upstream lakes and lateral connectivity with ponds and wetlands in the landscape. The concentrations of total phosphorus (TP) and chlorophyll-a (Chl) are key water quality parameters in the management of lakes. The relationship between the two, the Chl:TP ratio, provides a key metric of ecosystem functioning. Much research has focused on landscape drivers of TP, but little is known about how hydrological and landscape connectivity alter the Chl:TP ratio. Here we report on the influence of a number of measures of freshwater connectivity and their interaction with catchment land-use on TP, Chl and Chl:TP ratio in 167 shallow and 134 deep lakes, spanning a range of landscapes across the UK. Results indicate that, in shallow lakes, the Chl:TP ratio is negatively explained by % urban land cover (positively affecting the TP response), and by the humic type of the waterbody affecting the chl-a response, the latter classified by the proportion of peaty soils in the catchment. There were no significant effects of any of the connectivity metrics. In contrast, in deep lakes, connectivity appeared to be more important, with the Chl:TP ratio positively related to the density of ponds in the landscape (negatively affecting TP concentrations) alongside % agricultural land cover. The implications of these results for landscape management of shallow and deep lakes is discussed.

## Macroinvertebrate communities of lowland peatland streams

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5D\_SS03 The role of small water bodies in the landscape, July 27, 2021, 13:15 - 14:45

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Peatlands account for about 10% of the world's freshwater resources. In Ireland they cover c. 21% (or 1.46M ha), occurring as raised bogs, blanket bogs or fens. Those in the midlands are drained by a network of streams of variable size. Many of these streams are naturally soft bottomed with peat underlain by either high-pH marl or glacial till/clay as substrate. Despite their common occurrence in countries such as Ireland the biological communities are poorly studied. This in part relates to the difficulty of sampling soft-bottomed streams. Nevertheless, it is important that knowledge of the communities of near-natural systems is characterised to enable assessment of the impacts of peat extraction and other anthropogenic activities that alter flow and habitat conditions. This paper presents results from an investigation of macroinvertebrate communities of streams draining near natural, raised bogs in the midlands of Ireland. This is part of the research being undertaken for the SWAMP project (<https://www.ucd.ie/swamp/>). The results highlight the importance of these streams in terms of trichopteran, odonate and dipteran biodiversity.

## Developing the UK Freshwater Network: an evidence-based approach to freshwater biodiversity conservation

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<sup>1</sup>*Freshwater Habitats Trust*

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In the UK, Freshwater Habitats Trust (FHT) has been developing an evidence-based approach to freshwater biodiversity conservation planning and practical action called the Freshwater Network. Working with a range of specialist partners, the Freshwater Network links together concepts derived from the Key Biodiversity Area approach, fundamental understanding of the role of different water body types in harbouring freshwater species (particularly the role of small waterbodies), species threat data and freshwater habitat quality information. The Freshwater Network has three main components: (1) Important Freshwater Areas, which are identified at national and regional level and are the sites and landscapes which are the best remaining reservoirs of freshwater biodiversity, (2) Floodplain Networks which are the zones defined in the UK by the 1:100 year flood envelope, inherently rich in freshwater biodiversity and, in the UK, already quasi-legally protected, and (3) Wetland Opportunity Areas, which are intervening landscape areas where measures to restore or recreate freshwater and wetland habitats can help to 'build out' from existing hotspots and protect declining species or habitats. Wetland Opportunity Areas are particularly areas which generate 'clean' water (equivalent chemically to Water Framework Directive High status) and therefore provide optimum areas for freshwater habitat restoration. Using this approach we have identified a range of practical actions for habitat creation and restoration, focusing on those with the best evidence for ability to protect and increase freshwater biodiversity. We are currently testing and applying this work in all aspects of FHT's organisational strategy for the 15 year period 2021-35.

## Peatland degradation and water quality impacts in Ireland

Dr Catharine Pschenycky<sup>1</sup>, Dr Florence Renou-Wilson

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Terrestrial and aquatic systems are interlinked; and this is particularly true for peatlands that contain more than 95% water in a natural, undrained state. Drainage and removal of surface vegetation alters the peat and pore water chemistry, as well as hydrology and flow regimes, equating to degradation of inland water quality. The type and quantity of material leaching from degraded peatlands and entering streams varies depending on site specific characteristics and management activities, but typically concentrations of N, P and DOC increase. A summary of changes in water quality indicators that have been observed following drainage and peatland utilisation in Ireland will be first presented in the context of recent pressures identified by the Environmental Protection Agency. Furthermore, initial water quality data from drained peatlands, either for peat extraction or forestry will be presented within the context of two EPA funded projects: 1) Reform Water project (<http://tiny.cc/74mutz>) which aims to investigate less invasive practices, such as Continuous Cover to reduce the harmful effects of peatland forest management on inland waters; and 2) SWAMP (<http://www.ucd.ie/swamp>) which aims to investigate the pressures on Irish water from extracted peatlands and propose mitigation measures.

## 5E\_SS01 Role of freshwater ecosystems in the carbon cycle and the climate system & RS22 Urban freshwaters

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### Warming drives ecosystem respiration towards CO<sub>2</sub> and CH<sub>4</sub> in mesocosms and nature

Prof Mark Trimmer<sup>1</sup>, Yizhu Zhu<sup>1</sup>, Prof Gabriel Yvon-Durocher<sup>2</sup>, Dr Diego Barnache<sup>3</sup>

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In 2005, we built a freshwater mesocosm facility to experimentally test the effects of warming on whole ecosystem carbon metabolism. We have consistently measured higher ratios of ecosystem respiration to primary production under warming, coupled to an increasing proportion of respiration as CH<sub>4</sub> compared to CO<sub>2</sub>. While we originally explained these shifts in the different components of the carbon cycle by their relative temperature sensitivities, the recent disproportionate increases in CH<sub>4</sub> emissions argue for structural changes in the methanogen community. Warming increases the proportion of H<sub>2</sub> from fermentation being metabolised to CH<sub>4</sub> – not only in our mesocosms, but in 100's of other sediments and soils – and favours a more hydrogenotrophic methanogenesis. Most recently we demonstrated how warming strongly decreases the trophic transfer efficiency of our mesocosm planktonic communities, essentially because proportionately more carbon is respired to CO<sub>2</sub> than is assimilated into biomass and exactly as expected at a higher ratio of ecosystem respiration to primary production. We can now demonstrate how that mesocosm finding is borne out as an increasing ratio of respiration to primary production in a variety of ecosystems across the globe and that – ultimately – with warming, temperate ecosystems will become increasingly less efficient at storing carbon. Combining global observations for CO<sub>2</sub> and CH<sub>4</sub> further suggests that not only will a greater proportion of primary production be lost as CO<sub>2</sub>, but a greater fraction will be lost as the more atmospherically potent CH<sub>4</sub>.

## Drinking water systems control and improvement: a novel way to assess water-stewardship-standards

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Delivering adequate, good quality drinking water, and returning it safely to the environment, while maximising users' utility and minimising costs, is a challenging task. Infrastructure, leakage and funding restrictions, combined with future threats can challenge the resilience of most Water Distribution Systems (WDS). We use Dublin's WDS (facing population growth, climate and Covid-19-driven demand challenges) to: analyse the perceptions and actions so far; select useful solutions from practical experience and academic literature; showcase a way to quantify each one of the aforementioned threats; and examine the water conservation practices under the concept of Water Stewardship (WS). The analysis examines the demand-driven pressures from a hydrological and socio-economic perspective to highlight their importance in balancing short-term and long-term planning for more resilient WDSs. WS literature and practices are also analysed; WS standards can be a useful demand-management tool if the indicators focus on the environmental component rather than individual corporates' efficiency. A simple and novel way to assess the WS standards and prioritise the investment options is presented. The framework is based on Utility Theory and is similar to benefit score-functions, enabling WS indicators to become measurable and thus optimise funding allocations depending on the specific goals for improvement. Finally, we scale up the findings for Ireland, in terms of aims, principles, standards, good and bad WS practices. Although facing challenges, Ireland has been slow to consider most of the above concepts, thus our analysis provides novel and valuable outcomes with useful practical recommendations for sustainable planning.

## The impacts of anthropogenic litter on biodiversity in urban streams

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Despite evidence of the prevalence of anthropogenic litter (solid manufactured waste) in urban streams, its impacts on river habitats and organisms are poorly understood. We previously discovered that litter was inhabited by different and more diverse communities of macroinvertebrates than gravel or cobbles in urban rivers, where there is a lack of alternative natural habitats. This presentation reports on our subsequent investigation into the effects of large anthropogenic litter (in this case car tyres). Because of their size, and consequent interactions with flow and sediment conditions, large litter could affect macroinvertebrates within the surrounding riverbed as well as those inhabiting its surface. These proposed effects are analogous to those of similar sized natural structures, like wood or boulders. We compared the macroinvertebrates living on and around car tyres, which were experimentally introduced to one sand- and one gravel-bed river and monitored for twelve months in Nottinghamshire, UK. The communities inhabiting tyre surfaces in the sand-bed river were significantly more diverse and included more sensitive taxa than the surrounding riverbed, whereas tyre surface communities were relatively impoverished in the gravel-bed river. In both rivers, we found that tyres significantly affected nearby benthic communities, which we attribute to the influence of the tyres on local flow and sediment conditions. These results show how relatively simple structures (including large anthropogenic litter) can diversify habitats and influence macroinvertebrates within their vicinity. This is especially relevant when large litter provides otherwise scarce, stable and solid habitat, as in the sand-bed river.



## Impacts of contaminants on macroinvertebrate abundance and community structure in peri-urban ponds

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Contamination by pollutants is among the major threats on freshwater biodiversity. Ponds are submitted to multiple contaminations according to their environment. Among other aquatic ecosystems, the distinctive feature of peri-urban ponds is to be embedded in human-dominated areas with different activities, which are sources of multiple stressors. To explore the effects of multiple contaminants on macro-invertebrate diversity and community structure, we monitored twelve ponds located in a peri-urban area (Ile-de-France region, France) during two consecutive years in spring and autumn. We measured classical water parameters and different contaminants (metallic trace elements MTE, pharmaceuticals, pesticides, and polycyclic aromatic hydrocarbons – HAP – in water and sediments). We analyzed the local and regional spatiotemporal macro-invertebrate diversity and the effects of contaminants on abundance and community structure. Our results show weak differences between pond local richness and Shannon diversity but strong effects of years and seasons. The comparison of macro-invertebrate communities between sampling sessions with the temporal biodiversity index shows few significant changes. The regional beta-diversity shows that the dissimilarity between ponds is mainly due to high abundances of pollutant-tolerant species. We analyzed the effects of environmental parameters on community structure with canonical correspondence analysis (CCA) and reduced the parameter numbers with partial CCA. The parameters explaining community structure are pharmaceuticals, fungicides and MTE in the sediments with chemical demand of oxygen, conductivity and suspended matter. The results suggest an important role of benthic invertebrate bioturbation. The parameters are not simply related to pond surrounding areas as human activities affect all ponds.

## Urbanization effects on river biofilm metabolism along a European gradient

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River ecosystems have historically supplied key services to human settlements, remaining nowadays essential to human well-being. Consequently, many rivers flow through or near urban areas and play a major role in the dynamics of urban development. However, their tight connection with the landscape and the stress exerted by urban areas has led to an increase in the ecological impacts faced by rivers. Currently, more than half of the global current population lives in urban areas, and this is expected to increase in the near future. Despite the acknowledged impact of urbanization on rivers, it is still uncertain how diffuse-source pollution alters the functioning of river ecosystems. URBIFUN (Urbanization effects on the relationship between microbial biodiversity and ecosystem functioning), the 3rd young-AIL collaborative project, addresses this knowledge gap by investigating how increasing urbanization across Europe alters river biofilm metabolism (primary production and community respiration). Rivers (n=50, from 7 countries) were selected across a complete range of land-use from forested to urban, and different spatial scales explored (from 5, 10, and 15-km buffers upstream to the whole basin). Biofilm metabolism will be measured in the field using sediment cores. We expect to observe metabolic differences according to land-use and spatial scale. Our results will shed light on the impacts of diffuse-source pollution from urban areas on autotrophic and heterotrophic processes. Results from the URBIFUN project can be of great significance to help guide future conservation policies and counteract the increasing pressures undergone by urban rivers over the coming years.

## The net carbon footprint of a boreal reservoir within a cascade complex

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There is still a large uncertainty concerning the magnitude of greenhouse gas (GHG) emissions attributable to reservoirs, especially in the increasingly prevalent reservoirs in cascade configurations (multiple connected reservoirs). This uncertainty results from a lack of clear accounting methodologies to determine pre-flood and post-flood GHG balances (i.e., net carbon footprint), incomplete accounting of all major emission pathways (i.e., diffusion, ebullition, degassing at the turbines), and insufficient understanding of the spatio-temporal variability of these processes. Here we present the net carbon footprint based on an improved framework for the newly created La Romaine 2 reservoir (RO2), which is situated between two adjacent reservoirs (RO1 and RO3). We sampled RO2 intensively in 11 field campaigns over 4 years. The pre-flood GHG balance was estimated via landscape modeling. For the post-flood GHG balance, we modeled CO<sub>2</sub> and CH<sub>4</sub> surface water concentrations based on field data to create a detailed grid across the whole reservoir to explicitly consider spatio-temporal variability and overlaid this grid with spatially weighted gas transfer velocities to calculate diffusive fluxes. Ebullition was estimated based on field data, which were upscaled in a spatially weighted approach while degassing at the turbines was estimated based on continuous CO<sub>2</sub> and CH<sub>4</sub> measurements and water discharge at the turbine. Furthermore, we subtracted the GHG input from the upstream reservoir (RO3) as well as the groundwater input from the post-flood GHG balance. This improved framework is transferable to other reservoirs across the globe and will help to narrow down the uncertainties of reservoir carbon footprints.

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### Accounting for flow intermittence when modelling the distribution of freshwater species

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To forecast species responses to environmental changes, it is crucial to understand the drivers of species distribution acting at multiple spatial and temporal scales. While hydrology is acknowledged as a key driver for freshwater species, most studies have been limited to perennial water flow regimes when exploring species distribution in rivers. Here, we developed a method to characterize stream flow in order to subsequently account for flow intermittence in species distribution models (SDMs). We used the hydrological Soil and Water Assessment Tool (SWAT) to simulate flow in the stream network of the French Pyrenees at a fine spatial grain and a large spatial extent. We then called for expert judgement to identify intermittent streams. Metrics characterizing flow intermittence were subsequently included as input variables in a SDM along with topographic, hydrographic, climatic and land use variables. We applied this methodology to an extensive dataset of the Pyrenean brook newt (*Calotriton asper*) presence in France, a stream-dwelling amphibian species endemic of the Pyrenees mountains. Based on stream flow simulations combined with expert judgement, we found that almost 60% of the stream network of the study area is intermittent. Monthly maximum air temperature and proportion of agricultural areas contributed the most in explaining species distribution. The probability of presence of the brook newt was also found to be negatively correlated to the frequency of zero-flow event. Our results provide new insights about fine scale hydrology in mountainous systems and open new perspectives for the conservation of freshwater species.

## Stream microbial communities and ecosystem functioning show complex responses to multiple stressors

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Inputs of urban wastewater potentially have pervasive impacts on biodiversity and ecosystem services in receiving freshwater habitats. Viewed through multiple disciplinary lenses, we combined field, flume, and laboratory experiments to investigate wastewater effects on microbial communities and organic-matter processing using a standardized decomposition assay. A mensurative field experiment showed that microbial respiration and decomposition rates were positively influenced by wastewater inputs via warming and nutrient enrichment, but with a notable exception: wastewater decreased the activation energy of decomposition, indicating a “slowing” of this fundamental ecosystem process in response to temperature. Next-generation sequencing of microbial communities showed that wastewater altered community structure, with significant compositional turnover and evidence of negative micropollutant influences on fungal richness. A series of experiments demonstrated how negative wastewater effects on ecosystem functioning are ‘masked’ by nutrients and wastewater-borne microbes. Taken together, our results affirm the multiple-stressor paradigm by describing how different aspects of wastewater (i.e., temperature, nutrients, microbes, and micropollutants) jointly influence biodiversity and ecosystem functioning in complex ways. The net increase in respiration rates driven by wastewater inputs have the potential to generate ecosystem ‘disservices’ via greater carbon evasion from streams and rivers.

## Aquatic hyphomycetes diversity from Azorean lakes

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Aquatic hyphomycetes, a polyphyletic group of fungi composed mostly by the anamorphs of Ascomycetes and Basidiomycetes, are diverse, abundant and play a key role in organic matter decomposition in minimally disturbed lotic systems. However, their presence in lentic systems has not been deeply investigated, despite litter decomposition being also a key ecosystem process in the littoral zones of lakes and reservoirs. This study aimed to investigate the presence and diversity of aquatic hyphomycetes in lakes in the Azores archipelago. Natural foam and lake water were directly filtered through membrane filters. Leaf litter submerged in the lakes was collected, incubated in the laboratory to induce conidial production, and the putative conidial suspension was filtered. Conidia of aquatic hyphomycetes were identified under a compound microscope. Azorean lakes show a diverse aquatic hyphomycete community, which differs among them. Lakes with remarkable littoral zones, located on forests that produce substantial litter inputs, and those having turbulent waters due to intense wind exposure had a richer aquatic hyphomycetes community. A better knowledge of the microbial assemblage structure is essential for understanding the functioning of insular lentic ecosystems. Keywords: aquatic hyphomycetes, Azores, diversity, lentic systems.

## Stoichiometric requirements of aquatic hyphomycetes control the nutrient immobilization/mineralization balance during decomposition

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Aquatic hyphomycetes (AH) require various essential elements (including carbon (C), nitrogen (N) and phosphorus (P)) in different proportions to ensure their development. Each species has an optimal ratio below and beyond which its growth could be affected. Consequently, such imbalance between elements' availability and demand for organisms (the "stoichiometric constraints") could greatly disrupt ecological processes, like the decomposition of plant litter in freshwater ecosystems. One of the central concepts of the ecological stoichiometry theory (Sterner & Elser 2002) states the elementary compositions of organisms reflect at least partially their demands. It has been shown that AH's elemental composition could be highly variable (Danger & Chauvet, 2013), but the ecological consequences of this non-homeostasis are still not well understood. In a 40-days experimental study, we grew five strains of commons AH -separately and their assemblage- on alder (*Alnus glutinosa*) leaf litter alongside a gradient of dissolved N:P ratios. We evaluated the impact of N:P ratio on leaf decomposition rate, fungal biomass, the structure of the fungal assembly, as well as the temporal dynamic of nutrient immobilization and mineralization (uptake and release of nitrate, ammonium and phosphate). Preliminary results confirm that phosphate availability promotes litter decomposition, increase fungal biomass, and positively correlates with nitrate and phosphate immobilization rates. Our kinetic results showed that nutrient immobilization arise during the first days while ammonium release is reduced, late, and dependent on water stoichiometry. Finally, comparison between individual strains and the fungal assemblage give us insights on the impact of N:P ratio over assemblage structure.



## Genomes and distributions of Tetracladium; fungi connecting forests, fields, and streams worldwide

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Aquatic hyphomycetes are important decomposers of plant litter in stream food webs. These fungi grow, reproduce, and disperse while submerged. However, some of these fungi are also found as endophytes and are increasingly sequenced from roots, soils, and extreme environments globally. These observations demand improved understanding of the biology and ecology of the aquatic hyphomycetes that appear to connect forests, fields, and streams. Toward this goal, a genomics study of all known species in the genus *Tetracladium* was undertaken (24 new genomes produced) and the data used to build a robust phylogeny. As first steps to using these genomes to understand the biology of these fungi (reverse ecology), CAZyme and secondary metabolite genome contents were predicted and compared to contents of pathogenic, endophytic, and mycorrhizal taxa. Additionally, ITS sequences from verifiable cultures and environmental sequences were analyzed together with the strains sequenced here. These data indicate that broad geographical and ecological diversity are achieved by species with highly similar genomic toolkits in this genus. This general "toolkit" appears to reflect phylogeny rather than ecology. Multifunctionality, the ability be an aquatic hyphomycete in water and endophyte or soil fungus on land appears to be widespread in the genus based on analyses of ITS sequence data. Thus, to understand populations of these fungi in their ecologically important aquatic roles, progress must also be made to understand their biology and ecology in forests and fields.

## Contributions to knowledge of Ingoldian fungi in Pampas region

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The Pampas region is an extensive plain territory, with rich humus soils, temperate and humid climate. The watercourses have high concentrations of phosphates, nitrates, dissolved oxygen and conductivity, neutral to alkaline pH, low speeds current, presence of macrophytes and absence of trees in the banks, which is being modified by the invasion of woody exotic plants. In order to characterize the assemblages of Ingoldian fungi in pampas region, plankton samplings were carried out in 36 sites of 21 streams. Also samples of leaf litter colonization experiments of *Gleditsia triacanthos*, *Populus nigra* and *Bromus unioloides* in 12 sites. The plankton samples were taken sub-surface in 100 meter sections and filtered with acetate membranes (5 µm pore). The leaf litter was incubated and removed in triplicate in increasing periods, and the species richness and sporulation rates in liquid medium were evaluated. We registered 75 species of Ingoldian fungi, of which 50 are first report in Argentina. The genera with highest species number were *Tetracladium* (8), *Anguillospora* (6), *Triscelophorus* (4), *Lemonniera*, *Tetraploa*, *Tripopersimum* and *Tricladium* (3). The distribution range species has been very wide, being observed in least 50% of streams. High sporulation rates were registered in sites with invasion of *Gleditsia triacanthos* and low sporulation rates when there was predominance of herbaceous in the banks. It is concluded that in Pampas region, Ingoldian fungi have a wide distribution. In addition, they have the ability to decompose leaf litter, with higher sporulation rates in sites with woody plants invasion in the banks.

## 6A\_SS16 The science and management of multiple stressors in aquatic ecosystems

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### Freshwater biofilms response to treated and untreated metal-mining effluent with exposure-recovery time

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6A\_SS16 The science and management of multiple stressors in aquatic ecosystems, July 27, 2021, 15:30 - 17:00

Abandoned mines represent a source of uncontrolled pollution caused by the release of metal-polluted effluents to freshwater ecosystems. Despite this global environmental problem, the environmental impacts to freshwater and the efficiency of different treatment technologies in reducing these impacts are not well understood yet. We evaluated the response of freshwater biofilms exposed to untreated and treated metal-mining effluent from a real abandoned mine and biofilms' potential to recover after this exposure. We incubated biofilms from a reference stream in a set of artificial indoor streams under controlled temperature and light. After four weeks of colonization, biofilms were exposed to treated (T), and untreated (U) metal mining effluent from Frongoch abandoned mine (UK), mimicking the real dilution occurring when the effluent reaches the receiving stream under realistic flow conditions: medium (HF) and low (LF). Biofilm responses were measured at 1, 3, 7, 14, and 21 days during exposure and 1, 3, 7, and 14 days during the recovery period. We observed a significant reduction in biofilm functioning during the exposure under T-LF, U-HF, and U-LF recovered during the recovery. Biofilm community structure changed during the exposure under all treatments and did not recover after the pollution removal. The diatom community demonstrated a loss in biodiversity and reduced cell size under all treatments, not achieving the control conditions during the recovery. These observations evidenced ecological impacts of treated and untreated effluents on aquatic ecosystems; even communities could recover their functioning, the structure did not recover when transitioning from polluted to clean water.

## Space as driver of synergism in insect meta-populations

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6A\_SS16 The science and management of multiple stressors in aquatic ecosystems, July 27, 2021, 15:30 - 17:00

In most ecosystems, multiple stressors co-occur in space and time and their interaction is most frequently additive or non-additive (antagonistic or synergistic). To date, most multiple stressor studies focused on effects at the local scale (i.e., patch experiments). However, it remains largely unknown how spatio-temporally differing stressors interact in their effects. Indeed, at larger spatial scales, biotic dynamics within ecological networks complicate our understanding. We simulated a wide range of scenarios of two stressors using a spatially-explicit meta-population model for a generic, hemimetabolous freshwater insect (Streib et al. 2020 - *Ecol. Model.* 416). Stressors were land-use and climatic extreme events, implemented in spatio-temporally different profiles with repeated co-occurrence. Land-use permanently influenced meta-population network connectivity and patch qualities, whereas climatic extreme events resulted in periodic mortality. Overall, we ran 51.300 simulations.

We found that the type of interaction between land-use and climatic extreme events depends on the stressor intensity, with higher levels of both stressors resulting in synergistic effects. Conversely, low land-use stress buffered long-term effects of climatic extreme events at all levels, by supporting recovery dynamics via the network. We discuss the relevance of the spatial dimension when assessing the effects of multiple stressors and for freshwater management.

## Effects of multiple stressors on the microbial communities in a mining area

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6A\_SS16 The science and management of multiple stressors in aquatic ecosystems, July 27, 2021, 15:30 - 17:00

Mining metal pollution is still of concern in fluvial ecosystems due to high toxicity, perdurability and trophic transfer of metals. This pollution is especially critical in Mediterranean rivers, where water stress can exacerbate the negative effects of the metal pollution, generating unexpected consequences in the biota. We studied the impact of multiple stressors and biological interactions on the structure and function of microbial communities of fluvial biofilms. A field mesocosms experiment was carried out in the Osor River (Catalonia, Spain) at five sites selected following a chemical gradient of mining metals around the effluent of an abandoned mine and the presence of fish (*Barbus meridionalis*) was manipulated. Water and biofilm samples were taken in order to characterize different physicochemical and biofilm parameters. Permutational multivariate analyses revealed that the prokaryotic community composition, determined by Illumina MiSeq sequencing of the V4 region of the 16S ribosomal RNA gene, varied among sites and fish treatments. However, functional responses such as nutrient uptake were almost unaffected. Interestingly, in the site most affected by metal pollution and hydrological alteration, endosymbiotic bacteria were detected, suggesting a metal adaptation lifestyle. Moreover, the fish bioturbation might increase the toxicity of metals by altering the composition of microbial communities. Therefore, this study highlights that the molecular analysis of the microbial community structure and field studies offers additional insights over traditional chemical and biological measures. We propose  $\beta$ -diversity and selection of some indicator families of bacteria living in biofilms as a first step to assess the health of freshwater ecosystems.

## Stressor interactions: regime shifts under multiple agricultural stressors

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6A\_SS16 The science and management of multiple stressors in aquatic ecosystems, July 27, 2021, 15:30 - 17:00

Aquatic systems in agricultural landscapes are threatened by multiple stressors including fertilizers, pesticides and climate-change related warming. Stressors and their interactions can induce non-linear shifts from macrophyte- to phytoplankton-dominated states. Effects of individual stressors have been described in detail, but neither effects of pesticides nor of combined stress have been investigated in terms of regime shifts, so far. We aimed at disentangling stressor interaction patterns of potentially opposed acting stressors on shallow aquatic systems. We hypothesized that combined stress modulates thresholds in systems potentially occurring in two alternative stable states. We performed a microcosm study using macrophytes, phytoplankton and periphyton. We used a factorial dose-response design of stressors, frequently observed in agricultural systems (nitrate, copper, pesticides). We tested them individually and in a mixture along a concentration gradient and at two temperatures (22 & 26°C). After four weeks of exposure effect sizes were calculated from biomass of autotrophic communities from single and combined treatments and compared to model predictions: nitrate in combination with pesticides showed synergistic effects on macrophyte biomass in mixture. However, this pattern was dose-dependent. A decrease in macrophytes indicated a system shift by indirect effects from elevated phytoplankton growth. This finding was driven by the strong nitrate effect and even more pronounced in pesticide treatments and at higher temperatures. The study illustrates the complexity of stressor interaction but also the need to understand multiple stressor effects when aiming to preserve aquatic systems in stable conditions.

## Assessing the response of grayling to multiple stressors in Austrian hydropeaking rivers

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6A\_SS16 The science and management of multiple stressors in aquatic ecosystems, July 27, 2021, 15:30 - 17:00

Multiple anthropogenic stressors in riverine ecosystems make it increasingly difficult to establish targeted conservation and restoration strategies. But targeted management approaches are urgently needed, especially to adequately protect indicator fish species such as the European grayling, *Thymallus thymallus*. Here, we conduct a heuristic multi-river investigation to assess the population status of grayling in Austrian rivers. Using the decision tree method and post-hoc tests of identified effects, we disentangle main and interaction effects of stressors related to peaking-hydropower, river channelization, longitudinal fragmentation, and water quality alteration. Furthermore, we use a special variant of the bootstrapping method to test the stability of identified effects and to elucidate if further parameters can be identified. Our analysis identified hydropeaking as the strongest single effect on grayling populations. Average downramping velocity and peak amplitude were the most important parameters for predicting grayling biomass, followed by habitat connectivity and river morphology. Here, we identified critical flow ranges of 0.2–0.4 cm/min and 10–25 cm for downramping rate and peak amplitude, respectively. Repeating the analysis steps with the cumulative bootstrapping dataset underlined that the identified parameters were most relevant in predicting fish population status. Overall, our results support the notion to protect fish populations in hydropeaking rivers by mandating ecological flow thresholds, as well as to establish measures targeted at improving river connectivity and habitat quality in order to dampen the negative effects of hydropeaking.

## Rapid evolution generates synergism between multiple stressors

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6A\_SS16 The science and management of multiple stressors in aquatic ecosystems, July 27, 2021, 15:30 - 17:00

Global change encompasses many co-occurring anthropogenic stressors. Understanding the interactions between these multiple stressors, whether they be additive, antagonistic or synergistic, is critical for ecosystem managers when prioritising which stressors to mitigate in the face of global change. While such interactions between stressors appear prevalent, it remains unclear if and how these interactions change over time, as the majority of multiple-stressor studies rarely span multiple generations of study organisms. Although meta-analyses have reported some intriguing temporal trends in stressor interactions, for example that synergism may take time to emerge, the mechanistic basis for such observations is unknown. In this study, by analysing data from an evolution experiment with the rotifer *Brachionus calyciflorus* (~35 generations, 31,320 observations), we show that adaptation to multiple stressors shifts stressor interactions towards synergism. We develop a theoretical framework to explain that trade-offs, where populations cannot optimally perform multiple tasks (i.e. adapting to multiple stressors), generate this bias towards synergism. We also show that removal of stressors from evolved populations does not necessarily increase fitness and that there is variation in the evolutionary trajectories of populations that experienced the same stressor regimes. Our results highlight outstanding questions at the interface between evolution and global change biology, and illustrate the importance of considering rapid adaptation when managing or restoring ecosystems subjected to multiple stressors.



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### Discovery of novel femtoplanktonic particles: characterisation and ecology

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6B\_RS11 Fundamental and applied freshwater ecology, July 27, 2021, 15:30 - 17:00

In recent years, advances in genomic analyses and microscopy have revealed a significant and unsuspected diversity of femtoplankton. Among this, we reported, in eutrophic freshwater environment, the existence of new entities not previously described. These entities have an original “aster-shape” (ALNs = Aster Like Nanoparticles) and a biovolume lower than the theoretical minimum required for the life. Yet, our experiments, carried out under controlled conditions, suggest that these pleomorphic entities are bio-organic and are able to maintain themselves without any hosts. These results raise fundamental questions about their exact nature, the presence of heredity supports (nucleic acids, other?), growth/replication mechanisms and their possible metabolism. We also explored the ecology of these entities through in-situ and microcosms studies. A spatial survey over the global Loire watershed and a temporal monitoring of more than 2 years on a eutrophic lake, showed high variability in abundance of ALNs, with evidence of blooms that can reach 108 entities.mL<sup>-1</sup>. These dynamics seems more closely linked to microbial environment, in particular with prokaryotes, than the physico-chemical environment. If their exact functional roles (specific metabolism, interaction with prokaryotes) remain to be determined, ALNs are undoubtedly new players to be considered in the study of matter and energy flows governing aquatic systems.

## Instream functional consequences of fungal-induced plant species loss

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6B\_RS11 Fundamental and applied freshwater ecology, July 27, 2021, 15:30 - 17:00

Alder (*Alnus glutinosa*) and oak (*Quercus robur*) are dominant tree species in Atlantic mixed forests, and their leaf litter is a key resource for stream ecosystems. While alder litter has high nutrient content and palatability and is rapidly processed in the stream, oak litter is a tougher and less nutritious but more persistent resource. Given that both species are declining due to the spread of the pathogens *Phytophthora alni* and *P. cinnamomi*, we investigated how their reduction or loss might alter stream ecosystem functioning through changes in litter decomposition, detritivore growth and stoichiometry, and fungal assemblage characteristics. We conducted a microcosm experiment where we incubated litter mixtures representing different scenarios of alder and oak reduction or loss (and a concomitant increase in the other species), compared to a control containing the most common species in the study area [alder, oak, hazel (*Corylus avellana*) and willow (*Salix atrocinerea*)] in the same proportions found in nature. The experiment lasted for 9 weeks, with measurements every 3 weeks. Despite an overall negative net diversity effect on decomposition, the process changed depending on which species was lost: it decreased when alder was lost and increased following oak loss. Detritivore nutrient assimilation also responded to species loss, increasing and decreasing following alder and oak loss, respectively, possibly due to compensatory assimilation. The presence of oak constrained microbial activity, possibly caused by the interaction of different inhibitory traits. Overall, our results evidence that restoration of native riparian vegetation would be advisable for maintaining normal stream function.

## Using macroinvertebrates functional information to assess flow alteration in rivers across Europe

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6B\_RS11 Fundamental and applied freshwater ecology, July 27, 2021, 15:30 - 17:00

Flow alteration due to climate change and anthropogenic water abstraction represents a severe stressor on aquatic communities. Macroinvertebrates are frequently used for river biomonitoring through the develop of specific biological indices. However, most historic approaches are limited in terms of their geographical application in other areas due to taxonomic constraints. Here a new trait-based index, Flow-T, based on the flow preferences of invertebrate taxa is presented. Flow preferences based on the ecological “current velocity” traits proposed by Tachet et al. (2010) and available for nearly 500 invertebrate taxa were obtained. The newly developed index was tested on a range of different river types from UK, Cyprus and Italy to evaluate its response in different biogeographic and hydro-climatic regions. Flow-t index displayed significant correlations with LIFE (Lotic-invertebrate Index for Flow Evaluation) in all countries examined. Furthermore, Flow-t was sensitive to the flow conditions within different aquatic mesohabitats (e.g., pools, riffles, glide). The trait-based approach facilitates research on the entire European invertebrate fauna. Flow-t can potentially be applied where information on hydraulic preferences of macroinvertebrate taxa (genus or species) are not available (e.g. new alien taxa) providing a highly flexible and geographically generalizable approach. The outputs obtained and the desirable properties of Flow-t mean this metric represents a promising flow sensitivity index that is applicable at the European scale and allows inter-regional comparisons that will help water resource managers to gauge the effects of changes in the pattern of flow at the local scale.

## Influence of nutrient addition on macrozoobenthos in tufa depositing system (Plitvice Lakes)

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The freshwater ecosystem of the Plitvice Lakes National Park represents a unique cascading system of 16 lakes separated by tufa barriers. This study was conducted on the tufa barriers of the outlet of one of the upper lakes (Gradinsko jezero lake - GJ) and one of the lower lakes (Novakovića brod lake - NB) at two microlocations on each barrier: with and without macrovegetation. Experimental treatments included: control, N, P and N+P treatments. Replicated nutrient diffusing substrates (NDS) remained in the water for 6 weeks during each season in 2015. The NDS were colonised by 13 macrozoobenthic groups, with 83 taxa determined. The highest abundance was recorded for Diptera (mean 94.5 ind. dm<sup>-2</sup>) and Oligochaeta (mean 22.5 ind. dm<sup>-2</sup>). Statistically significant differences were found between barriers and microlocations with increased abundance and taxa numbers at GJ barrier compared to NB barrier and at microlocations without macrovegetation compared to microlocations with macrovegetation. Seasonal dynamics were observed with increased abundance and taxa numbers in spring and decreased abundance in winter. Statistically significant differences were observed between treatments with higher mean abundance for the P treatment and the N+P treatment compared to other treatments. The proportion of functional feeding groups of grazers and detritivore-collectors was increased in the above treatments. Following the distinct positive response of phyto-benthos, macrozoobenthos weakly responded to the addition of nutrients. Spatial and temporal changes in the abundance of macrozoobenthos could be related to water velocity, phenology, tufa deposition processes and food availability.

## Direct habitat descriptors to better understand the spatial organization of aquatic communities

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6B\_RS11 Fundamental and applied freshwater ecology, July 27, 2021, 15:30 - 17:00

In large-scale aquatic ecological studies, direct habitat descriptors (e.g. water temperature, hydraulic features) are often approximated by using coarse-grain surrogates (e.g. air temperature, river discharge) since they are easier to measure or model. However, surrogates do not capture all the variability of direct habitat descriptors, and are likely to provide less insight into the ecological processes or patterns of interest. In this study, we aimed to compare the performance of direct habitat descriptors vs. surrogate environmental variables to explain the spatial organization of fish and macroinvertebrate communities across the Loire catchment in France (10<sup>5</sup> km<sup>2</sup>). For this purpose, we relied on high-resolution environmental data, extensive biological monitoring data (>1000 sampling stations with abundance data) and multivariate analyses. Fish and macroinvertebrates datasets were considered both separately and combined to assess the value of a cross-taxa approach. We found that fish and macroinvertebrates communities exhibited weak concordance in their spatial organizations and responded differently to the main ecological gradients. This is probably due to strong differences in their life-history traits and mobility. When considered separately, the spatial organizations of fish and macroinvertebrates communities were better explained by direct habitat descriptors than by surrogates. Furthermore, the spatial organization of fish and macroinvertebrates communities was better explained by environmental variables when the two biological groups were considered together rather than when considered separately. Our results emphasize the importance of using a cross-taxa approach in association with high-resolution direct habitat variables to more accurately explain the spatial organization of aquatic communities.

## 6C\_SS05 Multidisciplinary perspectives on invasive alien species in freshwater ecosystems

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### How native amphibians can survive fish introduction in mountain lakes and ponds.

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6C\_SS05 Multidisciplinary perspectives on invasive alien species in freshwater ecosystems, July 27, 2021, 15:30 - 17:00

Fish introduced in originally fishless mountain aquatic habitats usually extirpate or displace native amphibians, but sometimes amphibians can coexist with the invaders. Understanding which biotic and environmental factors enable their coexistence is a key step to assess the sensitivity of amphibian populations to the spread of alien fish and to undertake focused management/conservation measures. To this end, we analysed a dataset of presence/absence and abundance of alien fish and common frog (*Rana temporaria*) in a network of > 400 permanent mountain lakes and ponds from the Western Italian Alps. We tested the role of aquatic vegetation (as anti-predator refugia), habitat connectivity, and alien fish community composition (i.e., the presence of Salmonidae, Cyprinidae or of both the families) as factors that explain the persistence of *R. temporaria*. The ability of *R. temporaria* to breed in a large array of aquatic habitats, including non-invaded ones (e.g., small water bodies), is a very important factor explaining its persistence in mountain areas affected by fish introduction. The presence of such safe habitats may also explain the persistence of *R. temporaria* at the invaded sites, by providing source populations.

## Drivers of invasion success of non-native fish species across Europe

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6C\_SS05 Multidisciplinary perspectives on invasive alien species in freshwater ecosystems, July 27, 2021, 15:30 - 17:00

The spread of invasive non-native fish species is a major threat in freshwaters and is among the main reported causes for the decline of native freshwater fish worldwide. The aim of the present study is to disentangle the drivers that lead a non-native freshwater fish species to successfully get through the several stages of invasiveness in Europe. We developed empirical models for each main invasion stages - release, establishment, spread and impact - to predict how likely the species moves to the next stage. General linear models followed by a multimodel-inference approach were used. As predictors we used 18 traits from three categories: biology, ecology and invasion history of 127 established non-native freshwater fish species in Europe. Additionally, we evaluated the resulting models as a tool to predict the invasiveness of fishes and to predict which species will more likely be invasive in Europe. Different traits were found to affect each stage of the invasion. Release and spread stages were primarily driven by traits related to the invasion history, the establishment stage was mainly driven by biological and ecological traits and the impact stage was significantly driven by traits belonging to the three trait categories. The models also predicted as potentially invasive 10 out of the 16 fish species recently reported as the most potentially harmful. A good match between the resulting models and expert judgement tools to evaluate fish invasiveness was found. The proposed models are therefore a promising tool to detect invasion fish species at an early stage.

## INVASIVESNET: International Association for Open Knowledge on Invasive Alien Species

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6C\_SS05 Multidisciplinary perspectives on invasive alien species in freshwater ecosystems, July 27, 2021, 15:30 - 17:00

In a world where invasive alien species (IAS) are recognised as one of the major threats to biodiversity, leading invasion biology scientists from five continents have created INVASIVESNET: an international association for open knowledge and open data on IAS (<https://www.invasivesnet.org>). INVASIVESNET links networks of all interested stakeholders including scientists, citizens, expert working groups and initiatives, database managers, thematic open access journals, environmental agencies, practitioners, managers, industry, non-government organisations and educational bodies. The association will promote networking opportunities, knowledge sharing and learning and provide resources via high quality communication, information, publication and education services. Membership in INVASIVESNET is open to individuals and organizations wishing to participate in promoting the objectives of the association. The benefits of INVASIVESNET membership are: 1. Unique networking opportunities: share your knowledge on invasive species and collaborate with scientists and environmental managers from your field of expertise or interest; 2. Eligibility to support from the INVASIVESNET Open Access Publishing Fund: associate individual members are eligible for discounted article processing charges for their publications in the official open access journals of the Association. Regular individual members are eligible to publish in these journals free of charge; 3. Benefit from unlimited access via membership login to your INVASIVESNET Workspace. Here you can edit your personal profile or profile of your organization, find other people and organizations, and access our online network services; 4. Eligibility to place news items in INVASIVESNET media: make your organization, its achievements and events visible on the INVASIVESNET website and via our social media platforms.



## Effect of climate warming on the Ponto-Caspian gobies and their native counterparts

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6C\_SS05 Multidisciplinary perspectives on invasive alien species in freshwater ecosystems, July 27, 2021, 15:30 - 17:00

In connection with the expansion of alien gobies in European waters, a question arises whether this process can be enhanced or inhibited by ongoing global warming. The gobies are of Ponto-Caspian origin, where the climate is warmer than in invaded areas in Central and Western Europe. Therefore, they are likely to be able to physiologically tolerate elevated temperatures and cope with climate change better than native species. In this study, using a laboratory respirometry assay, we compared the effect of elevated summer temperature (17 vs. 25°C) on the physiological performance of four fish species: two alien gobies (the monkey goby *Neogobius fluviatilis* and racer goby *Babka gymnotrachelus*) and their native counterparts sharing similar ecological niches (the gudgeon *Gobio gobio* and European bullhead *Cottus gobio*, respectively). After four weeks of acclimation, standard metabolic rate (SMR), maximum metabolic rate (MMR) and aerobic scope (AS = M - SMR) of the fish were determined. We noted that the invasive and native fish species differed in their responses to elevated temperature. In general, responses of gobiids were weaker than natives. We found that with increasing temperature, the Sof native species only was increased substantially, which points to growing energy demands necessary to sustain an increased metabolic rate. Moreover, low Sand intermediate AS values differentiated invasive gobiids from their native counterparts irrespective of temperature. Our results suggest that because of ongoing global warming invasive gobiids might benefit compared to their native counterparts by bearing smaller energy expenditures on metabolism.

## Fish in Italian alpine-lakes: non-native species and anthropogenic pressures increases community dissimilarities

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6C\_SS05 Multidisciplinary perspectives on invasive alien species in freshwater ecosystems, July 27, 2021, 15:30 - 17:00

Anthropogenic pressures in European lakes increased significantly after 1950 facilitating the colonization by non-native species and increasing their potential for invasion. Here, we want to determine the effects that anthropogenic pressures (e.g. habitat alteration, non-native species) produced on fish communities in the Italian alpine lakes. We hypothesize that (i) the increase of anthropogenic pressures after the 1950s produced a homogenization of lakes' communities; (ii) non-native species have higher prevalence of competitive traits in front anthropogenic perturbations such as habitat alteration; (iii) thus, native species abundances will vary according to anthropogenic pressures. We tested these hypotheses on 15 alpine lakes, covering a broad geographical and morphologic gradient, comparing 2007-2014 fish community composition (sampled according to CEN protocol plus electrofishing) with their communities before 1950 (bibliography). We studied the relationship between anthropogenic stressors and fish community metrics using co-inertia analysis. By means of Infomap-Bioregions method we identified the fish assemblages present and their indicator species. We found that, since 1950, 19 non-native species colonized the alpine lakes and the occurrence of native species had been reduced by ~ 27%. Contrary to our expectation, these changes have increased differences between lakes' communities (higher  $\beta$ -diversity). Despite community composition was related with lake morphology, fish abundance (CPUE) and biomass (BPUE) were related with in-lake habitat conditions and anthropogenic pressures, respectively. Non-native species show higher prevalence in traits that might increase their competitiveness (e.g. tolerance to pollution), which in turn might explain their important weight in the five community assemblage identified (~ 80% of indicator species).

## Effects of stocking and introductions of brown trout on marble trout populations.

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6C\_SS05 Multidisciplinary perspectives on invasive alien species in freshwater ecosystems, July 27, 2021, 15:30 - 17:00

Massive amounts of allochthonous and domesticated stocks of Atlantic brown trout *Salmo trutta* are being introduced in the inland waters of the Verbano-Cusio-Ossola Province (VCO), to support angling activity, given the difficulty of rearing the native marbled trout *S. marmoratus*. Such introductions threaten the native species through hybridization, acting synergistically with pollution and loss of ecological connectivity. We conducted an investigation of the genetic structure of both wild-caught and hatchery individuals of phenotypically-discriminated *S. marmoratus*, using admixture analysis to estimate the degree of introgression. We found a scarce correspondence between phenotype and genotype. Most of the hatchery individuals used in supportive breeding were highly introgressed, with significant ancestry in *S. trutta* or hybrids. Nuclear and mitochondrial sequencing revealed contrasting patterns, with higher levels of maternally-inherited mtDNA introgression in the stocked population, and higher levels of nDNA introgression in the wild population. This pattern suggests that most hybridization events occur between female marble trouts or female hybrids, and male brown trouts. Our results also suggest that most of the stocked "*S. marmoratus*" are in fact hybrids, and that such individuals have been artificially selected to have a "marbled" phenotype. Further, numerical mismatches between introductions and the number of fish captured by anglers (catch record cards) suggest that most of the introduced phenotypic *S. marmoratus* are not viable in the wild, while most of the alien trouts survive, possibly due to domestication effects during artificial selection. Our results prompt for further investigations and changes in the current management practices in the VCO.

### Characterising the drivers of temporal cycles in phytobenthos biomass in UK streams

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6D\_RS14 Insights from long-term datasets, July 27, 2021, 15:30 - 17:00

Pronounced seasonal cycles in phytobenthos biomass are evident in a number of streams we have studied in the UK. However, at the same time, other streams of a similar size and in the same region do not show similar temporal patterns. This raises questions about the factors – physical, chemical or ecological – that drive seasonal cycles and the implications for river management and assessment. In this paper, we examine three different potential drivers of seasonal cycles in phytobenthos biomass: hydrology, nutrient hydrochemistry and top-down control of biomass by invertebrate grazers. We present data from a range of streams and rivers in Cumbria (northern England) and Northern Ireland. Seasonal trends in biomass over seven successive cycles from the River Ehen, an artificially regulated river in northwest England, are presented to illustrate a pronounced seasonal cycle with highest biomass always measured in winter months. By contrast, a nearby unregulated stream, Croasdale Beck, shows much less pronounced seasonal trends. Taken together, we hypothesise a combination of hydrological and ecological controls on phytobenthic biomass concentrations in these streams. Comparison with data from a range of other streams within the River Eden (Cumbria) and Upper Bann (Northern Ireland) catchments, as well as with Cumbrian lakes, allows us to test the hypothesised control of hydrology and grazing, but also to evaluate the effects of nutrient enrichment on phytobenthos biomass. The potential value of including biomass assessments within ecological assessment programmes will also be considered, alongside the broader implications of our findings for river management.

## Long-term trends and impact of environmental drivers on dystrophic lake plankton

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6D\_RS14 Insights from long-term datasets, July 27, 2021, 15:30 - 17:00

Understanding how planktonic communities respond to changing environmental drivers is vital to predict ecosystem responses to multiple stressors. Long-term biological monitoring programs are crucial to investigate gradual deterioration of freshwater ecosystems observed worldwide in recent years. To this end, this study assesses the role that temporal changes in weather conditions, lake thermal structure and nutrient stoichiometry have in determining plankton diversity, biomass and community structure. We focus on drivers of chlorophyll-a and zooplankton as part of a long-term monitoring program (2004-2020), in Lough Feeagh, a temperate dystrophic lake situated on the northwest Atlantic coast of Ireland. Preliminary results suggest that total nitrogen:total phosphorus (TN:TP) ratios increased in the lake over the study period but with no corresponding increase in TN:TP loadings from the main lake inflows. Primary production is mainly driven by physical factors, with increases in the relative biovolume of cyanobacteria associated with those years measuring warmer average water temperatures as well as longer periods of high Schmidt stability. Zooplankton community composition has a strong seasonal dynamic explained by a combination of environmental drivers including water temperature, food availability, seston nutrient elemental composition and light. This study provides evidence that changes in bottom-up parameters as well as more common projected extreme events impact plankton and hence the structure of the food webs of dystrophic lakes

## Multidecenal biodiversity trends in freshwater ecosystems reveal recent community shifts

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6D\_RS14 Insights from long-term datasets, July 27, 2021, 15:30 - 17:00

If there is no doubt that biodiversity declines at a global scale, surprisingly a review of the literature on this topic rises contrasting conclusions about local biodiversity trends. We still have an incomplete understanding of how ecosystems evolve under global change. Here, we aimed to characterize the recent temporal dynamics of river biodiversity in France, from both a taxonomic and a functional point of view, concerning different key organisms (diatoms, macroinvertebrates and fish), with a large panel of biodiversity metrics and through a multi-decennial time-span. We first observed a significant loss in diatom and fish taxonomical and functional richness. We further observed that such changes were likely to imply shifts in community functioning, and hypothesized substantial bottom-up modifications of the trophic web related to the structural modification of the biofilms. Finally, our results converge towards the evidence of a significant recovery of eutrophication-sensitive taxa, meaning that improvement in river quality over the period may have counterbalanced some potential negative effect of global change. Nevertheless, complementary markers responsive in particular to toxic pollutions should be routinely tracked to provide a comprehensive picture of recent changes in aquatic communities' health.

## Mapping elodeas invasions to Italy with occurrence records

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6D\_RS14 Insights from long-term datasets, July 27, 2021, 15:30 - 17:00

Herbarium records are unique and under explored data archives that can provide a window on the past. Even with bias, the amount of information provided by herbaria is still relevant and applicable to solve current problems. This study explores the potential of herbarium records to reconstruct the invasion history of two aquatic plants in Italy, *Elodea canadensis* and *E. nuttalli*, that were introduced to Europe in the 19th and 20th century, respectively. The invasion curves obtained with occurrence records from herbarium and field records suggest that both species escaped cultivation from botanical gardens and fish farming. *E. canadensis* had two expansion phases early in the 1900s and in 1990s, while *E. nuttalli* in the 1990s. Both species are still expanding their distribution range, although the expansion rate has been slowing down for the last 20 years, likely approaching the plateau. Although *E. canadensis* was introduced also to the Mediterranean region in 1800s, freshwater habitats in the Continental biogeographical region are the most threatened by these two species under climate change. The study addresses also the bias that are associated with herbarium collections and the homogenization of data from different sources and provides methods to improve sampling and dataset accuracy.

## Swedish Infrastructure for Ecosystem Science (SITES) long-term data: modelling extreme weather events

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6D\_RS14 Insights from long-term datasets, July 27, 2021, 15:30 - 17:00

The Swedish Infrastructure for Ecosystem Science (SITES) provides open access to long-term data series on key ecosystem variables across climate zones in Sweden. Measurements range from physical parameters such as water temperature to detailed biological data on bacterial community composition. The data is publicly accessible on the SITES Data Portal (<https://data.fieldsites.se/portal/>). We present research based on SITES data collected at Lake Erken, a mesotrophic, dimictic lake. In particular, we show how long-term, high-frequency data can support modelling efforts to reconstruct past climatic effects, predict future changes, and investigate effects of extreme weather events on lakes. Long-term data is necessary to discover climatic trends, but also to calibrate and validate process-based models to allow credible climate forecasts. Extreme events such as storms are rare and transient by definition, and long-term and high-frequency data are needed to study these phenomena. Storms can have contrasting effects on phytoplankton biomass; mixing causes upwelling of nutrient-rich water, but also increases light limitation due to mixed layer deepening. Long-term physical and biogeochemical SITES data was used to calibrate and validate a coupled physical-biogeochemical model to look at effects of storms on phytoplankton biomass in Lake Erken. Wind speed had non-monotonic effects on phytoplankton, where phytoplankton either increased or decreased after storms. Strong solar radiation and high hypolimnetic nutrient concentration promoted phytoplankton growth after storms, but if the mixed layer before the storm was deep, storms had less impact.



## Increasing temperature differences within lakes: consequences for stratification, oxygen and chemical cycling

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6D\_RS14 Insights from long-term datasets, July 27, 2021, 15:30 - 17:00

Temperate lakes are warming, but not all water layers are warming at the same rate. However, differential warming of surface and deep water might have consequences for lake ecology far beyond the expected increase of water temperature. While most studies have focused on analyzing surface temperatures during summer or short time-series only, we here present the analysis of a 48-year time-series of water temperature from nine depths together with chemical data in a small mountain lake using temporal trend decomposition of monthly measurements. We found warming in surface waters, a consequential lengthening and strengthening of the lake stratification, and cooling in deep water due to the longer separation from warming air. These physical changes show effects on oxygen and nutrient concentrations in the lake, which are related to the mixing of lake water columns. With the increasing stratification strength and length, dimictic lakes like Piburger See are expected to continue shifting toward monomictic mixing regimes with trends towards increasing summer hypolimnetic anoxia and nutrient concentrations, resulting in shifting habitat conditions for aquatic organisms.

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### In-stream microbial litter decomposition decrease as forests invasion by Acacia species increases

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6E\_RS22 Urban freshwaters & RS16 Management of riparian zones for water quality and biodiversity benefits, July 27, 2021, 15:30 - 17:00

The invasion of native riparian forests by exotic N-fixing Acacia species continues to increase, leading to decreases in tree species diversity, alterations in litter quality inputs to streams and increases in water nitrogen concentration. We assessed the effects of litter diversity (species evenness) and water nitrogen concentration in native and Acacia litter decomposition, and the activity and community structure of associated fungal decomposers. *Castanea sativa* (C) and *Acacia melanoxylon* (A) litter was enclosed in fine-mesh bags (0.5 mm) in a total of five litter treatments (100% C, 75%C+25%A, 50%C+50%A, 25%C+75%A, 100%A), and immersed in a stream running through a native forest and a stream running through a forest invaded by Acacia species. Litter decomposition and microbial activity generally decreased as the proportion of *A. melanoxylon* increased. When considered individually, *C. sativa* litter decomposition and microbial activity did not differ among treatments, while *A. melanoxylon* decomposition and microbial activity was generally lower in treatments with higher/even proportions of *C. sativa*. Litter diversity had (small) antagonistic effects on litter decomposition in the native, but not in the invaded stream, suggesting that in invaded streams, diversity effects can be suppressed even by small increases in water nitrogen concentration. Overall, results suggest that increases in nitrogen-fixing Acacia species in riparian forests will decrease litter decomposition and associated microbial activity, and alter their community structure, due to decreases in the diversity and quality of litter inputs to streams. These impacts will probably alter nutrient cycles in detrital food webs, with implications for stream functioning.

## Plastic trapping by riparian vegetation

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6E\_RS22 Urban freshwaters & RS16 Management of riparian zones for water quality and biodiversity benefits, July 27, 2021, 15:30 - 17:00

Plastic pollution has become a hot topic of growing issue in all type of ecosystems, although some environments are few investigated. Among these, riparian ecotones are under-represented in researches on plastics. However, they represent the interface between freshwater and terrestrial environments and can have an important role in plastic flux and storage. In this study, we assessed the riparian vegetation as trap for plastics, evaluating plastic occurrence and density in different vegetation structures. Specifically, arboreal, shrubby, herbaceous, reed, bush, and riverbank (i.e. unvegetated tract) structures of 8 rivers in Central Italy were sampled. Our findings showed that the main litter type collected was plastic (81%), followed by other material (11%), paper (3%), metal (3%), glass (1%) and cigarette (1%). Our research highlighted the act of riparian vegetation as plastic trap compared to riverbank. In shrubby structure was found the highest plastic density ( $18.96 \pm 36.7$  items m<sup>-2</sup>) suggesting that tree shape can trap plastics more easily due to branches, leaves and trunk. Although, specific categories, shapes and sizes of trapped plastics were similar among different structures. In fact, plastic pieces, bags, bottles, and food containers represented the most common specific categories. Film shape and macroplastic size are the most abundant overall (83% and 88% respectively). In conclusion, the plastic trapping by riparian vegetation provide an ecosystem service as they can reduce plastics available in environment. Through management and cleaning actions of litter stuck in riparian vegetation it is possible reduce plastic pollution and restore river ecosystem.

## Large-scale stressors hamper effects of woody riparian vegetation

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6E\_RS22 Urban freshwaters & RS16 Management of riparian zones for water quality and biodiversity benefits, July 27, 2021, 15:30 - 17:00

Woody riparian vegetation provides multiple functions beneficial for aquatic macroinvertebrate communities. They retain fine sediments, nutrients and pesticides, improve channel hydromorphology, shade rivers controlling water temperature and primary production and provide leaves as food source or large wood as habitat. In a recent conceptual model, woody riparian functions were considered either independent from large-scale landuse stressors (e.g. shading, leaf litter input), or depend on landuse at larger spatial scales (e.g. fine sediment, nutrient and pesticide retention). We tested this concept using high-resolution data on riparian vegetation and empirical data from 1017 macroinvertebrate sampling sites in German lowland and mountain streams. Macroinvertebrate metrics indicative for different functions were used as response variables in structural equation models. These represent the causal structure between stressors at different scales, i.e. catchment, local, upstream and local riparian landuse along with hydromorphology and water quality.

The analysis only partly confirmed the conceptual model. Functions considered independent from large-scale landuse were mostly not only explained by riparian but also catchment land use. Fine sediment retention, considered scale-dependent in the conceptual model, was poorly explained by large-scale stressors. Only water quality was strongly related to large-scale stressors as expected. While many empirical case or smaller-scale studies clearly document the positive effects of restoring woody riparian vegetation, our results suggests that larger-scale stressors persist even for functions considered independent from these. However, this study does not negate localized effects of managing woody riparian vegetation but contextualizes ineffectiveness of restoration measures targeting the macroinvertebrate community.

## Seasonal dynamics of periphyton along urban streams in the city of Zagreb

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6E\_RS22 Urban freshwaters & RS16 Management of riparian zones for water quality and biodiversity benefits, July 27, 2021, 15:30 - 17:00

Urban streams are characterised by altered hydromorphology, high fluctuations in water chemistry and energy flux, thus posing challenges for biota. In this study, we investigated periphyton along two urban streams (Bliznec, B and Veliki potok, VP) in Zagreb (Croatian capital) showing a strong gradient of hydromorphological degradation. Both streams were sampled near the source (exhibiting pristine conditions, located within the Medvednica Nature Park), in the middle reach (impaired by channelization and agricultural and urban influences), and in the lower reach (channelized and impaired by agriculture and dense population). Periphyton was sampled on 8 occasions in 2016 from stones, soft sediments and macrovegetation, accompanied by measurements of physicochemical parameters and chlorophyll a analyses. Both B and VP showed high fluctuations in discharge, with occasional drying of the lower reaches in summer. Nutrient concentration, conductivity, COD and chlorophyll a displayed a trend of increasing values from upper to lower sites, reflecting the influence of urbanization. The number of periphytic taxa and their abundance correlated positively with the increasing urbanization gradient, probably due to the increased food sources. Periphyton contained mainly ubiquitous taxa, with 55 phagotrophic protist and 10 micro-invertebrate taxa belonging to 11 higher taxonomic categories. Ciliates dominated both in diversity (44 taxa) and abundance (more than 90% share in mean abundance). Periphyton showed seasonal dynamics, with occasionally high similarity between two urban streams studied. This community exhibited the potential to withstand frequent disturbance and environmental variability in urban streams.

## Iris pseudoachorus plant canopy indicates limited wastewater filtering in artificial wetlands

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6E\_RS22 Urban freshwaters & RS16 Management of riparian zones for water quality and biodiversity benefits, July 27, 2021, 15:30 - 17:00

Emergent aquatic plants (AP) and associated microbiota are used to treat wastewaters because they retain dissolved nitrogen (DIN) and phosphorous (P) and can promote denitrification. Quantitative assessment of the filtering capacity of AP is needed to scale AP bio-engineered structures. We used planted *Iris pseudoachorus* in mesocosm channels with sub-superficial flow that were fed with wastewater to explore the nutrient retention capacity of this AP and its seasonal variation. For a year, we compared overall DIN and SRP retention along planted experimental channels with *Iris* N and P standing stock. Based on water mass balances, net nutrient retention was higher for  $\text{NH}_4^+$  and  $\text{NO}_2^-$  than for  $\text{NO}_3^-$  and SRP. Plant canopy height and areal biomass decreased along the channels thus providing estimates of nutrient retention (mean annual  $0.78 \text{ g N m}^{-2} \text{ d}^{-1}$  and  $0.05 \text{ g P m}^{-2} \text{ d}^{-1}$ ). Maximum uptake rates were close to maximum nutrient stocks ( $14.6 \text{ g N m}^{-2}$  and  $0.13 \text{ g P m}^{-2}$ ) which, in its turn represented 45 % of the inputs of dissolved inorganic nitrogen ( $33.2 \text{ g N m}^{-2} \text{ y}^{-1}$ ) and 23.3% of soluble reactive phosphorous ( $0.55 \text{ g P m}^{-2} \text{ y}^{-1}$ ) to the system. The large variation in the outflow nutrient concentration has impaired satisfactory estimates of the biofilm contribution to nutrient retention. This study provides evidence of the limited efficiency of *Iris* to filter nutrients, which could be explained by tied landscape patterns and unbalanced effluent wastewater stoichiometry.

## "Urban Stream Syndrom" What ecological degradation in the mediterranean urban river?

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6E\_RS22 Urban freshwaters & RS16 Management of riparian zones for water quality and biodiversity benefits, July 27, 2021, 15:30 - 17:00

This paper explores and identifies physicochemical and ecological degradation observed in the mediterranean urban river. Several symptoms are described in the term "urban stream syndrome" (Welsh et al., 2005) and are characterized by several factors such as the alteration of hydrological regime (baseflow reduced) and channel morphology, artificialization of substrate, reduction of habitat heterogeneity, increase concentrations of contaminants and nutrients and reduction of specific richness with a predominance of polluo-tolerant species. Other aquatic symptoms can be observed according to the level of urbanization and land uses such as salinization and conductivity increased, a high sedimentary metallic concentration often linked to the urban and industrial pressure exerted on the river. These symptoms, have an anthropogenic origin and risk compromising good and loyal ecosystem services. Hydrobiological monitoring of the urban freshwater "Les Aygalades" located in Marseille agglomeration integrates many abiotic and biotic compartments (cartography/chemistry/metals water and sediments/algae/macro-invertebrates /fish). The main objectives were identified the abiotic and biotic symptoms and their severity and estimated ecological potential. In this context, our results relate an excessive increase in ionic and metallic level and conductivity leading to ecological capital reduced and altered in addition to the classic symptoms described in the urban stream syndrome.

Keywords: urban stream, water quality, biotic richness, ecological potential

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### Environmental DNA assessment of riverine biodiversity and ecosystem function via spatio-temporal partitioning

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6F\_RS01 Advances in freshwater monitoring, July 27, 2021, 15:30 - 17:00

Rapidly assessing biodiversity is essential for environmental monitoring; however, traditional approaches are limited in the scope needed for most ecological systems. Environmental DNA (eDNA) based assessment offers enhanced scope for assessing biodiversity, while increasing sampling efficiency and reducing processing time, compared to traditional methods. Here we investigated the effects of landuse and seasonality on headwater community richness and functional diversity, to assess spatio-temporal dynamics using both eDNA and traditional sampling. We found that eDNA provided greater resolution in assessing biodiversity dynamics in time and space, compared to traditional sampling. Community richness was seasonally linked, peaking in spring and summer, with temporal turnover having a greater effect on community composition compared to localized nestedness. Our assessment of ecosystem function shows that community formation is driven by regional resource availability, implying regional management requirements should be considered. Our findings show that eDNA based ecological assessment is a powerful, rapid and effective assessment strategy that enables complex spatio-temporal studies of community diversity and ecosystem function, previously infeasible using traditional methods.



## Monitoring and early-warning of cyanobacteria blooms through a high-frequency sensor-based method

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6F\_RS01 Advances in freshwater monitoring, July 27, 2021, 15:30 - 17:00

An ever-increasing threat in lake and reservoir water quality is caused by cyanobacteria, photosynthetic bacteria and potential toxin producers. To comply with regulatory framework, monitoring cyanobacterial biomass is mandatory in both drinking water sources and recreational water bodies. When biomass overpasses a defined threshold, toxin analysis is also required. Chlorophyll-a concentration is frequently used as a proxy of total phytoplankton biomass and is considered as a reliable preliminary indicator of toxin concentrations. A rapid monitoring system can easily be implemented and solely based on field sensors of chlorophyll and/or cyanobacteria-specific pigments. In order to investigate the reliability of such a monitoring system, a survey has been performed during 4 years (January 2017 to December 2020), in a small and shallow lake (Lake Champs-sur-Marne, Great Paris, France). High-frequency measurements (time step 10 mn) of chlorophyll-a and phycocyanin fluorescence were collected at one central site, at 1.5m depth (maximum depth 3.5m). In parallel, vertical profiles of the four main phytoplankton groups were measured with a fluorimetric probe, during regular field campaigns (n=46). To provide reference data, microscope identification and enumeration of the phytoplankton species were performed as well as chlorophyll-a and phycocyanin lab analysis. The agreement between sensor and lab data was assessed through a statistical analysis. A correction algorithm is proposed for the adjustment of both chlorophyll and phycocyanin sensor data to the reference data. Using a neural network and the corrected data from chlorophyll and phycocyanin sensors, a short-term (3 days) forecast of the cyanobacteria biomass is then achieved.

## Effect-based-monitoring approaches for assessment of pharmaceutical occurrence in surface water in Ireland

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6F\_RS01 Advances in freshwater monitoring, July 27, 2021, 15:30 - 17:00

Pharmaceutical pollution has been a source of global concern in the last two decades due to increased consumption, especially in OECD countries. Pharmaceuticals are developed to be effective even at low concentration and leaching of these drugs into surface waters can occur. The presence of low dose pharmaceuticals in surface waters could have potential toxic effects to both humans and aquatic organisms such as rising antibiotic resistance and abnormal reproductive behaviours in aquatic animals. The unavailability of effect-based bioassays to test for the biological activities of pharmaceuticals in surface waters hinders water quality assessment. The EMPIRE project aims to develop an effect based monitoring system using a combination of in vitro and in vivo bioassays for determination of pharmaceutical pollution in Irish surface water. A list of thirteen chemicals including trimethoprim, sulfamethoxazole, carbamazepine, diclofenac and amoxicillin have been identified from Environmental Protection Agency (EPA) watch list and NORMAN list of Emerging Substances as they are commonly found in European surface waters with low elimination efficiency from wastewater treatment plants. A list of mode of actions (MOAs) including estrogenicity, androgenicity, oxidative stress response, and algal growth inhibition assay is currently employed to test contaminants biological activities. We will also look at the effect of the pharmaceuticals on life cycle and global gene expression of *Daphnia magna*. It is hoped that findings of this study will serve as a proof of concept and validation of effect based monitoring tools in addition to generation of data on environmental impact of the selected pharmaceuticals.

## Methodological approaches influence the detection of hydromorphological changes using stream macroinvertebrate communities

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6F\_RS01 Advances in freshwater monitoring, July 27, 2021, 15:30 - 17:00

Hydromorphological degradation is one of the most important pressures affecting streams across the world. The complex relationship between hydromorphological attributes, confounding pressures originating at different spatial scales and the dynamics of instream biota limit the efficiency of existing assessment methods in detecting the effects of hydromorphological changes on stream macroinvertebrate communities. Comparative methodological approaches could help improve the link between hydromorphology and the biota. We investigated how different metrics of macroinvertebrate communities respond to hydromorphological changes considering both a wide gradient of hydromorphological deterioration and paired sites approaches in headwater streams not affected by water quality alteration. We identified the main variables that explain the dissimilarities between sites. Then the hydromorphological deterioration was quantified using Morphological Quality Index and Habitat Modification Score. The responses of benthic macroinvertebrate communities were assessed using key attributes like density, diversity indices and indicator value analysis. Two levels of taxonomic resolution were considered: order level for all macroinvertebrates and species level for mayflies, stoneflies and caddisflies. We were able to show that the responses of macroinvertebrate metrics are approach specific. We conclude that no single method was the best in all cases, and the decision on which approach to be used could help improve the efficiency of the WFD and the achievement of the good ecological status of water bodies.

## Zooplankton index for assessing the ecological status of stratified lakes

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Zooplankton is generally regarded as a key component of pelagic trophic web. Although the use of zooplankton indices to assess the trophic status of lakes has a long tradition, this element has been not included as an obligatory element of the water assessment systems compliant with the WFD. This omission has been emphasised by many scientific authorities. Due to its sensitivity to the effects of anthropogenic eutrophication, the relative ease of identification as well as simple and inexpensive sampling zooplankton provides a straightforward and cost-efficient tool for assessing ecological status compared to other biological methods.

In this work, I present a new method to assess the ecological status of stratified lakes based on the zooplankton community - the Zooplankton Index for Polish Stratified Lakes Assessment (ZIPLAs). The indices used to compose multimetric ZIPLAs include: percentage share of the rotifer species indicative of high trophic in the indicative group's number, ratio of Calanoida to Cyclopoida individual numbers, percentage of form tecta in the population of *Keratella cochlearis*, Margalef's index and zooplankton abundance. All indices respond to eutrophication pressure expressed by total phosphorus (TP), total nitrogen (TN) and Secchi disc visibility (SD), as well as the pressure from catchments expressed by the nutrient loads generated in areas of different land use. Index ZIPLAs strongly correlated (Spearman's rank correlation) with all proxies of eutrophication (SD,  $R=0,86$ ; TP,  $R=-0,74$  and TN,  $R=0,68$ ). Obtained results show that ZIPLAs could be a valuable contribution to the WFD-compliant assessment system, in addition to the other biological elements.

## Relevance of Phosphorous storage for the assessment of water quality in reservoirs

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Surface water reservoirs are an important global source of drinking water. They are directly influenced by catchment processes and mass fluxes through the incoming rivers. The water quality of the reservoirs is often threatened by the accumulation of nutrients and especially through the particle-bound fraction of phosphorous, since it is retained efficiently by the impoundments. Most monitoring approaches focus on the water quality itself, disregarding the composition (e.g. phosphorous content) of the sediment. In our study we combined two different monitoring techniques for a precise calculation of the Phosphorous stock in the sediment, in order to support the decision making of the reservoir operator. Based on over 30 sediment samples from coring and grab samples, we defined the sediment phosphorous content in several sediment layers over the entire area of the reservoir. Additionally, we used more than 130 free-fall penetrometer measurements to create an interpolated high-resolution map of the sediment magnitude. A normalized P-loading of 470 (mg P/m<sup>3</sup>) was calculated, suggesting a high trophic status and chlorophyll-a concentrations of ~60 µg/l after the Vollenweider model updated by Jones and Lee (1986). However, only 2-6 µg/l chlorophyll-a were measured over the year. The gap between the stored Phosphorous and the actual water quality, suggests that future measures to maintain good water quality have to include the potential release of high amounts of phosphorous from the sediment.

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### Multi-stressor effects depend on the length of effective stressor gradients

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In water management, identifying multi-stressor effects is essential for the design of mitigation measures. Multiple regression analyses are commonly used to identify these effects. However, concern is increasing that multi-stressor effects are not linear along the stressor gradients. In this study, we examined how multi-stressor effects change when only partial stressor gradients are investigated. We collected data on paired-stressor responses, including land-use and climate change stressors acting on freshwater and marine animals and plants. Stressors acting strongest on the response were divided in half. The original and the resulting lower and upper gradient cases were analysed by linear regression to determine changes in multi-stressor effects of partial compared to original gradients. We investigated how these changes manifested in stressor effect sizes (i.e. individual stressor effect strengths) and multi-stressor effect types (i.e. dominant, additive and interactive). The effect sizes of the stronger stressors decreased slightly for lower and increased for upper partial gradient cases, whereas they generally increased for the weaker stressors and stressor interactions. Effects on animals were more influenced by gradient length changes than effects on plants. In more than 50% of all cases, halving the gradient led to changing multi-stressor effect types, with additive effects changing most frequently. These results show that information on multi-stressor effect types relevant for management depend on the stressor length investigated. Monitoring programs thus need to ensure full coverage of the prevalent stressor gradients. Management also needs to adapt to changing multi-stressor effects in cases of further system deterioration or successful stressor mitigation.

## Reservoir fertilisation and fishery response in a managed reservoir with uncertain flows

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Inland fisheries managers must account for multiple competing uses for aquatic resources; using methods such as ecosystem-based management allows for different priorities for aquatic ecosystems to be accounted for. Declining abundance of kokanee salmon (*Oncorhynchus nerka* Walbaum) in Arrow Lakes Reservoir in the 1990s led to the use of large-scale nutrient addition to improve productivity of kokanee and large piscivores. However, it is unclear what effect these measures have on the system given high discharge and highly variable annual flow regime throughout the watershed. An Ecopath with Ecosim model of the ecosystem was fit to available data and used to predict ecosystem structure and reservoir objectives under different nutrient-addition strategies and varying annual flow regimes. Results from the model indicate that nutrient addition is an important driver in the system, with lower flows resulting in higher biomass for higher trophic levels. Decision analysis demonstrates the importance of maintaining nutrient additions to achieve management objectives despite losses in some high-flow years.

## Evaluating toxicity effect on freshwater invertebrate communities in a multi-pressure context.

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Anthropogenic pressures (defined by a set of interdependent individual stressors) are intertwined and can impact freshwater communities at multi-scale. Many studies have examined the effects of pressures such as eutrophication or hydromorphological alterations at various spatial scales, but without integrating potential toxic chemical stresses. By now, toxic stress was only integrated in pressure-impact studies at the local scale, due to a lack of larger-scale measures. Active biomonitoring with caged gammarids allows measures of bioavailable contamination and toxicity at the organism level with a standardized biological probe, which enables accurate spatial and temporal comparison of freshwater systems. In the current study, we assessed the role of toxic stress on aquatic macroinvertebrate communities in a multi-pressure context, based on toxicity data of caged gammarids and samples of benthic macroinvertebrate assemblages in sites of the Water Framework Directive network, over metropolitan France. For 152 sampling events, the occurrence frequencies of 11 biological and 11 ecological traits were calculated as proxies of community functioning. Selected pressures were hydromorphological alterations, eutrophication and toxicity. Toxicity was represented by in situ feeding inhibition and mortality rate of caged gammarids. Co-inertia analysis was applied to identify relationships between stressors, and combinations of macroinvertebrate community traits. This approach has highlighted the role of toxic stress in a large-scale multi-pressure context. It has also assessed the effect of each stressor on the functioning of macroinvertebrate communities. The investigation of the links between stressors (especially toxicity) and the functioning of communities can provide understanding for aquatic managers when proposing protection strategies.



## Pesticide-induced metabolic changes are amplified by environmental stress

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In natural ecosystems, long-term detrimental effects of pesticides may occur at very low concentrations, below those considered safe by the governmental risk assessment. Mechanisms potentially responsible for this unexpected sensitivity include environmental stress-factors such as food deficiency. To understand the effect-paradox, we investigated how food stress interacts with insecticide-induced biochemical fingerprints. Therefore, we measured metabolomic perturbations in *Daphnia magna* following a 24h exposure to esfenvalerate under high and low food conditions. In total, 160 metabolites covering the groups of amino acids, fatty acids, lipids and sugars were analyzed. At 0.001µg/L esfenvalerate – a factor of 50 below the NOEC (0.052 µg/L) provided by the regulatory authorities, and a factor of 200 below the acute LC50 – the endogenous metabolome was significantly affected. Further, the effect under low food conditions was considerably stronger compared to high food conditions. Individual metabolites showed up to 7-fold stronger effects under low food conditions. In general, the metabolomic changes were largely dose-specific and increased over seven days after contamination. We conclude that the metabolic profiles are altered for at least seven days after a pulse exposure, and therefore might be a key process to understanding population level changes at ultra-low pesticide concentrations in the field.

## Multi-stress conditions challenge the advantage of genetic adaptation

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Exposure to pesticides may exert a considerable pressure for genetic adaptation, which results in increased pesticide tolerance of populations. However, adaptation to pesticides is often associated with considerable fitness costs that are revealed under fluctuating environmental conditions. Under global change scenario, such multi-stress conditions are expected to occur regularly. For predicting their ecological consequences, the question is how individuals that are genetically adapted to pesticides react in a multi stressed environment. A question with increasing relevance but never addressed. Here we investigated the combined effect of pesticides and heat stress on the crustacean (*Gammarus pulex*) collected from agricultural and reference streams. We were particularly interested in multi-stress effects on populations that are genetically adapted to pesticides compared with conspecifics from forested streams not genetically adapted to pesticides. We show that the *G. pulex* from agricultural streams were up to 5 fold more tolerant to insecticide clothianidin as compared to the forest populations under optimum temperature. However, only agricultural populations adapted to pesticides showed increased mortality with increasing temperature. In contrast, combined stress of pesticides and warming revealed a similar tolerance of agricultural and forest populations. Both stressors acted synergistically and the combined effects could be predicted with the SAM (Stressor Addition Model). We conclude that under multi-stress conditions typical for global change scenarios, genetic adaption to pesticides loses its advantage and the general fitness of genetically adapted populations is compromised.

## Coherent response of Alpine lakes to combined global warming and airborne contamination

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Due to their remoteness and simple foodwebs, Alpine lakes are considered as sentinels of climate change and as ideal research-objects to investigate the ecological effects of global warming combined with anthropogenic airborne contamination. Nonetheless, long term (decadal) monitoring is still very scarce for mountain lakes, so that the temporal perspective necessary to evaluate environmental and ecological lake evolution must rely on the palaeolimnological approach. We present the results of a sediment study conducted on a set of mountain lakes located in different catchments of the southern Central-Eastern Alps, aimed at investigating the effects of the current Alpine deglaciation on lake habitat and biodiversity. The study aimed also at revealing signs of airborne contamination. Radiometrically dated short cores from each study lake were analysed for lithological (water and organic content), biogeochemical (C and N stable isotopes and CN content of bulk organic matter) and biological (subfossil diatoms) proxies. Despite the different habitat setting and glacier/permafrost influence, all the lakes studied show clear responses to the end of the Little Ice Age, around 1850 AD, and to the warming acceleration since the 1980s. The observed responses consist in enhancing lake productivity and changing diatom species composition and biodiversity. The isotopic signature shows a coherent increase in nitrogen atmospheric deposition during the last 100-150 years, in agreement with results from many lakes in the northern hemisphere. The results suggest a possible synergy between global warming and nitrogen enrichment in driving the recent biological changes observed in all the study lakes.

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### High-resolution river water quality modelling to estimate ecosystem metabolism in lowland rivers

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With the availability of cheaper and robust technology for high-resolution monitoring of water quality, modelling tools can be developed for long-term prediction of functional indicators such as ecosystem metabolism. Here, we present a novel approach to estimate ecosystem metabolism by linking it with the process-based modelling of in-stream flows and water quality. We implement the model along a 62 km long stretch in the lower River Thames in England for two years period (2013-2014). The model allows us to estimate specific metabolic pathways such as photosynthetic production and respiration, reaeration, benthic oxygen demand, removal of biochemical oxygen demand (BOD) and nitrification, which may influence the diurnal oxygen variations in the river. We found that the lower River Thames was primarily autotrophic from mid-spring to mid-summer and represented heterotrophy during the rest of the year. Respiration at the upstream end of the network was mainly driven by oxygen loss through BOD decay, autotrophic respiration and nitrification (total 97% of respiration). Downstream sites also displayed an important role of benthic oxygen demand (19%) in addition to the former processes (80%). Sensitivity analysis of modelled metabolism rates showed that primary production was mainly influenced by light intensity, water temperature, flow and inorganic phosphorus levels, whereas ecosystem respiration showed sensitivity to flow, inorganic phosphorus and suspended sediment levels. Overall, our study demonstrates the utility of high-resolution monitoring in river modelling to make long-term, network-scale predictions of ecosystem functioning.

## Macroinvertebrate functional composition and litter processing as surrogates of riverine ecosystem functioning

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Expansion of agriculture is particularly worrying in tropical regions of the world, where native forests have been replaced by croplands and grasslands, with severe consequences for biodiversity conservation and ecosystem functioning. In this study, we used leaf litter decomposition and the composition of macroinvertebrate functional feeding groups (FFGs) as indicators of ecological integrity and ecosystem functioning in headwater streams in western Kenya. Overall, leaf litter decomposition rates did not respond to agricultural land-use, but the combined role of both shredders and microbiota (coarse-mesh litterbags) was greater than the sole role of microbiota. Both shredder and microbially driven decomposition rates were influenced by leaf quality (leaf species), with the soft-leafed leaf species having the fastest decomposition rates and the exotic Eucalyptus species having the slowest. Macroinvertebrates were classified into functional feeding groups (collector-gatherers, collector-filterers, scrapers/grazers, predators and shredders) and used to derive five metrics that are surrogates of ecosystem attributes; 1) a balance between autotrophy and heterotrophy (production/ respiration (P/R) ratio), 2) linkage between riparian inputs of coarse particulate organic matter (CPOM) and fine particulate organic matter (FPOM), 3) top-down predator control, 4) geomorphic channel stability, and 5) relative dominance of fine particulate organic matter (FPOM) in transport compared to FPOM deposited in the sediments. Catchment land use did not influence leaf litter decomposition rates and metric performance, suggesting that reach scale influences played a predominant role in structuring communities and determining ecosystem functioning.

## Convergence of macroinvertebrate traits across continents and multi-trait responses to environmental stressors

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Over the last recent decades, comprehensive databases on macroinvertebrate traits have been compiled by aquatic ecologists. Traits can be linked to environmental drivers to establish mechanistic explanations of species distributions and assemblage compositions. Trait–environment relationships could potentially be transferred across regions, as studies showed a largely similar trait distribution over North America and Europe. However, inconsistent and spurious trait–environment relationships may arise when trait interactions are ignored, given that the entire organism, not an individual trait, responds to its environment. In fact, evolutionary processes such as natural selection have likely selected multiple traits simultaneously that together provide adaptation to changing environmental conditions. For example, the combination of rapid growth and obligate diapause allows adapting to habitats with predictable intervals of short favourable conditions and long adverse conditions. We collated and harmonised the available freshwater invertebrate trait information from different biogeographic regions (Europe, North America, Australia, and New Zealand) to establish comparable trait datasets that allow large-scale trait analyses. We delineated groups of organisms with similar trait profiles by hierarchical cluster analysis, so called trait profile groups (TPGs), and identified the most important traits for TPG selection with random forests. By comparing the TPGs across regions and across climatic zones we evaluate convergent evolutionary adaptation. We further compared the response of individual traits and multiple traits of the TPGs to pesticide-stress across biogeographic regions using field and stream monitoring data. Our results provide insight into the consistency in the response of combinations of traits in trait–environment relationships.

## Can river metabolism be an integrative indicator of ecosystem health in rivers?

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A proper assessment of ecosystem health is key to long-term restoration success. However, integrated assessments are expensive and whole-ecosystem responses are difficult to determine, especially for large and medium-sized rivers due to their size-related limited accessibility. River ecosystem metabolism has been proposed as an easy-to-measure and important tool to determine ecosystem health, over other more time-consuming parameters such as biological surveys. As yet, its capacity as a sentinel for ecosystem health is not fully explored for large and medium-sized rivers. We present a systematic analysis of river ecosystem health, measured across a wide array of parameters, such as dissolved nutrients, biodiversity or riparian vegetation and its relationship to river ecosystem metabolism (gross primary production, GPP, and ecosystem respiration, ER). We provide a critical review of the advantages and flaws of ecosystem metabolism as an integrative measure of river functioning. One clear expected response to restoration measurements was the decline in GPP due to increased shading by riparian vegetation. However, these patterns were not observed in all the studies, as other parameters may be having a stronger influence on metabolism. Such parameters could be attributed to land-use, nutrients or biological and morphological heterogeneity. While river metabolism is a valuable functional parameter to assess ecosystem health, it must be evaluated in conjunction with additional metrics, in order to gain comprehensive insights into the functioning and recovery of medium and large-river ecosystems.

## Large-scale patterns of metabolic regimes and main environmental drivers in Spain

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7B\_SS18 Functional indicators of freshwater ecosystem health, July 29, 2021, 10:30 - 12:00

Rivers worldwide have come under increasing pressure from human activities and climate change, affecting their ecological integrity and compromising the delivery of many services. In this context, improving our understanding of the drivers inducing impacts on rivers is needed to provide scientific defensible management actions. River Ecosystem Metabolism (REM) is considered to integrate the response to a broad range of catchment and river reach elements, both natural characteristics and human-induced stressors. In this study we took advantage of the time series of water quality recorded at the national scale by the Spanish Automatic System of Water Quality Information (SAICA) to calculate Gross Primary Production (GPP) and Ecosystem Respiration (ER). We aim to: 1) characterise the temporal variation of river metabolism (metabolic regimen) at the national scale; 2) determine the most important environmental variables and human induced stressors influencing it. Results showed contrasting metabolic regimes attending to the spatial variation of environmental variables such as temperature, catchment land-uses and river size. In addition, human pressures significantly alters the natural metabolic regime, modifying the seasonal and annual rates of both GPP and ER. However, it must be pointed out that most of SAICA sites are located in large and impacted rivers, which made it difficult the comparison with unaltered conditions. This is a unique study in Spain to characterize REM at the national scale and one of the first attempts worldwide, and it may serve as a basis for increasing the understanding of ecosystem functioning at large scale.



## Organic-matter decomposition and ecosystem metabolism as tools to assess stream functional integrity

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Streams and rivers provide valuable services to societies across the planet, and preserving and restoring their ecological integrity have become widespread societal goal. The notion of ecological integrity encompasses both structural and functional integrity, but ecosystem functioning is rarely considered in stream bioassessment. Organic-matter decomposition and ecosystem metabolism are presently the best candidates to be considered as indicators of stream functional integrity. We carried out a systematic review of studies since the year 2000 that have addressed organic-matter decomposition (88 studies) and ecosystem metabolism (50 studies) as bioassessment tools of stream functional integrity. Studies were mostly carried out in temperate regions. Bioassessment based on organic-matter decomposition often used *Alnus* spp., *Quercus* spp. and *Fagus sylvatica* leaf litter enclosed in coarse mesh bags, but fine mesh bags were also common; cotton strips and wood were frequently used in New Zealand, and are increasingly used elsewhere. Ecosystem metabolism was most often based on the open-channel method, used a single station and a single measurement per site. Both functions performed well in detecting environmental change (~ 75% studies). Interestingly, 100% of studies found that both functions were sensitive to stream restoration practices. Incorporating these functions in stream bioassessment programs is an essential step towards improving the management and conservation of running waters.

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### Development of Thiocapsa mass bloom in a karstic lake. Molecular key issues

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7C\_RS11 Fundamental and applied freshwater ecology, July 29, 2021, 10:30 - 12:00

Results of the seasonal limnological dynamics and 16S NGS sequencing of the vertical profile of the Lagunillo de Cardenillas, a very small, shallow (4 m), wind -sheltered karstic lake in located Cuenca, Spain, are presented. The study was carried out during a complete event of massive growth (mass bloom) in the whole lake of a purple, photosynthetic and anaerobic, sulfur bacteria. This is a new Thiocapsa species of the family Chromatiaceae. The genome of this Thiocapsa was sequenced. Limnological features, together with the molecular characterization of all the microbial diversity, allowed to identify the key environmental factors modulating this process both at the physical-chemical and microbial associations levels. Furthermore, the study of the genome of Thiocapsa allowed to relate these key factors to the metabolic potential of the newly discovered microorganism, favoring the understanding the key molecular aspects linked to the appearance of this kind of mass blooms. Thiocapsa population shows a range between 1-40% of with very specific associations to both environmental variables and microbial assemblages. The Thiocapsa bloom in Lagunillo de Cardenillas begun in autumn and colonized the entire water column with a maximum abundance of  $2.5 \times 10^6$  cells ml<sup>-1</sup>. At late winter early spring the population collapsed in the upper layers of the lake, and most cells settled to the bottom, where they remained in high abundance during the summer stratification period.

## Seasonal effects of human impacts on macroinvertebrate communities and biomonitoring

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Multimetric indices (MMI) are an efficient tool to describe human impacts on macroinvertebrate communities across large spatial scales. However, their performance might differ among seasons due to biological changes of the communities and changes in environmental conditions or human impacts. In this study, we developed and tested an MMI for macroinvertebrate communities in the Karoon river system, Iran, based on seasonal sampling of 54 sites. We coupled macroinvertebrate community data with environmental data on physico-chemistry, hydromorphology and status of riparian vegetation. Metrics were selected based on pressure gradients derived from seasonal PCA. Morphological score, EC, TN and BOD were the most influential variables in all seasons. Other influential variables differed between seasons e.g., DO, which was higher in spring and summer and TS, turbidity and TP which were higher in summer. We combined two highly responsive, non-redundant metrics from each of the categories of tolerance/intolerance measures, community composition and taxonomic richness to develop seasonal MMIs. Metrics including Ephemeroptera+Plecoptera Taxa richness, %Insecta, %sensitive individuals and %Gastropoda taxa richness were selected for most seasonal MMIs. Other metrics were just selected in one season (%Tubificidae in spring and %oligochaeta in summer). However, these metrics were highly correlated with the metrics selected for other seasons and are therefore indirectly represented also in those MMIs. All selected metrics have been shown to efficiently distinguish between different impairment levels and have been used in other indices. MMI performance based on precision, responsiveness and sensitivity tests was best in summer for macroinvertebrate communities in the Karoon River.

## Nutrient concentrations in Italian reference rivers: influence of anthropogenic and environmental factors

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7C\_RS11 Fundamental and applied freshwater ecology, July 29, 2021, 10:30 - 12:00

European awareness on nutrient related problems is historic but nutrient enrichment still remains one of the main causes of river degradation. Appropriate management measures should be put into practice to remediate and prevent further degradation and setting benchmark values for nutrients can be crucial. This study provides a first national scale assessment of the nutrient status of Italian river reference sites covering a broad north-south geographical gradient. We applied Affinity Propagation (AP) clustering technique to explore the variability of nutrient concentrations and identify possible influence of natural and anthropogenic factors. Results suggest that major factors determining differences in nutrient concentration were nitrogen atmospheric deposition and presence of artificial and high-impact agricultural land use in the catchment. Our results show that anthropogenic factors, even if very limited in presence, resulted more effective in determining differences between sites in comparison to typological factors like e.g. altitude and river size. Nonetheless nutrient levels observed for reference sites were in line with nutrient threshold values identified for undisturbed sites in other countries. We reckon that an approach based on 'regionalization', in which human effects are included to a low degree, can be effective for the management and assessment of the environment. Moreover, the approach of identifying a fixed reference percentile of least disturbed sites can be straightforwardly applied to other EU countries to derive thresholds for single parameters, offering a tool for the management of river ecosystem easily transferable into policy regulations.

## Towards understanding the functional role of invertebrates in rivers: Lessons from linking bio/ ecological to stoichiometric traits

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7C\_RS11 Fundamental and applied freshwater ecology, July 29, 2021, 10:30 - 12:00

Functional traits are often used to describe communities when addressing questions of functioning from community to ecosystem level or consequences of global changes. Nutrient enrichment, a worldwide stressor in freshwater systems, affects taxa with different functional traits differently, for example favoring small, fast-growing taxa under high phosphorous conditions. The integration of stoichiometric traits – the elemental composition of organism body tissue – can help understanding the mechanisms behind such observations. Especially life history traits have been correlated to body phosphorous content (e.g. Growth Rate Hypothesis) which helped explaining species distribution/ community composition along nutrient gradients.

So far, there is no large-scale knowledge of the general link between stoichiometric and functional traits. We applied a series of multivariate analyses on six stoichiometric traits (%C, %N, %P, C:N, C:P, N:P) and 23 biological and habitat-related traits of freshwater macroinvertebrates. We found significant co-structures between both types of traits, when analyzing overall trait profiles as well as when considering functional traits individually. For traits related to organism development or nutrient cycling, the patterns were in line with our assumptions based on concepts within ecological stoichiometry (e.g. traits describing predators were associated with high %N, small maximum body sizes with high %P). Demonstrating the link between stoichiometric and functional traits underlines the potential of the integration of stoichiometry into ecological analyses to improve our understanding of community or ecosystem responses towards changing nutrient conditions.

## Environmental drivers of macroinvertebrate communities in alpine catchments

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7C\_RS11 Fundamental and applied freshwater ecology, July 29, 2021, 10:30 - 12:00

Alpine catchments display particularly complex hydrographic networks, characterized by high environmental and hydrological heterogeneities, as they include streams from different water sources. This mosaic of stream habitats generates high spatial variability in aquatic communities within catchments. Combined effects of climate change and anthropogenic pressures on water resources induce rapid environmental changes in alpine catchments. To maintain the sustainability of alpine streams, it is urgent to quantify the relative effects of hydrological and environmental drivers on aquatic communities. To date, relationships between stream habitats and macroinvertebrate communities have not been compared among multiple alpine catchments. In this study, we measured physico-chemical and hydraulic conditions, estimated hydrological conditions (simulation), and sampled benthic macroinvertebrates in 66 stream reaches located in three catchments in the French Alps. Based on Co-Inertia analyses and Negative Binomial Generalized Linear Mixed models, we quantified, respectively, the responses of macroinvertebrate at both community and taxa level to stream habitat characteristics, and we tested the transferability of invertebrate responses across different catchments.

## Protective role of overwintering macrophytes from global warming effects on lake eutrophication

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7C\_RS11 Fundamental and applied freshwater ecology, July 29, 2021, 10:30 - 12:00

One of the greatest threats for temperate lakes is the warming of winters, the rainfall and drainage catchment the intensification, followed by a trophic increase in and a biodiversity drop. This research aimed to investigate the influence of climatic factors on the dynamics of macrophytes in a lake co-dominated by common vascular plants and the endangered charophyte *Lychnothamnus barbatus*. The research was conducted in a seasonal cycle from November 2016 to November 2019 in Lake Kuźnickie (West Poland). Macrophytes were collected from permanent macrophyte stands with *L. barbatus* along three transects, at three different depths. Water properties, chlorophyll-a concentration, and light availability were also measured to test the relationships between the spatial and seasonal variation of the water properties and macrophytes biomass. In addition, overwintering of macrophytes under varied winter conditions was investigated. The research revealed two gradients to be responsible for the macrophyte structure: 1) the depth and light gradient, and 2) the seasonality in water properties. In the studied lake, the peak of macrophyte biomass occurred in autumn, and this phenomenon is mainly related to the biomass of *L. barbatus* in the studied stands and illustrates the extension of the growing season by climate warming. Mass wintering of macrophytes in mild winter conditions in 2018 significantly improved the water quality and suggests that compact macrophyte communities can protect lakes from the negative consequences of global warming.

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### Impact of extreme weather events frequency and intensity in shaping phytoplankton communities

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Lake habitats and communities can often be correlated with general morphometric and geographic characteristics such as depth, latitude, altitude, or watershed area. Further, communities are typically correlated with average environmental conditions such as seasonal temperature and nutrient levels. The frequency and intensity of extreme weather events (rain and wind) are typically not encompassed by average environmental descriptors, yet, can modify the physical habitats of lakes, significantly influencing phytoplankton growth and survival. We tested the hypothesis that lakes with a higher frequency and intensity of extreme weather events have a functionally different phytoplankton assemblage from lakes with a lower frequency of extreme weather events. We compiled long-term (mean = 20±13 years, range 0.6-44 years) phytoplankton datasets for 22 lakes across a wide gradient of altitude, latitude, depth, and trophic state. We classified the phytoplankton genera into morpho-functional groups and C-S-R strategists, and compared among lake phytoplankton assemblages' characteristics across the gradient of wind and rain conditions experienced by the lakes. We discuss how the frequency of extreme weather events can affect phytoplankton functional groups, the dominance of differing life history strategies and ultimately community structure. The frequency and intensity of extreme events is expected to increase with climate change, with the potential to drive shifts in phytoplankton composition.



## Long-term trends in nutrients, temperature and chlorophyll in Ireland's largest lake

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Trends in external and internal nutrient loading and their relation to lake nutrient concentrations are important for lake management. Phytoplankton biomass (chl-a), water temperature and lake water nutrient concentration changes were investigated in hypereutrophic Lough Neagh, the largest lake in Ireland. Although lake water total phosphorus (TP) concentration has increased since the 1990s, there was no correlation with catchment inputs which showed no significant trend. The pattern of internal loading of P has changed since the mid-1990s, with an earlier and larger mass of P released from the sediments each summer. In contrast to TP, catchment inputs and lake concentrations of oxidised N were highly correlated ( $R = 0.88$ ). Water temperature increased by approximately 1 C and was a significant predictor of variation in chl-a. After the peak chl-a concentration in 1993, dissolved inorganic N (DIN) also became a significant predictor, accounting for almost half of the variance explained by a hierarchical partition model. The decreasing chl-a concentrations and log (DIN:TP) ratios observed since the mid-1990s suggest that N limitation of phytoplankton has become more important in the Lough.

## Long term datasets are a key to River Science: the example REFCOND\_Volga

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River science is a “rapidly developing interdisciplinary field at the interface of the natural sciences, engineering and socio-political sciences” (sensu Gilvear et al. 2016). Management decisions should be based on sound monitoring data, because this supports the development of sustainable measures. Thus, basic ecological research is needed at reference sites in order to analyse the occurring natural variation (process understanding). Our LTERM project REFCOND\_VOLGA is operated continuously since 2006 and collects limnological data, with the aim to analyse the inter-annual variation at reference or least disturbed sites along the Upper Volga and its tributary Tudovka. The assessment includes classical (cartometric, hydrometric, hydrochemical and biological analysis) as well as innovative approaches (remote sensing and eDNA). The results demonstrate how lowland rivers are characterized by their biota, integrating abiotic (hydrology, temperature regime, substrate, catchment conditions) and biotic (ecological preferences, “keystone / flagship spp.”) factors. Long-term monitoring is the only way to analyse variations as well as effects of rising air and subsequently water temperatures (related to climate change) on aquatic biota.

Water management needs to take into account the 4d nature (longitudinal, lateral, vertical and temporal scale) of river ecosystems, but nowadays we also need to consider a fifth dimension the “human uses”. The Water Framework Directive defined targets for all European surface waters and stipulated an integrative planning process. Based on long term datasets we can identify and develop sustainable measures. Overall, “best practice solutions” can only be achieved with international collaboration and combining basic research with applied aspects.

## Quantifying high-mountain lakes' ecosystem services through translating limnological parameters

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The European Alps are home to numerous small and natural alpine lakes. Although such lakes are monitored as sentinels of global change due to their location in mostly remote and pristine environments, they have received little attention so far in terms of their contribution to human well-being. In particular, it is still unclear which indicators can be used to assess crucial ecosystem services provided by these lakes and how climate change will affect their provision. This study therefore aims to identify limnological parameters useful to quantify key ecosystem services associated with high-mountain lakes such as maintaining populations and habitats, aesthetic values, educational values or existence, option and bequest values. For this purpose, we are observing more than 25 lakes in the northern (>20) and southern Alps and relating limnological parameters, including transparency, productivity, species richness, occurrence of keystone organisms and ratios of phototrophic to mixotrophic organisms to the selected ecosystem services. Our results suggest that lakes provide different levels of ecosystem services in dependence on their ecological state and location. By comparing the recent data with twenty-year-old data from our study lakes, we also aim to identify future trends hypothesizing how the provision of ecosystem services will be affected by climate change.

## Microbial long-term data highlight the impact of environmental change on freshwater lakes

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Lake ecosystems are shaped by constantly changing environments, translating into dynamic responses in physical, chemical and microbial lake characteristics. To discriminate between such directional and random long-term responses, we analysed a 17-year long-term data set comprising concurrent monthly measurements of autotrophic and heterotrophic microbial production rates in the epilimnion of five lakes differing in numerous environmental variables. This extensive data set provides an excellent opportunity to explore whether and to what extent lake responses such as microbial production rates result from direct influences of climate change such as temperature increases or other anthropogenic influences, such as eutrophication or brownification. Across all five lakes, we observed increased decoupling of autotrophic and heterotrophic microbial production rates over time, largely due to year-on-year increases in bacterial production. This ratio of autotrophic and heterotrophic microbial production delivered a consistent signal across the five lakes that otherwise differed greatly in their histories and characteristics, suggesting that the production ratio could serve as a useful indicator of global change-induced trends in lake ecosystems. By integrating across various environmental influences, the ratio appears to be more sensitive to environmental change than other broadly applied response parameters (e. g. chlorophyll-a and DOC concentrations). Consequently, including concurrent measurements of autotrophic and heterotrophic production in long-term lake research may greatly expand our understanding of climate-induced changes in lake ecosystems and their role in global carbon cycling.

## 7E\_SS19 Aquatic metacommunity ecology in depth: ecosystems, scales and applications

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### Unraveling connections between biodiversity and riverscape dispersal

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The metacommunity scenario is recognized as the framework in which the mechanisms that shape biodiversity operate. Particularly, dispersal to local communities was identified as a main determinant of its structure. However, dispersal emerges from the combination of different movement behaviors as: upstream and downstream movements, large-scale immigration from the outlet, or from a species pool unconstrained by the riverscape, interacting with natural and artificial barriers as waterfalls and dams. In addition, their relative importance may systematically change in the headwaters-outlet gradient. These are non-excluding hypotheses about the role of metacommunity dispersal on biodiversity patterns, for which the empirical evaluation is a current challenge. Lottery models, extensively used in theoretical studies, can explicitly include different dispersal mechanisms and the real riverscape structure. With the focus in a fish metacommunity in the Negro River basin (Uruguay), we translated hypotheses about riverscape dispersal to lottery models contrasting expected diversity with those observed in 58 local communities. Models ranked by Maximum Likelihood discrepancies support a main role of outlet dispersal that dismiss in the outlet-headwaters gradient, an asymmetric upward-downward movement and a minor role of dispersal unconstrained by the riverscape. In addition, the effect of three large dams on biodiversity is observed at riverscape level. These metacommunity dispersals explain 50% of variation in alpha and beta diversity. These results identified a main role of riverscape structure on biodiversity, the large scale effect of local fragmentations, and the potential of lottery models to advance on the explicit evaluation of metacommunity mechanisms and management strategies.

## Scaling of biological rates with body size as a backbone in the assembly of metacommunity biodiversity

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Metacommunity theory identifies dispersal among communities, richness of the regional species pool and community size as main determinants of diversity patterns. However, it has focused on the dispersal-body mass association with seldom attention to the scaling in density and regional richness with body size. Among active dispersers, the increase in movement with body size fosters local richness but decreases beta and gamma diversity. Contrary, the small size of populations and lower regional richness of larger organisms may determine the opposite diversity-body size association. Consequently, metacommunity diversity probably emerges from the combined effect of dispersal, density, and regional richness scaling with body size. Here we advanced in this framework analysing the observed scaling in alpha, beta and gamma diversity with body size in a metacommunity of temporary ponds. A coalescent-based metacommunity model closely resembles observed trends in diversity. Theoretical results indicate that the diversity-body mass relationships were probably driven by the combined effect of the scaling in local density and regional richness with mass, while the positive scaling in dispersal with body size has the effect of reverting this trend. In the same line, other recognized scaling with body size as turnover rate, assimilation efficiency, growth rate, trophic interactions, or the size and number of dormant structures may also impact on metacommunity biodiversity but were less attended by metacommunity theory. We call to advance in a more comprehensive understanding of the role of body size and associated mechanisms in metacommunity diversity and its variation among taxa.

## The geography of metapopulation synchrony in dendritic river networks

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Dendritic habitats, such as river ecosystems, promote the persistence of species by favouring spatial asynchronous dynamics among branches. Yet, our understanding of how network topology influences metapopulation synchrony in these ecosystems remains limited. Here, we introduce the concept of fluvial synchrogram to formulate and test expectations regarding the geography of metapopulation synchrony across watersheds. By combining theoretical simulations and an extensive fish population time-series dataset across Europe, we provide evidence that fish metapopulations can be buffered against synchronous dynamics as a direct consequence of network connectivity and branching complexity. Synchrony was higher between populations connected by direct water flow and decayed faster with distance over the Euclidean than the watercourse dimension. Likewise, synchrony decayed faster with distance in headwater than mainstem populations of the same basin. As network topology and flow directionality generate fundamental spatial patterns of synchrony in fish metapopulations, empirical synchrograms can aid knowledge advancement and inform conservation strategies in complex habitats.

## Anthropogenic land–use impacts the size structure of stream macroinvertebrate communities

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Body size descriptors and associated community resemblance measurements may provide useful management tools for forecasting ecological responses to increasing anthropogenic land–use disturbances. Yet, the influences of agricultural intensification and urbanisation on the size structure of biotic communities have seldom been investigated in running waters, a particularly vulnerable ecosystem type that is facing biodiversity loss at unparalleled rates. Using a comprehensive dataset on stream macroinvertebrates from 105 stream sites of 21 drainage basins across Western Finland, we assessed if community organisation via changes on taxonomic composition and body size distributions respond predictably to anthropogenic land–use impacts. More specifically, we applied a combination of community resemblance measurements based on cumulative abundance profiles and spatially constrained null models to understand faunal impairment by agricultural and urban development, and the most likely mechanisms underlying the observed shifts in community size structure. Anthropogenically impacted stream sites showed less variation in community composition and size distributions compared with least disturbed sites, with strong declines in internal variation also occurring for the transition from near–pristine to moderately impacted landscapes. These results were consistent whether based on species–level or genus–level data. Variation in community size structure seemed to be more predictable than taxonomic composition, supporting the notion that resemblance measurements based on body size distributions can represent an improvement to traditional descriptive approaches based on taxonomic identities alone. In addition, we showed that community organisation resulted from effects of land–use degradation mediated through local conditions and spurious spatial dependencies in the distribution of anthropogenic activities across the landscape.



## Taxonomic, functional, and phylogenetic structure of an insect metacommunity inferred from metabarcoding

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Metacommunity structure is generally explored using data generated with morphology-based identification, meaning that insights are limited by the coarse resolution to which some taxa are identified. The use of taxonomic levels higher than species can thus limit pattern detection. In this context, metabarcoding may outperform morphological approaches by enable genetic characterization of entire communities. We collected aquatic insects from 13 perennial and intermittent sites in a mountainous river network (Ceno Valley, northern Italy). Our aim was to test if an increased identification level up to the operational taxonomic unit and haplotype influences the detection of metacommunity structure compared to higher taxonomic levels (i.e. genus, family) in an aquatic insect metacommunity. Specifically, we tested the effects of taxonomic resolution on richness, nestedness, and community assembly processes using taxonomic, functional, and phylogenetic information. The contribution of different orders to total taxonomic richness changed as taxonomic level increased, with Ephemeroptera and Diptera showing the most pronounced increases. Similar patterns were observed for phylogenetic richness, whereas functional richness was more evenly distributed among orders. We found significant nested structure in community composition across all taxonomic levels, with the significance of phylogenetic and functional structure depending on taxonomic resolution. The importance of dispersal in explaining metacommunity structure decreased when using finer taxonomic levels (i.e. haplotypes). Our study shows that taxonomic resolution can be a major influence on the detection of metacommunity structure and suggests metabarcoding as a promising tool for metacommunity characterization.

## Temporal scale of observation in the metacommunity framework

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A complex combination of processes structures ecological communities, including selection, species interactions, drift and dispersal. Previous studies with a metacommunity approach (i.e. groups of local communities linked by dispersal) highlighted the importance of the spatial scale of the study for our perception of these processes, depending on spatial distances and environmental heterogeneity among localities. However, the effects of the temporal scale of observation have been less treated than the spatial one. Here, we explore the importance of metacommunity dynamics by analysing the temporal scales in previous studies and their effects in our perception of the underlying processes, by means of metacommunity simulations. We carried out a wide literature search about metacommunities, focused on empirical studies using spatiotemporal data. Despite a general view of a lack of studies incorporating time, we found a number of studies dealing with this topic (over 200 until December 2020). Nevertheless, the spatiotemporal data evaluated encompassed generally short-term durations (less than 5 years), focusing on intra-annual dynamics with only two temporal points. On the other hand, our simulations reveal an increment of temporal relevance with the temporal extent observed. Yet, this scale effect rely on high dispersal rates (avoiding spatial dissimilarities) and the spatiotemporal distribution of the environmental variation, suggesting a reduction of temporal relevance as we increase the spatial extent observed. These results emphasize the influence of sampling design for our perception of ecological processes and the importance of a better integration of temporal dynamics in the metacommunity framework.

## 7F\_SS04 Citizen science and public participation in freshwaters: engaging citizens to research and management of freshwater ecosystems

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### Citizen Science = Citizen Crane: Long term research by a local community

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The River Crane is an important tributary of the River Thames on the west side of London. The river benefits from an active group of Citizen Scientists as has been highlighted at SEFS6 to SEFS10 and is relevant to the implementation of the Water Framework Directive. During 2019 and 2020 there continued further research on the River Crane and the data strongly suggest that little has changed in the Crane river system with regards to water quality and biodiversity. Determinants of the river ecosystem using the River Monitoring Initiative which utilises macroinvertebrate identification, show a range of pollution impacts that includes phosphate and ammonical nitrogen from the upper and middle catchment and contamination from sewer misconnections and cross connections as well as airport and road traffic run off. Over 60 volunteers have been involved, trained by staff from the Zoological Society of London and many were involved in the fifth Citizen Crane Forum in 2019. After the Covid pandemic, a meeting in late 2021 should explore further collaboration through the Smarter Water Catchments (SWC) programme which started in April 2020. Members of the Citizen Crane programme continue to collect and analyse samples from long – term locations which provide scientific robustness while enhancing knowledge about potential and specific pollution threats. The aim over the next five years is to work with the SWC stakeholders to radically improve the Water Quality in the River Crane and monitor the impact of interventions delivered through the SWC process such as constructed wetlands.

## Contaminants of emerging concern through the lens of citizen science

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Among the numerous global change stressors, micropollutants or contaminants of emerging concern (CECs) pose a threat to aquatic ecosystems due to potential sub-lethal effects on organisms at low concentrations (ng/L - µg/L). Pharmaceuticals, personal care products, pesticides, micro- and nano-plastics are representative CECs in water bodies worldwide. Negative effects of micropollutants are well studied and addressed to cause direct and indirect effects and alterations in ecosystem functioning. For example, pharmaceutical metformin has been observed to cause intersex and reduced fecundity in fish. In order to understand the effects of CECs on aquatic ecosystems, it is important to know their concentrations in the different aquatic compartments. Even with the attention given to understanding the impact of CECs on water quality and aquatic ecosystem health, there is a disproportion in terms of monitoring. Citizen science is a potential tool by which disparity in the monitoring of different groups of CECs can be overcome. The aim of this literature review is to explore the landscape of citizen science and community science projects with a focus on monitoring different groups of CECs. We also seek to identify the benefits and drawbacks of using citizen science methods to assess contaminants of emerging concern in water bodies, thereby proposing a framework to incorporate citizen science to monitor emerging contaminants in freshwater systems.

## Pescadors de Plàstic: citizen science in schools to explore freshwater plastic pollution.

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Although plastic pollution is one of the major environmental challenges of our time, there is still a huge gap of knowledge in relation with the real sources, fluxes and impacts of plastics in freshwater ecosystems. Citizen science can be a powerful tool to address this gap by obtaining data over large spatial and temporal scales, while also increasing awareness of plastic pollution in freshwaters that can result in positive behavioural changes to face this problem. In addition, citizen science can play an outstanding role in school science and environmental education as it engages the students directly with these environmental problems at local level while gives them an understanding of the scientific process. “Pescadors de Plàstic” is a citizen science project in schools that aims to engage students in a real research project to explore plastic pollution in freshwater ecosystems. This project uses standardized methods to quantify and characterize plastic litter at riversides and to identify possible plastic sources along rivers and streams from contrasting Mediterranean watersheds (Besòs, Tordera, Ter and Fluvià; NE Spain). Since 2019, around 800 students from 30 schools have worked together with scientists, applying a scientific method to collect, document and analyse data on plastics in 50 rivers reaches. Results from this project not only provides evidences on the prevalence, sources and distribution of plastic waste in Mediterranean rivers, but also on the important role that citizen science can play to promote scientific culture among school children and to upraise public awareness of plastic pollution in freshwaters.

## Adapting participatory processes in temporary rivers management

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So far, the Water Framework Directive (WFD) implementation has been mainly focused on perennial rivers without considering temporary rivers properly, neither in biomonitoring programs nor participatory processes. This paper aims at adapting participatory processes in river basin management to enhance the inclusion of ecosystems with poor or no social recognition such as temporary rivers. We examined previous experiences of participatory processes conducted in the WFD and adapted them to propose and implement an approach for promoting stakeholders' engagement in temporary rivers. The approach is based on a collaborative leadership, includes multiple participatory engagement mechanisms, uses future global change scenarios and the concept of ecosystem services at different stages of the process, and aims at involving stakeholders not only in the proposal of measures stage but in the diagnosis of the ecological status. It also includes an evaluation of participants' satisfaction on the process. We tested our approach in temporary rivers from the Mediterranean region. We found that the combination of environmental education and citizen science activities, together with the inclusion of the ecosystem services concept, was the most useful way to raise awareness on the biodiversity and ecological value of temporary rivers and to promote stakeholders' engagement. Workshops conducted during the diagnosis stage played an important role in both including stakeholders' suggestions and increasing their knowledge on temporary rivers. As future environmental changes will increase the proportion of rivers with temporary flow regimes, our approach can contribute to adapt current participatory processes to future needs.

## Citizen scientist water quality monitoring of an urban river

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This paper investigates water quality along the river Liffey in Dublin city with the help of citizen scientists, including the community of river users such as paddle boarders and those accessing the river from the bank. The primary objective was to evaluate water quality near sources of pollution observed by citizens, while filling data gaps for the United Nations (UN) Sustainable Development Goal (SDG) 6, Indicator 6.3.2. The participants used field chemistry kits to measure nitrate ( $\text{NO}_3\text{-N}$ ) and phosphate ( $\text{PO}_4\text{-P}$ ) at 19 locations on a monthly basis over the course of nine months, recording the results on an app. 10% of nitrate samples were indicative of low quality water values while 14% of phosphate samples were indicative of low quality water. Historical rainfall over the study period was analysed to investigate the impact of run-off from rainwater on the river. Results indicate that excessive rainfall was not a factor in lower water quality in this area. Citizen scientists' observational notes and photographs entered onto the database, with accompanying test results were key to highlighting pollution sources at specific locations which correlated with high levels of nitrate and phosphate resulting in low quality water. Land use was a factor in these areas of recent housing development indicating possible domestic misconnections. Citizen scientist data has the potential to fulfil UN SDG 6, in contributing to Indicator 6.3.2 while detecting contamination.

## Operationalising citizen science in river quality monitoring in Ireland—opportunities and challenges

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It is widely acknowledged that there are considerable data gaps on the quality of surface waters globally and Ireland is no exception. This is particularly true for the small stream network which represents 75% of the river network, at total of 64,000km of 1st and 2nd order streams, so called headwaters. There are few EPA monitoring points on small streams in Ireland and the water quality of much of the network is unknown. At the same time this is the most vulnerable part of the river network due to high land-water contact and low dilution capacity. Water quality in the headwaters will also influence water quality further downstream and efforts to meet WFD objectives. Here is whether citizen science is best targeted. Various individuals and groups have been working to develop a strategy to operationalise the potential of citizen science. This presentation will provide an overview of the strategy and challenges to be addressed to enable effective citizen science, together with progress to date in terms of monitoring schemes (based on macroinvertebrates targeting different levels of expertise), data handling and communication.



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### Analyzing multiple stressor effects on EPT taxa with DNA metabarcoding

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Globally, multiple stressors affect freshwater ecosystems and therein living organisms. Therefore, understanding multiple stressor effects has implications for improving ecosystem management. However, organisms such as stream macroinvertebrates are often identified at a coarse taxonomic resolution as species-level identification is - due to their high abundance and diversity - often not achievable with morphology based approaches. An alternative for studying multiple stressor interactions with a high taxonomic resolution is DNA metabarcoding. For this study, over 10,000 specimens from the insect orders Ephemeroptera, Plecoptera and Trichoptera (EPT) were used. In a preceding outdoor experiment, their responses to three anthropogenic stressors (increased salinity, fine sediment deposition and reduced flow velocity) were studied in a full factorial design in 64 mesocosms with two microhabitats each (streambed and leaf litter), resulting in eight replicates per treatment. With DNA metabarcoding, 122 EPT Operational Taxonomic Units (OTUs) were obtained, from which the most abundant 27 OTUs alone showed 14 different response patterns to the applied stressors. With the high taxonomic resolution achieved by DNA metabarcoding, species-specific stressor responses that were hidden at a coarse taxonomic resolution could be revealed. For instance, we obtained two different response patterns to the applied stressors from two species even within the same mayfly family. The results highlight the potential of DNA metabarcoding in the context of multiple stressor research: Response patterns can be detected at species or OTU level and thereby help studying multiple stressor interactions and their effects on macroinvertebrates in more detail which can be beneficial for ecosystem management.

## Does biofilm response to contamination depends on the anterior stream hydrothermal regime?

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As a result of global change, the frequency and duration of drying events in non-permanent rivers are increasing, while some perennial rivers are becoming to experience drying events. Flow interruption and decrease in water level are accompanied by an increase in streambed temperature. In addition to these physical disturbances, chemical stressors are also threatening aquatic ecosystems. Pollutants stored in agricultural soils are washed during the rains associated with rewetting. The aim of this study was to assess in what extent a previous hydrologic and thermal disturbance could modulate the sensitivity of stream phototrophic microbial communities to a pulse of agricultural run-off during rewetting. In microcosms, biofilms previously subjected to different conditions of hydrology (no, short or long drying) and temperature (22°C or 32°C) have been exposed to a complex agricultural run-off (copper, pesticides, nitrates) at increasing concentrations. One week after the pulse of contaminant, the structure (e.g. pigments, bacterial density, polymeric substances) and functioning (respiration, primary production, photosynthetic efficiency) of the biofilms have been assessed. The results show that biofilm composition and functioning at the end of the experiment was mainly driven by the anterior hydrologic and thermic disturbance, even at high concentrations of contaminant. One week after the pulse of run-off, the resulting effects on biofilms that had not been dried were rather low, certainly due to antagonistic effects of the different components of the run-off. As expected, the previous drying strongly affected the response of biofilms to the gradient of run-off, with main effects on algal community structure.

## Impacts of heat waves and biological invasions on shallow lake ecosystems

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Climate change and biological invasions are leading drivers of biodiversity loss in freshwater ecosystems. Heat waves are predicted to increase in frequency and intensity with climate change, and with this the success of potential biological invaders may increase. Given the critical role that higher frequencies of heat waves will play in affecting freshwater biodiversity and ecosystem services during the coming 50 years, it is crucial to understand the mechanisms behind these interactions. Therefore, we conducted an experiment consisting of 24 (400L) outdoor mesocosms. We used a 2x2 full factorial design with four treatments: (i) control ambient conditions mimicking the current climate state in a temperate shallow lake; (ii) temperature increase via heat waves; (iii) biological invasions; (iv) combined heat waves and invasions. The heat wave treatment mimics future projected temperatures according to IPCC with a temperature increase ranging 0-8°C (average 4°C) above ambient. For the invasion, organisms collected from a site with 3°C higher mean temperature than lakes in southern Sweden, were added. Community composition, measured via eDNA metabarcoding (18S and 16S) in combination with identification via microscopy of zooplankton and phytoplankton was affected by both heat wave and invasion treatments. In particular, a *Cryptomonas* algal species showed a more pronounced establishment in the heated than in the control conditions. This may suggest that some biological invaders may be more successful under predicted increased frequency of heat waves either because of the decreased diversity in native communities or because invaders are better adapted to warmer conditions.

## Chances and limitations to infer multiple stressor effects from macroinvertebrate biomonitoring data

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For freshwater biodiversity management it is important to understand the effect of different stressors on freshwater organisms. Multivariate statistical models are widely used tools to infer the effects of multiple environmental factors on species distributions and community assembly from biomonitoring data. They are based on niche-theory and can be used to rank the importance of multiple stressors for single species or whole assemblages. However, classical species distribution models lack the explicit consideration of important processes that are known to affect community assembly, such as biotic interactions and dispersal limitations. In recent years, several attempts have been made to increase the ecological realism in statistical models, such as the development of joint species distribution models. With this contribution, I want to discuss chances and limitations to use multi- or joint species distribution models and trait-based approaches to infer multiple stressor effects from biomonitoring data. I will illustrate two attempts to better ground statistical species distribution models in ecological theory: 1. by parameterizing residual correlations among species in joint species distribution models and 2. by taking into account existing knowledge about ecological preferences from trait databases. The application of Bayesian inference allows us to quantify parameter and model output uncertainty of these models. This can help to assess what we can learn from biomonitoring data for the management of freshwater ecosystems.

## Toxic effect of microcystin-LR to *Chironomus riparius* in a multistress environment

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It is mainly unknown how aquatic ecosystems respond to multiple stressors, which is especially true for eutrophic freshwater where due to phytoplankton blooming, cyanotoxins influence aquatic biota. To establish the type of interaction and determine whether there is any interaction at all between cyanotoxins and most common pollutants in aquatic ecosystems, the lethal toxicities of the four pollutants: nitrates (NO<sub>3</sub>-), ammonium (NH<sub>4</sub>+), phosphates (PO<sub>4</sub>+), cadmium, and microcystin-LR, the cyanotoxin which often present in eutrophic water bodies, were determined for the 1st larval instar of the freshwater macroinvertebrate *Chironomus riparius*. The methodology of OECD 235 protocol, acute immobilization assay on chironomid larvae were used. The obtained LC<sub>20</sub> concentrations from the experiment where larvae were exposed to only one agent were 401.69 mg/l for nitrates, 79.687 mg/l for ammonium, 872.24 mg/l for phosphates, 2.081 mg/l for cadmium, and 10 µg/l for microcystin-LR. The LC<sub>20</sub> concentrations obtained were then used to test pollutant-toxin interactions. The combined effect of microcystin-LR and single pollutants resulted in the summation of the individual mortalities of combined stressors in all four cases. In conclusion, the joint effects of microcystin-LR and all four pollutants revealed clear additive interactions and stress the necessity of further investigation under the field conditions which will help in the control and management of cyanobacteria in aquatic ecosystems.

Keywords: microcystin-LR, pollutants, multistress, *Chironomus riparius*

## New Zealand streams; multiple-stressor effects of climate-change drivers on ecosystem functioning.

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Freshwater ecosystems are under continued pressure from multiple stressors. These can negatively impact freshwater communities and ecosystem processes and can interact to produce unexpected ecological outcomes. Predicted future climatic changes are expected to exacerbate the negative effects of stressors and place further pressure on freshwater ecosystems with an additional amalgam of stressors. This study investigated the individual and combined effects of multiple climate change drivers (temperature variation, flow velocity variation [due to changes in precipitation], and increased carbon dioxide) and deposited fine-sediment on stream ecosystem processes (respiration, decomposition) in Otago, New Zealand. This study used the ExStream System (an experimental stream mesocosm system comprising of 128 circular stream channels). Cotton strips and leaf packs were placed in each channel to study respiration and decomposition (mass loss and tensile strength). Leaf packs consisted of mahoe *Melicytus ramiflorus* leaves. Dry-mass and ash-free dry mass were determined for leaf packs and analysed. Respiration and tensile strength loss were measured for 128 cotton strips. Analyses of cotton strips show that there were significantly lower rates of respiration in channels enriched with carbon dioxide. However, there were no significant differences in tensile strength loss among treatments. This result suggests that increased carbon dioxide impacts certain hydrochemical conditions which could potentially impact stream communities and other ecosystem processes. Further analysis of microbial communities on cotton strips and leaf packs will provide insight into the observed differences in respiration rates.

## 8B\_SS18 Functional indicators of freshwater ecosystem health & RS18 Microplastics: sources and impacts

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### Microalgal colonization of microplastics: results from a mesocosm experiment across biogeographical zones

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A variety of organisms can colonize microplastic surfaces (or “plastisphere”) through biofouling processes. Heterotrophic bacteria tend to be the focus of plastisphere research, however, the presence of epiplastic microalgae within the biofilm has been repeatedly documented. Despite the importance of biofouling for microplastics in aquatic systems, data about this process are still scarce, especially for freshwater ecosystems. Here, our goal was to evaluate the biomass development of biofilms on plastic substrates and determine whether plastic surfaces exert a strong enough selection to drive species sorting, overcoming other niche-defining factors driven by spatial patterns. We added microplastic pellets of high-density polyethylene (HDPE), polyethylene terephthalate (PET) and a mix of the two polymers in 15 mesocosms of 5 different locations of the Iberian Peninsula (totally 45 samples) and after one month we evaluated species composition and biomass of microalgae developed on plastic surfaces. Results show that all the different plastic substrates in all sites were colonized by microalgae with mean biomass of  $3.05 \pm 0.40$  mg cm<sup>-2</sup>, with PET having the highest value ( $3.63 \pm 0.83$  mg cm<sup>-2</sup>). Microplastics supported the growth of many different species of microalgae (242 species), with some cosmopolite species that were able to colonize all different geographic regions and plastic surfaces. We found several species colonizing only one substrate, but with very low recurrence. Local species pools and different environmental conditions, mainly linked to biogeography, seem to prevail in driving community sorting on plastic surfaces.

## Microplastics increase susceptibility of amphibian larvae to the chytrid fungus *Batrachochytrium dendrobatidis*

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Microplastics (MPs, plastic particles < 5mm in size) are of growing concern due to their near ubiquity in marine, freshwater and terrestrial ecosystems. Although their biological impacts are still poorly known, evidence is accumulating that they interfere with core physiological processes including photosynthesis, food ingestion, metabolism, growth, and reproduction. They are also known to synergise with chemical pollutants to potentially increase their harmful effects in organisms, but there is virtually no information about whether MPs influence the dynamics of infectious diseases. The amphibian-infecting chytrid fungus *Batrachochytrium dendrobatidis* (Bd) causing the disease chytridiomycosis is emerging worldwide as a threatening process. This fungus causes chytridiomycosis, and it is responsible for mass mortality and population declines of amphibians worldwide. We examined the potential interaction between MP pollution and infection by Bd in the common midwife toad *Alytes obstetricians*. We mimicked natural exposure of *A. obstetricians* tadpoles to Bd-infected reservoir species (fire salamanders) and maintained them in mesocosms with or without microplastics (increasing concentrations of fluorescent, 10-µm polystyrene microspheres) until their metamorphosis. We analyzed the mortality, Bd load, body condition and MP presence. We found that MPs accumulated to a greater extent in tadpoles that were not exposed to Bd. In tadpoles exposed to Bd, MP ingestion enhanced Bd load in a dose-dependent manner, showing an alarming interaction between two emergent processes, chytridiomycosis and MP pollution.



## Classification of streams ecological status: comparing expert-knowledge and data-driven approaches

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Expert knowledge is increasingly used in conservation science to classify dynamic and complex ecosystems, while overcoming typical data-limitations. Based on the expertise of field operators from the local Environment Agency, we classified 161 stream sites in Trentino according to the presence of known hydrological, morphological and chemical alterations, while also identifying sites in reference conditions. We then used machine learning approaches to examine the degree to which a-priori expert classification matched data-driven classification based on the taxonomic and functional composition of benthic macroinvertebrates. The majority of stream sites were a-priori considered impacted by either one or a combination of anthropogenic alterations (~80%), with only 16% of sites in reference conditions. Random Forest a-posteriori classification of stream sites according to taxonomic and functional macroinvertebrate data matched the expert-based classification only partially. While stream sites considered in reference conditions were correctly classified, discrimination among hydro-morphological and chemical alterations was often poor. This suggests that indicators used to assess the ecological status of streams in mountain areas based on macroinvertebrates taxonomic and functional classification can assess the overall stress of a waterbody, but they show poor sensitivity to specific stressors, with relevant outcomes for the water management of Alpine running waters.

## Microplastics are incorporated into caddisfly cases and reduce case stability

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Plastic is a versatile material which is widely used in everyday products. Upon its usage, it is often mismanaged and washed into streams and rivers, where it becomes fragmented into smaller plastic pieces. While it is well known that such plastic pieces (microplastics, < 5 mm) can be ingested by aquatic organisms, other interactions between animals and microplastics are still under-researched. In our study, we show for the first time that microplastics (such as polyethylene, polypropylene, polyester) of various shapes (fibres, films, fragments, spheres) and colours are present in the larval cases of the caddisfly *Lepidostoma basale*. This caddisfly usually builds cases using sand grains during its larval development. Furthermore, we conducted a laboratory experiment showing that *L. basale* case stability decreases with increasing microplastic (polyethylene terephthalate PET, polyvinyl chloride PVC) particle content in the cases. Hence, an increasing microplastic particle load in caddisfly cases could facilitate predation by case-crushing predators such as juvenile dragonflies and fish. As fish often ingest the larvae together with their cases, microplastics in caddisfly cases may be transferred to fish, potentially causing harm since it is known that microplastics can cause inflammatory responses in fish. Interestingly, when offered microplastics together with sand grains, most *L. basale* larvae started building their cases using plastic instead of sand. Our studies show that microplastics are used as building material by a common freshwater invertebrate and affect caddisfly case stability. Hence, microplastics in aquatic ecosystems may influence predator-prey interactions.

## Effect of salinization on zooplankton size structure: an intercontinental coordinated mesocosm experiment

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8B\_SS18 Functional indicators of freshwater ecosystem health & RS18 Microplastics: sources and impacts, July 29, 2021, 13:15 - 14:45

Freshwater lakes are increasing in salinity due to human activities including agriculture, resource extraction, and road salting. Increased salinity can impact all levels of biological organization, from individuals to ecosystems. Body size is a key organismal trait due to its relation to metabolism and growth, species interactions, and food-web structure (which affects ecosystem functioning). Although the effects of salinization on zooplankton community composition in lakes have been studied to some extent, the changes in community size-structure remain to be explored. In this study, 5 coordinated mesocosm experiments were conducted using a standardized protocol in different regions (Canada, US, and Europe) to evaluate the responses of zooplankton size structure to salt addition (range: 0.21-2920 NaCl mg/L). We analyzed zooplankton size spectra and size-based metrics across the chloride gradient, and we expected to see similar variation across regions (i.e., a decrease in both mean size and size diversity, as well as steeper size-spectra slopes). Preliminary results showed a decrease in size diversity as chloride concentration increased, despite the regional differences. However, we did not observe a similar pattern in the slope of the size spectra and the mean body mass. Instead, we observed a strong decrease in slope (more negative) as chl<sub>a</sub> increased. Overall, our results can be useful to anticipate the effects of salinization on trophic cascades and ecosystem functioning in lakes.

## Testing the nutritional value of plastic-associated biofilm for a common freshwater gastropod

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8B\_SS18 Functional indicators of freshwater ecosystem health & RS18 Microplastics: sources and impacts, July 29, 2021, 13:15 - 14:45

Plastic pollution poses an increasing threat to aquatic organisms, e.g. via ingestion or entanglement, but can also affect associated microbial communities and consequently have an indirect impact on the consumers of this biofilm. This study investigates the primary production on three common plastic types in a freshwater environment and its food quality for a benthic invertebrate grazer. We incubated polyethylene (PE), polyethylene terephthalate (PET) and polystyrene (PS) as well as glass slides (control) in a freshwater creek for natural biofilm establishment. To account for seasonal variations, the experiment was conducted twice during winter and late spring. The biofilms were offered to the freshwater gastropod *Physa fontinalis* as food source for a period of 8 weeks, respectively. Growth and reproduction of the snails were measured to monitor sublethal effects. Additionally, biofilm composition was observed using confocal laser scanning microscopy. In winter, *P. fontinalis* feeding off PET and PE showed a significantly lower egg production, and lower growth rates were observed on PET compared to PS and glass. No such effects occurred in spring. Microscopy data revealed, that algal growth was significantly inhibited on PE and PET during the winter treatment, which may have adversely affected the nutritional value of those biofilms. However, this effect probably underlies seasonal variations, since we could only find these effects during the colder and darker month (Jan-Mar). Future studies need to consider such fluctuations to further understand the influence of plastic pollution on primary production and higher trophic levels.

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### The problem of agricultural 'diffuse' pollution: getting to the point

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8C\_RS02 Agriculture/Forestry operations and water quality, July 29, 2021, 13:15 - 14:45

Despite the adoption of the EU Nitrates and Water Framework Directives, agriculture remains a major contributor to poor water quality in many EU member states. Agricultural inputs can emanate from diffuse sources such as fields, and small point- or intermediate- sources, including farmyards and trackways. These latter sources can contain high concentrations of soluble and particulate matter, and yet their contribution to catchment-wide water quality is rarely assessed. In this study, we quantified water chemistry and ecology throughout the multiple watercourses within a single drainage network dominated by dairy agriculture. We found that most of the headwaters were impacted chemically and biologically by organic matter inputs from drainage ditches connecting farmyards directly to watercourses. These farmyard drains had high concentrations of ammonium, phosphate, potassium, suspended sediment and high BOD. Within headwater tributaries, concentrations of SRP declined downstream from yard inputs, indicating high biological, chemical or physical uptake and attenuation. Within the main stream channel, however, phosphate concentrations increased downstream, suggesting biological or biochemical release of stored phosphorus from the stream bed. In contrast, ammonium concentrations decreased and nitrate concentrations increased downstream in all waterbodies, likely due to instream nitrification of the ammonium inputs and/or increased diffuse nitrate inputs from groundwater or surface springs. Our results have shown that small farmyard point-sources were likely the dominant source of agricultural pollution within the study catchment. Further, the strong attenuation potential demonstrated by the small tributaries in this study may effectively mask the true scale of agricultural pollution within agricultural catchments.

## Pesticides in surface waters – fig leaf of the Water Framework Directive?

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8C\_RS02 Agriculture/Forestry operations and water quality, July 29, 2021, 13:15 - 14:45

The Water Framework Directive (WFD) stipulates that good status is to be achieved for all European water bodies. While numerous scientific studies found surface water pesticide concentrations high enough to cause adverse ecological effects, the governmental monitoring under the WFD mostly concludes a good chemical status with respect to pesticides. To identify reasons for this contradiction, we performed a monitoring of 116 agricultural streams in 2018 and 2019 with sampling efforts beyond WFD requirements including event-driven sampling, an extended analyte spectrum respecting current pesticide use statistics and additional pesticide thresholds complementing the WFD Environmental Quality Standards (EQS). That way, we found 41 different pesticides and 94% (n=109) of agricultural streams to exceed threshold levels. The monitoring and assessment as performed under the WFD identified only 24% (n=10) of pesticides exceeding thresholds and 35% (n=38) of streams that actually were at risk. Reasons for this deviation could largely be explained by (i) an absence of critical pesticides and corresponding thresholds in the WFD list of priority substances and river basin specific pollutants, (ii) increased pesticide concentrations measured by event-driven sampling and (iii) current WFD threshold levels often too high to protect the aquatic ecosystem. We thus conclude a significant underestimation of the actual pesticide risk by current WFD monitoring practices. Only refined pesticide sampling and assessment strategies allow to adequately characterize the chemical status and better explain the biological status of surface waters.

## Contrasting reforestation strategies impacts on the water balance in a Mediterranean catchment

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8C\_RS02 Agriculture/Forestry operations and water quality, July 29, 2021, 13:15 - 14:45

Land abandonment processes are affecting to large extensions in rural areas, leading to a high potential of forest restoration. Forest restoration is a useful strategy to increase nature contributions to people, due to its key role in carbon sequestration, biomass production and water retention at local and landscape levels. However, different options in restoration efforts could lead to marked differences in the water cycle. Particularly, spatial aggregation and quality of reforestation areas are options that managers must assess. Our study evaluates the potential impacts of reforesting on the hydrological cycle in the Salado River basin (central Spain), by using contrasting scenarios depending on the spatial distribution (i.e. reforestation in islands or continuous) and the slope (i.e. high-medium vs. low slope). First, reforestation scenarios were designed using a multicriteria analysis, and secondly, the potential impacts on the hydrological cycle were simulated using a SWAT model. Results show that reforestation would cause a decrease in surface runoff and an increase in water loss due to evapotranspiration for all the scenarios. We also observed that reforestation generally led to an increase in groundwater flow and aquifer recharge by favouring infiltration through the soil profile. The spatial distribution and the slope of the reforestation did not yield strong differences in the patterns observed in the water balance. However, scenarios with low slope and spatial distribution in islands had a greater groundwater flow contribution than scenarios with high slope and continuous reforestation (3.1% and 4.5%, respectively).

## Subsurface transport of plant protection products from and into ponds

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8C\_RS02 Agriculture/Forestry operations and water quality, July 29, 2021, 13:15 - 14:45

Small freshwaters in agricultural landscapes are important habitats for a variety of species, especially macroinvertebrates. Compared to larger freshwater systems they host more biodiversity and endangered species. They are crucial stepping stone habitats contributing to maintain species populations and distribution. At the same time, small agricultural freshwaters are explicitly exposed to nutrient and pollutant loads as well as habitat degradation due to former and current farming activities. Especially the entry of plant protection products (PPP) can have severe effects on aquatic species. While fluxes of PPP into freshwaters are usually considered to take place via surface runoff or wind-induced drift, subsurface fluxes are mostly neglected. Here, we present results from monitoring of shallow groundwater adjacent to ponds in a region intensely used for agriculture. We show that a large portion of PPPs found in the ponds are also present in the near-shore groundwater. Additionally, some PPP metabolites are present in both, groundwater and surface water in high numbers and concentrations. Besides currently approved substances we find PPPs and related metabolites whose approval expired decades ago. Hydrological measurements reveal transport directions of PPP and metabolites between groundwater and surface water. The results imply that protection measures such as buffer strips should be adapted to local hydrological conditions to increase subsurface retention of PPPs and metabolites. The current focus on surface runoff as a main source for surface water pollution with PPPs may hinder effective protection measures. We suggest that subsurface transport should be considered in future management considerations.



## Pesticides - a dominant stressor for vulnerable insects in lowland streams

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8C\_RS02 Agriculture/Forestry operations and water quality, July 29, 2021, 13:15 - 14:45

Despite elaborate regulation of agricultural pesticides, their occurrence in non-target areas has been linked to adverse ecological effects on insects in several field investigations. Their quantitative role in contributing to the biodiversity crisis is, however, still not known. In a large-scale study across 101 sites of small lowland streams in Central Europe we revealed that (i) pesticide pollution was the major driver in reducing vulnerable insects in aquatic invertebrate communities (ii) 83% of agricultural streams did not meet the pesticide-related ecological targets (iii) the current authorisation of pesticides underestimates the ecological risk. To provide more reliable thresholds, the authorization process needs to include monitoring-derived information on pesticide effects at the ecosystem level. Exemplarily, we derive pesticide-related thresholds to improve the protection of invertebrate stream communities.

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### An ecosystem service-based decision-support tool for river basin management

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8D\_RS05 Ecosystem services and natures contributions to people, July 29, 2021, 13:15 - 14:45

Freshwaters contribute a disproportionately high level of ecosystem services, including water for consumption and food production, regulation of flooding as well as places for recreation and appreciation of nature. However, freshwater ecosystems are among the most degraded and threatened ecosystems, undermining these services. The ecosystem services framework can be a useful management tool to facilitate a focus on targets, both in terms of pressure mitigation and ecosystem services enhancement that are of direct interest to policy makers, managers and stakeholders who are concerned with river health. We developed an evidence-based decision-support tool for Ireland's rivers using a Bayesian Belief Network model capable of linking management decisions to the desired ecosystem service outcomes through biotic and abiotic cause-and-effect chains. Using three case studies we demonstrated that the individual and interactive effects of globally pervasive freshwater stressors can be expressed in relatively simple terms of changes to ecosystem services and benefits; focusing on wildlife value, water quality, and angling. This evidence was then presented to stakeholders and policy makers in a series of deliberative workshops, where participants could evaluate alternative policy options to identify 'shared' visions for catchment management solutions that maximise societal benefits.

## Data needs for integrating the ecosystem services approach into water resources management

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8D\_RS05 Ecosystem services and natures contributions to people, July 29, 2021, 13:15 - 14:45

The ecosystem services (ES) approach has emerged as a promising theoretical framework for coupling and communicating benefits to society from the underlying ecology and ecosystem functioning. However, the migration of the ES concept from a primarily theoretical environment to an essentially practical one presents numerous difficulties, among which is lack of information on data and model needs and their availability. Accordingly, the objective of the research undertaken here was to identify key data that should be prioritized for collection to characterize ES and for implementing different modeling approaches. To achieve this goal, we distributed a questionnaire focused on deciphering what questions practice, policy or both need to answer regarding ES and what data and models are required to do so. To describe modeling needs, we conducted a review covering scientific studies published in peer-reviewed journals, together with content included in other resources such as technical reports. The results show that most of the questions that those in the practice domain need to address can be tackled using data derived from habitat/ecosystem maps, land use inputs and water quality indicators. Regarding the policy domain, besides the above, inputs from economic modelling, stakeholder analysis and hydrological regime are also acknowledged as highly useful. Over 35 modelling tools and approaches have been identified. Provisioning ES are characterised primarily with conceptual and physically based models. To characterise regulating ES, beyond the above, biogeochemically based modelling is also employed. Finally, cultural ES are characterised from spatial pattern analysis and questionnaire surveys designed to elicit perceptions.

## An integrative approach to evaluate ecosystem services of mountain lakes

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8D\_RS05 Ecosystem services and natures contributions to people, July 29, 2021, 13:15 - 14:45

Mountain lakes are increasingly affected by global change and direct anthropogenic stressors requiring sustainable management strategies to ensure their conservation and ecosystem service provision. However, mountain lakes have rarely been considered in context of ecosystem services assessments, whereby especially stakeholder perspectives remain largely unexplored. Therefore, this study aimed at an integrative evaluation of key ecosystem services of four pilot mountain lakes in the European Alps (South Tyrol, Italy). We facilitated a workshop with stakeholder representatives and experts to identify key ecosystem services of mountain lakes. We administered questionnaires to diverse stakeholders to elicit ecosystem service priorities. To quantify key ecosystem services, we selected 19 limnological, spatial and socio-economic indicators. Finally, we integrated all information within a multi-criteria decision analysis framework to assess the ecosystem service provision of the pilot lakes and evaluated the results regarding the social-ecological context of the pilot lakes. The stakeholders prioritized five ecosystem services, attributing highest importance to maintaining populations and habitats as well as the aesthetic value, followed by surface water for non-drinking purposes, outdoor recreation, and representation & entertainment. The results of the integrative evaluation suggest a varying level of ecosystem service provision across pilot lakes in dependence of their social-ecological context. This study presents a first step towards a more comprehensive understanding of mountain lakes and their ecosystem services, which could support management strategies aiming to foster the sustainable development of these sensitive ecosystems under global change.

## New challenges towards an integrated watershed management improving biodiversity conservation and ecosystem services through nature

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8D\_RS05 Ecosystem services and nature's contributions to people, July 29, 2021, 13:15 - 14:45

The alterations on the environment produced by anthropogenic activities can be described as part of the global change process. Consequently, the overexploitation of ecosystems, introduction of invasive species, alteration of biogeochemical cycles and climate and land use/cover changes, are real threats to the natural environment and to populations as well. The impact of these factors can cause losses of biodiversity and on Ecosystem Services (ES) supply. The long-term functioning of the biosphere and human well-being rely mostly on the good status and resilience of natural and semi-natural ecosystems. The implementation of Blue and Green Infrastructures (BGINs) have been studied as a landscape planning instrument to optimize the spatial arrangement of ecosystems, habitats and practices to promote nature conservation, while delivering ES to populations. Therefore, the premise of ALICE project <https://project-alice.com/> is to demonstrate the benefits of implementing nature based solutions within the EU Atlantic Region, to enhance the delivery of ES and biodiversity. This project is focused on a catchment scale approach to identify the benefits delivered by the introduction of potential BGINs under different future scenarios for each of the ALICE Case Studies (Northern Ireland/Republic of Ireland, France, Spain and Portugal). Here we will focus on the Portuguese CS. The key objective is to develop a full-package of new methods and tools to assist with landscape management, based on participative learning and modelling processes, accounting for stakeholders' interests, incorporating socioeconomic and climate change scenarios.

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## Relevance of Riparian Ecological Infrastructures for next generation of EU agricultural policies

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8D\_RS05 Ecosystem services and natures contributions to people, July 29, 2021, 13:15 - 14:45

The relevance of riparian areas to improve nature condition and human well-being is widely acknowledged. These are also important in intensive agricultural landscapes to mitigate effects caused by farming intensification, negatively affecting nature and “nature’s contributions to people” (NCP). However, current EU agricultural policies (eg, CAP) neglect riparian values to support decision-making strategies for effective management of coupled social-ecological agricultural systems. Under the Optimus Prime project, we assessed the effects on biodiversity and biodiversity-related NCP of remnant riparian ecological infrastructures (EI) in two intensive agricultural landscapes (floodplain areas of Tejo and Sorraia rivers, Portugal). Sampling occurred from May to July 2019 in riparian EIs and agricultural areas, with sites separated at least by 500m to avoid autocorrelation biases. Field sampling included pitfalls for ants and spiders (132 sites; 660 pitfalls) and passive acoustic sampling for bats (207 sites; 371917 records), while predation services were estimated using dummy caterpillars (59 sites; 590 caterpillars). To assess differences between riparian EI and agricultural areas we used Bayesian ANOVA or GLMM. Results show that riparian EI tend to have higher ecological activity, predation services and generally higher species/functional richness than surrounding agricultural areas. In agricultural landscapes, rivers and associated features stand out as relevant ecological structures where biodiversity and biodiversity-related NCP are noticeably higher than in agricultural fields. Moreover, even considering groups of species with distinct spatial-scale requirements, their relevance remains unquestionable. Hence, EU should redesign agricultural policies including riparian EI in their agro-environmental objectives and management practices to enhance biodiversity and biodiversity-related NCP.

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8D\_RS05 Ecosystem services and natures contributions to people, July 29, 2021, 13:15 - 14:45

The INCASE (Irish Natural Capital Accounting for Sustainable Environments) project is piloting the UN System of Environmental and Economic Accounting (SEEA) – Ecosystem Accounting (EA) at catchment scale in Ireland. We present examples from the study catchments to demonstrate how the SEEA-EA can support Integrated Catchment Management. Building the core accounts (extent, condition, services, benefits) of the SEEA-EA framework requires the integration of an array datasets. In Ireland, CORINE remote sensing data are presently the only standard, reliable time series data available to build extent accounts. Datasets developed by the Irish Environmental Protection Agency (EPA) overlain on CORINE, inform the extent of freshwater rivers and lakes within a catchment. Data gathered under the Water Framework Directive by the EPA provides comprehensive time series data for ecological status to sub-basin level for all catchments in Ireland. Further data are also gathered on pressures, and the EPA characterises rivers At Risk of achieving good ecological status in the future, allowing for identification of targeted measures. Aligning data gathered under the Water Framework Directive, with datasets from focused ecosystem services approaches, supports development of services accounts (supply and use tables) for water provisioning and water quality. Information on the flow of other ‘competing services’ such as food and timber production, is also necessary to inform decision making and make trade-offs in relation to benefits, such as the sustainable use of water resources and protection of ecosystem services.

## 8E\_SS19 Aquatic metacommunity ecology in depth: ecosystems, scales and applications

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### Community-isolation determines fish biomass, species richness and functional evenness in a river-metacommunity

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8E\_SS19 Aquatic metacommunity ecology in depth: ecosystems, scales and applications, July 29, 2021, 13:15 - 14:45

Dendritic networks are exceptional metacommunity models to advance on the role of individuals flow among communities as determinant of biodiversity patterns. Incoming dispersers and local conditions are expected to systematically change along connectivity gradients from headwaters to downstream communities in riverscapes. However, the interplay between isolation-centrality gradients and environmental conditions as drivers of biodiversity structure and function has seldom been considered. Herein, we represented the dendritic structure of the Negro River basin riverscape (Uruguay) in a directed graph quantifying the isolation-centrality of each river section and evaluated the direct and indirect pathways by which riverscape structure and environmental local conditions determine fish community assembly—i.e., abundance, biomass, richness, and functional diversity. We showed that the range of isolation among river sections strongly determines fish community structure. Additionally, isolation-centrality was positively associated with local temperature and conductivity, while negatively related to local depth. These variables and taxonomic richness accounted for most of the variation in total fish biomass (81%), used as measurement of ecosystem function. Local fish abundance was negatively and positively associated with functional evenness and taxonomic richness, respectively. Furthermore, once the effect of isolation on biomass and richness was accounted for, an effect of diversity on biomass became evident. Our results provide empirical evidence for the role of riverscape structure on taxonomic and functional diversity, biomass, and the relationship between biodiversity and ecosystem function. We emphasize that in the understanding of biodiversity and its management, local determinants should not be considered without attention to metacommunity processes.



## Disentangling local and spatial drivers of macroinvertebrate community organisation in intermittent rivers

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8E\_SS19 Aquatic metacommunity ecology in depth: ecosystems, scales and applications, July 29, 2021, 13:15 - 14:45

The metacommunity framework faces conceptual challenges when it comes to understanding the relative importance of local environmental factors and spatial processes in shaping communities, especially where those communities interact among multiple habitats (i.e. rivers, pools), and are in highly dynamic ecosystems through time and space. Temporary rivers are characterised by flow cessation, and thus shift between lotic, lentic, and dry habitat phases that are spatio-temporally dynamic, making them a relevant model ecosystem to investigate those conceptual challenges. Biodiversity has been traditionally studied by using a taxonomic approach, but species functional characteristics also strongly influence their persistence in an ecosystem. The aim of our study is to examine whether spatial processes (e.g., dispersal limitation/source-sink processes) or local environmental variables (niche processes) dominate variation in macroinvertebrate community composition among perennial and intermittent mesohabitats by using a taxonomic and functional approach. For this study, we used an aquatic macroinvertebrate dataset from four braided rivers and streams of the Po River catchment in Northern Italy. Aquatic macroinvertebrates were collected from 3 mesohabitats (i.e., the main channel, a secondary channel, and pools) from perennial and intermittent sections during seven sampling occasions from June 2015 to April 2016. The Moran Spectral Randomisation Mantel procedure will be used to disentangle the local and spatial drivers of macroinvertebrate community organisation among perennial and intermittent mesohabitats.

## Mapping lake plankton communities: the role of landscape scale and network centrality-isolation.

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Landscape features may affect aquatic communities in two very different ways. On the one hand, geo-physical characteristics at the catchment level have direct implications for its waterbodies (e.g., bedrock, soil, water residence time). On the other hand, landscape position and/or structure define how aquatic habitats are connected (e.g., geographically close or via waterways). While catchment physical characteristics role is out of question, the role of connectivity is often debated - especially for microscopic and passively dispersing organisms. The influence that landscape structure might have on these organisms may largely vary depending on the different scale at which the landscape is considered. Therefore, to understand the role that different landscapes might have on the biodiversity of such groups appears key to understand their assembly processes. Here, we sampled the plankton communities of 55 lakes in the northern Alps (16S & 18S amplicon sequences, phytoplankton and zooplankton) and calculated several community indices (e.g., environmental tracking, alpha, beta diversity). We then built several regional networks responding to different landscape scales and calculated several connectivity indices. Each group showed variable patterns but beta-diversity partitions changed their interaction with centrality values both across scales and among groups. For example, increased centrality was related to greater replacement in zooplankton while other groups presented opposite patterns. Such responses would highlight not only that smaller taxonomic groups are affected by the relative position of their habitat along a centrality-isolation gradient, they also indicate that the assembly of these groups is being affected at the regional scale.

## Can hydrological connectivity affect metacommunity assembly in streams at small spatial scales?

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According to the metacommunity theory, environmental filtering should prevail over spatial factors at small spatial scales due to low dispersal limitations. The response of metacommunities to changes in hydrological connectivity mainly depends on the dispersal ability of the species. Obligate aquatic species need flow connectivity between sites to disperse, whereas those taxa that can disperse overland (either actively or passively) do not. For example, in Mediterranean stream networks, sites that are close in space can be fairly isolated from each other due to seasonal drying. Here we studied 25 sites belonging to 7 pristine and small stream networks in northeast of Spain. We hypothesized that hydrological connectivity could play a significant role in explaining metacommunity assembly at very low spatial scales, especially for obligate aquatic taxa. We focused on aquatic macroinvertebrates due to their abundance, diversity and wide range of dispersal strategies. We measured flow permanence using data-loggers and local habitat variables, and calculated hydrological connectivity using network analysis. In this talk we will present our preliminary results and discuss the importance of hydrological connectivity for regional biodiversity in stream networks with recurrent drying.

## The role of local, regional and network scales across a dispersal gradient.

**Dr David Cunillera-Montcusí<sup>1</sup>**, Dr Jordi Bou<sup>2</sup>, Dr Miguel Cañedo-argüelles<sup>3</sup>

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According to the metacommunity theory local aquatic communities are assembled through a combination of local and catchment scales processes, which are further modulated by network connectivity and the dispersal abilities of the organisms. Understanding the relative importance of local and regional drivers at different spatial scales and/or different dispersal gradients is one of the main challenges currently faced by metacommunity ecology. In this regard, lotic systems are especially interesting as their connectivity has as a strong directional influence (i.e., dendritic networks). The interplay among this directional component and different dispersal modes and abilities plays a central role in metacommunity assembly. In this study, we compiled and analysed a dataset covering the whole Ebro river catchment (the largest river catchment in Spain) with hundreds of sampling sites and four taxonomic groups (macrophytes, diatoms, macroinvertebrates and fish) to understand and quantify the influence that local, regional and network properties have on alpha (species richness) and beta diversities (replacement and richness difference). Preliminary results show that local factors significantly explained changes in alpha diversity for all groups whereas a combination of local and regional factors explained beta diversity patterns (especially for macroinvertebrates and fish). Network connectivity was strongly relevant for fish whereas its importance was minimal for the rest of studied organisms. Overall, our study shows that the 3 spatial scales considered (local, regional and network) play a role in shaping aquatic communities, but their importance is highly dependent on the dispersal mode and ability of the organisms.

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### The Citizen Science Stream Index –a novel, simple, biomonitoring protocol for non-experts.

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<sup>1</sup>*UCC, Ireland*

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Despite several decades with the European Nitrates and Water Framework Directives, the water quality of many of Europe's river and lakes remains stubbornly unsatisfactory. The cause is largely due to inputs of nutrient-rich organic matter of agricultural and municipal origin. Despite this depressing state of affairs, the vast majority of Ireland's waterways - especially smaller streams - are not routinely monitored in terms of water quality. A spatially-extensive biomonitoring programme involving non-expert citizens would provide valuable data on how - and where - streams are being polluted. It would also give citizens a much greater stake in the quality and health of the streams in their neighbourhood. Current biomonitoring protocols – even those targeted at non-experts – tend to require advanced levels of taxonomic expertise, which are likely to discourage citizens from engaging in the important issue of local stream water quality. Here we report on the development of a Citizen Science Stream Index (CSSI) – a simplified macroinvertebrate biomonitoring protocol, based on a small number of commonly occurring, easily identifiable and distinct taxa that are strong indicators of clean or polluted waters. We show that despite the basic nature of the protocol, it relates well to other more complex and established schemes. We believe that the CSSI can be a practical and important tool in the effort to improve water quality in Ireland and Europe.

## A citizen science project to tackle plastic pollution in Pyrenean rivers

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The accumulation of plastic in aquatic ecosystems is a growing global problem, since it continues to impact the environment as it fragments and degrades. Recent works indicate that rivers may function as (temporary) sinks for land-based plastic pollution and a potential source of its future remobilization. Under PLASTICØPYR project, we have performed field protocols to monitor macro (MacP > 5 cm), meso (MesP 5 cm – 5 mm) and microplastic (MicP < 5 mm) pollution in rivers of the Pyrenees. We observed that the riparian areas with higher tourism activity present a larger density (item/m<sup>2</sup>) of macroplastics. Because of that, we want to address our citizen science programme to the importance of educating population about litter focusing on single-use plastics. A mobile application (Marine Debris Tracker), designed originally for costal sites, is the key element where users can upload the MacP and MesP found in riparian areas to contribute to the study. It has been created adapting the scientific protocols into simpler instructions to obtain rigorous feedback. The app and the protocols of analysis provide geo-localized data of plastic items disaggregated by categories on a known area. Also, a section is dedicated to characterise the sampled area to give knowledge about the river ecosystem. Finally, the programme includes educational guides that provide complementary tools to contextualize the results, make conclusions and elaborate plastic reduction proposals. On SEFS12, we will explain you about our methodological approach to face the challenge of making science closer to citizen.

## The role of citizen science in regulatory water quality monitoring

**Dr Isabel Bishop**<sup>1</sup>, Stuart Warner<sup>2</sup>, Frank Nyoni<sup>3</sup>, Arron Watson<sup>4</sup>, Matthew Fry<sup>5</sup>, Steven Loiseau<sup>1</sup>

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Citizen science (the involvement of non-scientists in scientific research) is widely used to collect valuable scientific data while simultaneously engaging the public. There is increasing interest in harnessing the scientific, social, economic, environmental, and political benefits of citizen science by using it within official national environmental monitoring schemes. Here, we explore the biases and opportunities for combining citizen science and regulatory water quality monitoring data within two national monitoring programmes with different characteristics. The first is the UK, where regulatory water quality monitoring is already widespread but new legislation requires a shift from catchment-based to national-scale water quality monitoring, following a natural capital approach. In this case, regulatory monitoring can be complemented by mass participation citizen science approaches to provide a spatially resolute snapshot of regional or national freshwater natural capital at a single point in time. The second case study is from Zambia, where a regulatory monitoring programme is being developed in tandem with citizen science activity. Regular monthly monitoring by citizen scientists at strategically-placed monitoring locations helps to fill gaps in the national programme, as well as promoting community involvement in natural resource management. Together these case studies demonstrate that freshwater citizen science helps to create a critical mass of information and informed local persons, both of which are key requirements of modern freshwater legislations worldwide.

## Designing nature-based citizen science for the Maigue River Catchment

Donna Weiner<sup>1</sup>, Dr Julian Bloomer<sup>1</sup>, Ruairí Ó Conchúir<sup>2</sup>, Dr Catherine Dalton<sup>1</sup>

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Protecting river water quality is challenging due to spatial and temporal geographical complexities, the number and variety of pressures, the political and administrative agendas and the oftentimes lack of meaningful opportunities for involvement of local communities. This doctoral project is examining the role of nature-based citizen science as a bottom-up approach to catchment management in the ‘at-risk’ Maigue River catchment in County Limerick. The sociology and psychology of environmental volunteerism is reviewed to understand pro-environmental behaviours and sustainable environmental stewardship. A questionnaire survey on people’s connections and concerns for their local river was undertaken to understand the priorities of communities. The survey also gathered data to identify what elements of citizen science might most attract or prevent involvement. Focus groups are being implemented to further elucidate motivations, preferences, barriers and experiences of active environmental volunteers and non-volunteers. The survey and focus groups will act as a first step in connecting a network of conservation volunteers focused on the Maigue River catchment and will also provide opportunities for the co-design and co-development of citizen science initiatives.



## The use of citizen science tools to characterise temporary stream habitat conditions.

Chloe Hayes<sup>1</sup>, Dr Judy England<sup>2</sup>, Dr Carl Smith<sup>1</sup>, Dr Rachel Stubbington<sup>1</sup>

<sup>1</sup>Nottingham Trent University, <sup>2</sup>Environment Agency

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Temporary streams, which sometimes stop flowing in time and/or space, form approximately half the global network, and are widespread in cool temperate countries such as the UK. Temporary stream science is advancing, but our understanding of how aquatic macroinvertebrates respond to changes in habitat conditions that covary with intermittence remains limited, as does research exploring terrestrial dry-phase community responses to hydrological variability. We investigated responses of temporary stream communities to varying habitat conditions, using two sources of citizen science data. Firstly, we analysed dry-phase community responses to hydrological data collected with CrowdWater, a citizen science mobile app. CrowdWater captures visual observations of flowing, ponded and dry instream conditions, thus providing extra information on flow state that cannot be determined from discharge data by distinguishing ponded from dry. Secondly, we used the Modular River Survey method (MoRPh, a citizen science tool) to document instream hydrological conditions, sediment composition and channel morphology, and instream and riparian vegetation. MoRPh data allowed characterisation of macroinvertebrate responses to instream habitat variability at a catchment spatial scale. Our research shows how data collected using simple citizen science tools can advance our understanding of community responses to environmental variability in temporary streams.

## Drinking water management perceptions, priorities, and expectations: comparing decision-makers and water consumers using Multicriteria Analysis

Dr Angelos Alamanos<sup>1</sup>, Dr Alec Rolston<sup>1,2</sup>, Dr Suzanne Linnane<sup>1</sup>

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The coverage of water needs with the optimum way and quality of services is a major concern of most Water Utilities today. Water resources are not infinite and therefore water conservation measures are increasingly examined. The Water Utility's response to this, the enhancement of public participation and the use of new technologies in urban water management are key factors in improving water services. The research question arising is how to achieve efficient and sustainable drinking water supply, in a socially acceptable way, involving water-users in the decision-making process, and satisfying their needs. This study assesses the perceptions of a Greek Water Utility and its consumers, the respective managerial priorities and expectations, regarding water supply services. A questionnaire survey designed to illicit information relating to consumer demographics, water consumption and conservation, and services provided by the Water Utility. Relevant Water Utility personnel were also surveyed. A detailed statistical analysis was performed, followed by the Analytical Hierarchical Process (AHP) to set weights to water conservation measures, policy and desired future objectives. AHP provided a ranking for each sample-group's perceptions and priorities on the factors affecting water consumption, and water conservation measures. The results were compared, gaps in understanding and cooperation were identified and used for informing both consumers and Water Utility personnel about each other's preferences. The model used has an operational character and could be applied to any similar case, promoting cooperation between DMs and stakeholders, towards a sustainable and globally optimum management.

## 9A\_SS16 The science and management of multiple stressors in aquatic ecosystems & SS21 Chemistry, biology and ecology of protected oligotrophic lakes in Europe

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### Establishment of synthetic benthic community as a model system for freshwater periphyton

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Freshwater biofilms, also known as periphyton, are important players in ecosystem functioning. Periphyton is influenced by a multitude of biotic and abiotic factors, which may alter its composition and the ecological functions it provides. However, due to the high complexity of natural periphyton, understanding the mechanisms that underlie such alterations is challenging. In this work, we developed a standardized workflow to establish a reproducible synthetic periphyton, which enables to overcome such challenges and test for various mechanistic hypotheses via targeted manipulation. This model system consists of 29 benthic phototrophic species (17 diatoms, 7 green algae and 5 cyanobacteria) sequentially added to a bacterial EPS layer and growing under controlled conditions. As a proof of principle, we used the established biofilm community to study the combined effects of the herbicide terbuthylazine and temperature (i.e., 17 and 20°C) on species composition, 3D structure and function during periphyton formation. Our results show that exposure to terbuthylazine altered species composition and 3D structure of the community at both temperatures. Moreover, the photosynthetic activity of the community was severely impaired upon exposure to terbuthylazine. Importantly, by using a synthetic periphyton, with a known microbial composition, we were able to examine precisely how each species within the community responded over time to the tested stressors, singly or in combination. Overall, such a complex benthic community, can be used as a tool to perform mechanistic studies on periphyton structural and functional responses, as well as on species propagation, to any biotic and abiotic stressors and their combinations.

## Multi-stressor effect types comparison between salt and freshwaters

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Aquatic systems are exposed to a combination of stressors more frequently than to a single stressor. Although studies considering effects of multiple stressors exist, they do not usually categorize them to allow a homogenous comparison across fresh and salt waters to detect patterns that could help in the implementation and effectiveness of management measures. In this work, a quantitative analysis was conducted of 351 cases distributed worldwide to compare multi-stressor effect types (dominant, additive, interactive) between fresh and salt water domains. Data on paired-stressor responses, including land-use and climate change stressors, were collected and their effect type calculated by a uniform statistical approach, making cases directly comparable. The frequency of the three multi-stressor effect types were compared between domains. For identical pairs of stressors the relative absolute effect sizes were calculated to reveal which of the two stressors had the stronger effect on the biological response. We found that effect types' frequencies were similar across both domains despite being impacted by very different stressor combinations. Nutrient enrichment was the most frequent stressor in both domains, morphological alterations were most frequent in freshwaters and thermal stress and acidification were most frequent in salt waters. Results show some general mechanisms yet to be understood that affect both domains and drive multi-stressor effect types despite the different nature of the paired-stressor combinations. It is also noteworthy the different behaviour in terms of effect types of transitional waters according to their main dynamic, which remarks their complex functioning.

## Impact of land use on water, sediment and macrophytes of soft-water lakes

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The water quality of soft-water lobelia lakes and their characteristic vegetations are sensitive to the pH and nutrients concentration changes. In Poland, due to land use policy and climate change, those ecosystems are at a threat of increased eutrophication and systematically decline. This study focused on 14 lakes, in which 11 are included in Natura 2000 system as habitat 3110 - oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*) and four are additionally protected as a natural reserve. The investigated lakes had at least one characteristic species of mentioned Natura 2000 habitat. The aim of the study was to linked physio-chemical variables of water and sediments of lakes to the aquatic plant species composition and the land use in the immediate neighbourhood (100 m buffer zone) along the pH gradient. The research was carried out in July of 2020 on lakes characterized by pH from 4.78 to 9.21. We found out that several physio-chemical variables correlated with the land use characteristic. The nutrients concentrations, pH and conductivity positively correlated with the presents and the coverage area of the discontinuous urban fabric, similar findings were noted for non-irrigated arable land. Opposite relationships were found in respect to pine forest. Moreover, most frequently recorded aquatic species as *Littorella uniflora*, *Lobelia dortmanna*, *Isoëtes lacustris*, and *Luronium natans* also responded on water and sediments parameters as well as land use. The studies were financed by Polish National Science Centre, under project No 2019/32/C/NZ8/00147.

## Mapping dystrophic waterbodies through time – a new approach for England

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Dystrophic waterbodies are a distinctive freshwater habitat, typified by peat-stained, acidic waters that only specialist macrophyte species are able to tolerate. Peatland degradation across England is considered to have reduced the range of dystrophic habitats, but understanding these changes is difficult because previous habitat assessments have typically been made on a site-by-site basis, rather than on the national scale. Furthermore, small waterbodies are thought to comprise a large part of the habitat and these can only be delineated with detailed mapping. This study combined Natural England's peat data for England with high resolution OS MasterMap data to map potentially dystrophic waterbodies across England, using hydrological catchments for lakes (>1ha) and scaled buffer catchments for ponds (<1ha) to assess peat coverage. Biological records data for 12 key dystrophic macrophyte species were analysed to further assess dystrophic habitat, using a presence/absence approach at the hectad (10x10km) scale. This new data driven approach for a national habitat assessment led to a current total predicted habitat dystrophic waterbody surface area of ~24 km<sup>2</sup>, considerably more than previous figures. Using historical records for key dystrophic species over three time periods: pre-1950, 1950-1990 and post-1990, it is clear that for much of England the general trend is towards decline in occurrence, inferring that dystrophic habitats, particularly small, shallow pools, have been lost. There are some notable areas where species occurrences have increased and these places are likely to be most important for the future maintenance of the dystrophic habitat in England.

## Peatland oligotrophic lake habitats in Europe: A case study from Ireland

**Dr Emma Gray**<sup>1</sup>, Giovanni Cappelli<sup>1</sup>, Dr Martin Gammell<sup>1</sup>, Dr Cilian Roden<sup>2</sup>, Dr Heather Lally<sup>1</sup>

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Oligotrophic lakes and pools, situated within blanket bogs, are rare and unique habitats containing a suite of specialist species. Two examples of these habitats defined under the EU Habitats Directive are: '3110 Oligotrophic waters containing very few minerals of sandy plains or oligotrophic isoetid lake habitat type' and '3160 Natural dystrophic lakes and ponds or acid oligotrophic lake habitat'. Historically, these habitats have been subject to widespread degradation caused by the overgrazing and cutting of the blanket bog, in addition to eutrophication and climate change. As a result, 3110 and 3160 lake habitats in the Republic of Ireland have an "unfavourable-bad" and an "unfavourable-inadequate" conservation status, respectively, under the EU Habitats Directive. Despite this, small lakes and pools such as oligotrophic peatland lakes, are often overlooked in conservation efforts and monitoring programmes. This means there is a lack of knowledge pertaining to their typical physico-chemical and ecological characteristics along with reference conditions to guide conservation targets. This review summarises our current understanding of 3110 and 3160 lake habitats; assesses the current methods used to derive their conservation status under the EU Habitats Directive and identifies gaps in our current understanding of these habitats. We also suggest that additional biological monitoring elements such as algae, macroinvertebrates and chydorids could help further elucidate the structure and function of these lake habitats, while metrics that quantify biodiversity and species rarity, could guide conservation and management efforts.

## 9B\_RS18 Microplastics: sources and impacts

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### Analysis, prevalence and impact of microplastics in freshwater and estuarine environments.

Dr Iwan Jones<sup>1</sup>, John Murphy<sup>1</sup>, Dr Amanda Arnold<sup>1</sup>, Dr James Pretty<sup>1</sup>, Prof Kate Spencer<sup>2</sup>, Dr Arjen Markus<sup>3</sup>, Prof Dick Vethaak<sup>3,4</sup>

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Using the systematic review procedure, we assessed the evidence available on the analysis, prevalence and impact of microplastics in freshwater and estuarine environments. Measurement methods are yet to be standardized and a wide variety of methods have been used. We found that sampling methodology influences the concentration of microplastic particles returned, with relationships among the volume of water sampled, the size of the smallest particles studied, and the mean abundance of microplastic particles reported. Similarly, we assessed the influence of the methodology used in toxicological tests, and found that the size of the particles used affects threshold concentrations above which microplastics affect freshwater and estuarine biota. Hence, standard species sensitivity distribution (SSD) approaches for setting a threshold concentration where microplastics present a hazard to a limited number of taxa are not appropriate for microplastics. We present an approach that provides a size-specific concentration of microplastics that is lower than 90% of the thresholds identified for survival and, as a more conservative limit, across all endpoints tested including sublethal effects. By comparing these thresholds with the data on concentrations of microplastics reported by field studies, we assess the risk presented by microplastics in freshwaters and estuaries in a way that is not constrained by the limitations of the methods used to date.



## Ecology of freshwater bacterial communities confronted with tyre wear and PET particles

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Although tyre wear derived microplastic particles (TW) represent up to 50% of microplastic (MP) pollution in rivers and seas, very little is known on their impact on aquatic microbial communities.

We experimentally tested the potential of TW in comparison to a widely studied particle (PET) to favour the establishment of allochthonous bacteria in open waters, exposed to constant contamination by wastewater effluents, along a gradient with different relative abundance of the two plastic types. The gradient, in semi-continuous cultures, ranged from 100% PET to 100% TW, with plastic free triplicates control treatments.

While PET in high concentrations maintains bacterial diversity better than TW or the surrounding water, bacterial abundances are higher at higher concentrations of TW, possibly because of a modulated effect of the compounds released by this complex particles. TW supports the growth of biofilms with potential pathogenic groups better than PET, but strongly reduces potential pathogen diversity, to those genera already present, as rare species, in lake water (e.g.: *Legionella*, *Pseudomonas*, *Aeromonas*, *Acinetobacter*). When PET is proportionally dominant, potential pathogens diversity is higher, and many allochthonous (introduced in the system with the wastewater effluent) potential pathogenic bacteria (e.g.: *Escherichia*, *Enterobacter*) seems to find a refuge on PET. Rising the percentage of TW these groups get outcompeted. This study is the first experimental attempt to assess the impact of tyre wear particles on microbial communities in waters, and our results are calling for the important role played by this neglected MP in shaping natural communities exposed to plastic pollution.

## PLASTICØPYR-PROJECT. Quantifying plastic litter in mountain riverine systems: from macro- to microplastics

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9B\_RS18 Microplastics: sources and impacts, July 29, 2021, 15:30 - 17:00

Plastic pollution is one of the most serious environmental issues worldwide. Plastics have been proved to affect all-natural habitats, even the most pristine, via the global network of land, rivers, lakes, seas and oceans, and atmospheric transport and deposition. Although the effects of plastic pollution in freshwater ecosystems are poorly understood, recent works indicate that rivers may function as temporary sinks for land-based plastic pollution and as a potential source of its future remobilization. The PLASTICØPYR project responds to the task of making tourism compatible with the conservation of mountain freshwater ecosystems by developing unique protocols that are to be applied in natural areas located in the Pyrenees of Catalonia, Andorra and France. These areas are selected based on their different levels of human impact, mainly due to the presence or absence of ski resorts and hiking areas. Our results prove that the riparian areas with higher tourism activity present a larger density (item/m<sup>2</sup>) of macroplastics. When exposed to erosion forces, such macroplastics are broken into microplastics which can, among other things, directly affect the health of aquatic organisms. On SEFS12, we will explain you about our integrative methodological approach to tackle the challenge of extracting and quantifying microplastics in different river matrices (water column, biofilm, sediment and fish) concurrently. We aim to acquire a holistic understanding of the link between human activity and plastic pollution in fluvial systems in order to tackle and remediate this environmental problem in pristine areas such as the Pyrenees.

## Fate and effects of microplastics in freshwaters: insights from a microcosm experiment

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9B\_RS18 Microplastics: sources and impacts, July 29, 2021, 15:30 - 17:00

Ever-increasing anthropogenic activities have led to elevated concentrations of plastics and microplastics (<5mm) in freshwater environments, the presence of which has been shown to adversely affect many aquatic organisms. As freshwater systems play a fundamental ecological role, the need to examine the impact microplastics have on these environments and their biota is dire. The aim of this study was to improve our understanding on how microplastics affect aquatic insects at the aquatic-terrestrial habitat linkage. A two-month microcosm experiment was conducted with a simplified freshwater food web containing nonvascular macrophytes and caddisfly (Trichoptera) larvae feeding mainly as shredders. The microcosm was exposed to a mixture of four types of microplastics (polypropylene, polyethylene, polystyrene, high-density polyethylene) at environmentally relevant concentrations, after which samples of caddisfly tissues and cases, moss and sediment were collected and analyzed. Our results indicate that caddisfly larvae mostly ingest polyethylene, but only a small quantity of particles accumulates in their tissues. No microplastic particles were detected in emerged adults. The response of caddisflies and moss to microplastic stress at the molecular level is currently being investigated, the results of which will further be discussed. Considering the far-reaching impacts microplastics can have on aquatic biota, the results of this study are essential for broadening our understanding of emerging contaminants in the environment.

## Longitudinal distribution of microplastic in rivers, potential sinks and implications for biota

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9B\_RS18 Microplastics: sources and impacts, July 29, 2021, 15:30 - 17:00

It is assumed that 80% of the marine plastic originates from land and major parts may be transported via rivers. In each river studied so far for plastic contamination, plastic was found. However, the longitudinal distribution of plastic in rivers is largely unknown. We investigated the microplastic distribution along a 70 km long stretch of a German river, starting at the source. We sampled floating microplastic every seventh kilometer and upstream and downstream of major inflows, towns and waste water treatment plants. Results showed that the amount of suspended plastic does not correlate with the kilometers flew. Some sampling points downstream other contain less plastic than sites located more upstream. Weirs and reservoirs may act as sinks for microplastics as decreasing flow velocities lead to higher sedimentation rates. This may enhance the uptake of plastic by benthic organisms and (temporally) excludes plastic from the water column. This may result in unexpected patterns of plastic distribution in freshwaters and diverse impacts on freshwater fauna.

## The effect of microplastic particles on the interspecific competition of *Daphnia*

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9B\_RS18 Microplastics: sources and impacts, July 29, 2021, 15:30 - 17:00

Microplastics pollution (MP) of freshwater environments is currently one of the most intensely studied issues in the field of ecology. Many studies attempt to estimate the distribution and concentration of MP in various environments and determine how MP affects their inhabitants. However, much less effort has been undertaken to assess the effect of MP particles on the inter- and intraspecific interactions between aquatic organisms, including interspecific competition in *Daphnia*. We assumed that the presence of MP may mitigate interspecific competition. To test it, we performed 3 long-lasting (60 days) competitive experiments in the absence (control) and the presence of different types of MP particles (polyhydroxybutyrate, polystyrene and high-density polyethylene, each of 30  $\mu\text{m}$  in diameter), at limiting algal food concentration ( $0.2 \text{ mg} \times \text{C L}^{-1}$  supplied daily) and 3 pairs of *Daphnia* (*D. magna* and *D. pulex*, *D. magna* and *D. galeata* and *D. pulex* and *D. galeata*). In the presence of each of the three types of MP the population density of a superior competitor (*D. magna* in relation to *D. pulex* and *D. galeata*, and *D. pulex* in relation to *D. galeata*) decreased while the population density of an inferior competitor increased in relation to the controls. The negative effect of MP on the population density of superior competitors was due to increasing mortality rate rather than decreasing birth rate.

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### The environmental impact of cattle access on watercourses

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9C\_RS02 Agriculture/Forestry operations and water quality, July 29, 2021, 15:30 - 17:00

Cattle access to watercourses has been reported to impact water quality; however, some conflicting studies have indicated that cattle do not have a significant effect on some aspects of stream water quality. Despite some divergence of opinion in the literature, cattle exclusion measures, typically in the form of fenced riparian buffers, have been included in most European agri-environment schemes. Whilst the effectiveness of riparian buffers as a multi-functional management tool has been widely researched, few studies have specifically assessed the impact of cattle exclusion on water quality parameters, especially within Europe. The COSAINT project, Cattle access to watercourses: environmental and socio-economic implications, assessed the environmental and ecological impact of cattle impact on freshwater ecosystems, across a gradient of farming intensities. Results indicated that cattle access to watercourses resulted in significant increases in the deposition of fine bed sediment and the infiltration of sediment into the interstitial habitat. Increased stream sediments acted as reservoirs for faecal bacteria and phosphorus, which persisted when cattle were removed periodically from the field, but did not persist after cattle were fully removed. Increased sediment deposition was also a dominant driver of macroinvertebrate community change, although results here were more variable. Near real-time monitoring also showed increases in turbidity and suspended sediment, E. coli, TP and ammonium when cattle were in the stream. These results will provide important information for policymakers in relation to the Nitrates and Water Framework Directives. It will also help guide agri-environmental policy and facilitate sustainable objectives under Farm to Fork Strategy.

## Implications of downstream agrochemical pollution for organisms in refuges

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9C\_RS02 Agriculture/Forestry operations and water quality, July 29, 2021, 15:30 - 17:00

In the last two decades, several studies have shown that pesticides shape invertebrate communities in streams, typically associated with an increase in the relative abundance of tolerant taxa. However, our understanding of the population and community response to toxicants is still deficient with respect to spatial and temporal dynamics of potential adaptation processes. Several studies showed that non-polluted upstream sections can buffer effects in pesticide-polluted downstream patches. Modelling studies suggested that this buffering of effects in polluted patches reduced population sizes in upstream sections. However, empirical studies regarding the potential propagation of downstream pesticide effects to organisms in upstream sections (hereafter: refuges) are scarce. If present, such effects are most likely to occur at the edges, i.e. the downstream section of the refuge that directly connects to the polluted stream section. In this project, we tested the assumption that pesticide exposure sets off adaptation processes and that pesticide effects can propagate to organisms in refuges. Gammarids and trichopterans were sampled from pesticide-polluted downstream sites and two upstream forest locations (edge of refuge and further upstream) in six small streams in South-West Germany. To evaluate potential adaptations, the tolerance of the invertebrates was determined by rapid toxicity tests using a widely detected insecticide in streams of the region. Moreover, we investigated whether pesticide exposure is associated with higher energy costs for defense mechanisms, resulting in lower energy reserves, through analysis of the lipid content as an important indicator of long-term energy storage.

## Natural water retention measures: Water quality management in an Irish agricultural catchment

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9C\_RS02 Agriculture/Forestry operations and water quality, July 29, 2021, 15:30 - 17:00

Agricultural catchments are affected by elevated loadings of nutrients and suspended solids, channelization of low-order streams and the presence of complex networks of sub-surface drainage. Such aspects of the hydro-morphological and biological character of agricultural landscapes have the combined effects of inducing both chronic and flood-driven surges of nutrients and suspended solids to receiving water bodies. While legislation such as the Nitrates Directive and the Water Framework Directive may achieve some degree of reduction in the flux of water quality pressures to receiving streams, rivers and lakes, water quality continues to degrade both in Ireland and internationally at a worrying pace. Temporary offline retention of surface water is known to reduce downstream flood risk and to encourage the deposition of suspended solids and biological uptake of labile nutrients such as Soluble Reactive Phosphorus (SRP) and Dissolved Organic Carbon (DOC). In-stream structures which help to retain Particulate Organic Matter (POM) and enhance interactions between hyporheic microbial communities and nutrients in the water column have also been shown to aid in attenuation of pollutants. The current study, conducted on a mixed-use farm in Co. Cork, Ireland, is investigating the potential for nature-based solutions, namely Natural Water Retention Measures (NWRM) such as in-stream and offline water retention areas, to attenuate floods and entrained water quality pressures. Chemical and hydrological data are being collected from a low-order stream within the farm as it is diverted and temporarily retained on forested and rye-grass dominated retention areas, and as its flow is altered by in-stream structures.



## Mitigating water pollution from agriculture: can advice-led approaches create long-term behavioural change?

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9C\_RS02 Agriculture/Forestry operations and water quality, July 29, 2021, 15:30 - 17:00

Agricultural land management can have an adverse impact on water quality. Advice-led, voluntary initiatives have been shown to reduce agricultural pollution and improve water quality; however, the evaluation of such initiatives on long-term behavioural change is limited. This study assesses the long-term impact of the Catchment Sensitive Farming (CSF) programme, an initiative which has provided advice to enable farmers to reduce pollution at over 20,000 holdings across England since 2006. A survey was undertaken to assess the implementation of previous CSF advice at 100 farm holdings across 11 “legacy catchments”, where CSF had previously been engaged but had not been active for at least four years. The results were compared with previous records to identify changes in the uptake of advice over time. The results indicate that the majority of advised mitigation measures implemented while CSF was active have been maintained and continue to be used, with <1% having lapsed. Of those mitigation measures which had been advised but not implemented while CSF was still active, more than 50% have subsequently been implemented. The high level of continued uptake and further implementation of recommended advice several years following active CSF engagement suggests that the advice provided by the programme has enabled long-term uptake of pollution mitigation measures in these catchments. This study provides valuable insight into the long-term impact of an advice-led initiative and suggests important considerations for similar assessments as well as future approaches to engaging with the agricultural sector.

## The impacts of cattle in-stream activity on water physicochemical and microbial parameters

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9C\_RS02 Agriculture/Forestry operations and water quality, July 29, 2021, 15:30 - 17:00

Where pastoral agriculture dominates, the practice of allowing cattle access to farmland watercourses as a cheap and low maintenance source of drinking water has been shown to have a potential adverse impact on water quality. Nevertheless, studies attempting at quantifying this impact are scarce, particularly in a European context. In this study, the impacts of cattle in-stream activity on water physicochemical (SRP, TP, NO<sub>3</sub>-N, NH<sub>4</sub>-N, TSS) and microbial (*Escherichia coli*) parameters were investigated using sub-hourly water monitoring in Ireland. Sampling was based on “events”, i.e. periods of up to 5 hours when water samples were collected automatically every 3 minutes, upstream and downstream of a used cattle access site. Motion-activated cameras deployed at the access site were used to determine times of cattle access to the stream, animal numbers, and episodes of in-stream defecation and urination. Cattle access to the study stream consistently led to increases in water concentrations of *E. coli* bacteria and TSS, and, less frequently, of NH<sub>4</sub>-N, which overall resulted in significantly higher loads to the stream compared to loads observed at times of no cattle access. In contrast, no significant increase in loads was observed for SRP, TP or NO<sub>3</sub>-N. These results suggest that unrestricted cattle access to watercourses can potentially contribute to water quality deterioration and increased public health risk. To our knowledge, this is the first study attempting at quantifying the impacts of cattle in-stream activity on a broad range of water quality parameters at a high temporal resolution.

### Cryptic diversity in *Heterocypris salina* (Ostracoda) using mitochondrial and nuclear DNA sequences

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9D\_SS06 European Freshwater Ostracoda, July 29, 2021, 15:30 - 17:00

*Heterocypris salina* (Brady, 1868) is a halophilic ostracod with a Holarctic distribution, occurring almost exclusively as asexual (all-female) populations in slightly brackish inland or coastal waters. This classical morphospecies displays remarkable phenotypic variation in carapace shape, size and coloration, but its genetic diversity has thus far not been studied. Such an approach seems nevertheless relevant, as recent molecular studies have shown the astonishingly high cryptic diversity within some species of the family Cyprididae. Here, we present the first results of a molecular study exploring genetic differentiation of *H. salina* from thirteen localities in Greece, Italy, Morocco, Poland and Australia, using both mitochondrial (COI and 16S) and nuclear (LSU) DNA sequence data obtained from a total of ninety eight individual females. The results of phylogenetic reconstructions, genetic networks and estimates of genetic distances strongly support the existence of distinct genetic lineages within *H. salina*. Some mtDNA haplotypes were separated by more than fifty mutational steps and showed a genetic divergence of more than 20%. To test species boundaries comparing intra- and inter-lineage differences, we applied the barcoding gap identification and the  $K/\theta$  method, as well as a tree-based bPTP approach. The obtained results showed a high degree of congruence between the mitochondrial and nuclear data analyses, although some mito-nuclear discordance was observed. Our results show that the morphospecies *H. salina* actually comprises a complex of at least five cryptic genetic species.

## European freshwater ostracods in a Holarctic context: Taxonomic harmonisation of large databases

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9D\_SS06 European Freshwater Ostracoda, July 29, 2021, 15:30 - 17:00

Worldwide freshwater ostracod studies are taxonomically rooted in Europe by the pioneering activities of 18th, 19th and early 20th century scientists (e.g., G. Alm, W. Baird, G.S. Brady, O.G. Costa, S. Fischer, A. Hartwig, N. Hirschmann, T.R. Jones, L. Jurine, W. Kaufmann, C.L. Koch, W. Lilljeborg, G.W. Müller, O.F. Müller, A.M. Norman, K.A. Ramdohr, D. Robertson, G.O. Sars, W. Vávra, W. Zenker). According to a recently published checklist there are presently 2330 subjective species of non-marine ostracods in 270 genera worldwide, with 799 species in the Palaearctic region and 439 in the Nearctic. In view of the increasing online availability of large databases of ostracod distribution in non-marine environments, which include saline as well as fresh waters, we recognise a need for taxonomic harmonisation to improve the compatibility of regional datasets and thus facilitate their applications in fields such as biogeography and conservation. Such efforts will benefit from a combination of morphological and molecular approaches. The unparalleled fossil record of non-marine ostracods presents additional taxonomic challenges as well as opportunities for applications, for example in the reconstruction of past environments and climates. To illustrate progress and future needs we will map and discuss the current state of database coverage of the Holarctic (i.e., Palaearctic + Nearctic) zoogeographic region at species and higher levels, considering issues around endemism and cosmopolitanism. The challenges of taxonomic harmonisation between databases will be discussed and illustrated with examples at generic and specific levels. Case studies of selected taxa will explore the utility of harmonised datasets.

## A new and exotic Cyclocypridinae ostracod expanding over Iberian wetlands

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9D\_SS06 European Freshwater Ostracoda, July 29, 2021, 15:30 - 17:00

A previous study carried out in 2000 showed a total lack of living ostracods at the bottom of the Albufera lake (Eastern Iberian Peninsula). However, after slight water quality recovery, some ostracods were found alive in the lake in 2012-2013, including *Limnocythere inopinata*, *Cypridopsis vidua* and an unknown species of Cyclocypridinae. This species has been provisionally assigned to the genus *Dentocypria*, recently described from Thailand. Since its finding in Iberian waters, this *Dentocypria* sp. has been found widely distributed in coastal wetlands of the Iberian Peninsula, particularly in areas with a high influence of rice field cultivation. We assume that the species has been introduced by humans, as it is not known from the paleolimnological record of the Iberian Peninsula. The putatively invasive *Dentocypria* species also has some similarities to *Physocypria* spp. and *Cypria* spp., but we could not find any described species with the same hemipenis morphology. Preliminary results from field data, and from experiments on tolerance to salt content and on oxygen consumption indicate it is a widely tolerant ostracod. This may allow it to dwell under the stressful conditions of eutrophic water bodies and to expand its distribution through disturbed wetlands.

Keywords: Ostracoda, exotic species, freshwater, integral taxonomy.

## First ostracod draft genomes providing insights into ostracod (Crustacea) biology and evolution

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9D\_SS06 European Freshwater Ostracoda, July 29, 2021, 15:30 - 17:00

Ostracods are small, bi-valved crustaceans with the most extensive fossil record of all living arthropods. Here, we describe the first draft genomes of three non-marine ostracod species. Two of these species, *Cyprideis torosa* (Jones, 1850) and *Notodromas monacha* (O.F. Müller, 1776) are obligate sexuals, while *Darwinula stevensoni* (Brady and Robertson, 1870) is a putative ancient asexual. We compare the quality and gene content of these genomes to those of published genomes of other crustaceans and discuss estimates of heterozygosity of *N. monacha* and *D. stevensoni* and the biological implications. We also present preliminary results on enriched coding genes in these genomes and compare the genomic patterns of *D. stevensoni* to those of other recent and ancient asexuals.

## Morphological, molecular and ecological differentiation between two species of *Cypridopsis* (Ostracoda, Cypridopsinae)

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9D\_SS06 European Freshwater Ostracoda, July 29, 2021, 15:30 - 17:00

During the past decades, a small Cypridopsinae ostracod has been frequently found in small waterbodies of the Iberian Peninsula, and assigned to the species *Cypridopsis parva* G. W. Müller, 1900, which is considered a senior synonym of *Cypridopsis concolor* Daday, 1900 since the 1950's. More recently, both species have been considered junior synonyms of *Cypridopsis vidua* (O. F. Müller, 1776), although some ostracodologists still consider these three species as separate taxa based on valve anatomy. To clarify this, we checked the shell morphology of Iberian *Cypridopsis* specimens previously identified as *C. parva* and found that their traits are more consistent with the description of *C. concolor*, as they can be differentiated based on shell shape, color, and intensity and distribution of pits on the valves surface, which also allow differentiation from *C. vidua*. To further clarify the distinction from this later species, we compared their soft parts and found some differences, particularly in the shape and relative size of female genital hooks, the serration of Zahnborsten on the third endite of the maxillula and the number of teeth of the rake-like organ. Molecular analysis of the 18S ribosomal gene confirmed marked differences in the DNA sequence between *C. concolor* and *C. vidua*. In addition, Iberian ecological data show that *C. concolor* prefers more temporary waterbodies, with higher pH and lower salt content than *C. vidua*. Therefore, our new evidence supports the validity of *C. concolor* as a distinct species.

Keywords: Ostracoda, integrative taxonomy, biodiversity, ecology

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## No Rivers for old fish: Longitudinal connectivity impairment of diadromous fish species

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9E\_SS15 Progress on the understanding of the water quality and habitat requirements for European unionid mussels & RS07 Fish & Fisheries, July 29, 2021, 15:30 - 17:00

Longitudinal connectivity in rivers is very important for freshwater fish, especially considering Diadromous species since it is determinant for life cycle completion. Large dams impose a serious fragmentation on river networks and affect diadromous species occurrence. This work aims to assess the structural and functional longitudinal connectivity impairment occurring in European rivers from the early 20th-century until nowadays, using historical information on 15 diadromous fish species. Historical data was obtained via databases and historical sources and curated to obtain a consistent output dataset of historical occurrence at river segment scale. Using dam location and completion year, metrics of connectivity impairment were calculated at three spatial scales (basin, sub-basin and segment) for 12 sequential time periods. Considering large river basins (78% of Europe's area), 69.5% of all basins, 55.4% of the sub-basins and 68.4% of river length are impaired. In 60 years, large rivers went from a low level of structural impairment to over two-thirds with connectivity issues, with a peak in impairment rate after WWII. As for functional connectivity impairment, in the 21st-century all species have been affected with 47% of large basins showing potential distribution losses. In some basins, certain species have more than 60% of their historical river length distribution impaired. Results are coherent across European regions and for different species, revealing the deleterious effect of dams on diadromous fish and foreseeing a challenging future for diadromous fish species. The output of this work can be used to prioritize management actions towards species conservation.



## Lake-dwelling freshwater pearl mussels (*Margaritifera margaritifera*) - A unique Irish phenomenon?

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9E\_SS15 Progress on the understanding of the water quality and habitat requirements for European unionid mussels & RS07 Fish & Fisheries, July 29, 2021, 15:30 - 17:00

The freshwater pearl mussel *Margaritifera margaritifera* L. is critically endangered throughout its range. Direct pressure from pearl fishing and indirect pressures from river pollution and physical modification, has caused a steep decline in almost all populations and extinction in some countries. The optimal habitat for pearl mussels is almost universally described as well-oxygenated, fast-flowing oligotrophic rivers and streams. Although adults can tolerate a range of habitat conditions, juvenile mussels require extremely clean waters with little or no anthropogenic impacts. Very few, if any rivers currently support self-sustaining pearl mussel populations in Ireland due to poor juvenile recruitment. We report here the discovery of a large population of freshwater pearl mussels living at between 1m and 8m depth in an oligotrophic lake in southwest Ireland. Within the lake, pearl mussel were found in two contrasting habitats – a relatively shallow (ca 1m) stretch of lake littoral, and a more extensive benthic area of 2-8m depth. The maximum depth at which a living pearl mussel was found was 9m – to our knowledge the greatest depth yet described for this species. We estimate that the population of *M.margaritifera* in the lake is between 150,000-200,000 individuals. This constitutes a significant proportion of the known pearl mussel population in Ireland. We observed occasional juveniles within the population, indicating that at least some recruitment is occurring. Our discovery of Irish lake-dwelling freshwater pearl mussels challenges our current understanding of the biology of *M.margaritifera*, and suggests that Ireland may represent a unique part its worldwide range.

## The thermal sensitivity of foraging rate in rudd and Malabar danio

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9E\_SS15 Progress on the understanding of the water quality and habitat requirements for European unionid mussels & RS07 Fish & Fisheries, July 29, 2021, 15:30 - 17:00

Numerous studies have demonstrated the trend towards a smaller body size in freshwater zooplankton at an elevated ambient temperature. This pattern could be explained by a greater effect of temperature on the foraging rate of positive-size-selective planktivorous fish and in turn on the mortality rate than on the birth rate in zooplankton populations. While it is well known that the latter effect is close to the one anticipated by the  $Q_{10}=2$  assumption, the hypothesis would be confirmed if the effect of temperature on the foraging rate of planktivorous fish were greater than  $Q_{10}=2$ . This could occur either when the thermal sensitivity of the standard metabolic rate (SMR) of planktivorous fish is greater than this prediction or when the traits relevant for the performance of both planktivorous fish and their prey (e.g. swimming speed) are affected asymmetrically by the elevated temperature. We compared the foraging rate and S<sub>of</sub> of rudd and Malabar danio and the swimming speed of the fishes and their zooplankton prey (*Daphnia*) at temperatures of 16, 21 and 26 °C. The results confirmed our hypothesis as the foraging rate increased with rising temperatures much more than expected from the  $Q_{10}=2$  assumption, particularly for Malabar danio. Such a great effect cannot be explained by the thermal sensitivity of Salome, since the  $Q_{10}$  for *S<sub>was</sub>* merely around 2. The most likely explanation seems to be a much greater effect of temperature on the swimming speed of the fish than of their *Daphnia* prey.

## Climate change impacts on freshwater pearl mussel habitats, substrate, and potential dispersal

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Climate change potentially affects the Freshwater Pearl Mussel through e.g. hydrological regime alteration and increased fine bed material deposits (FBMDs). Understanding how such factors impact the mussel during its life cycle is essential for conservation planning. To project the impacts of climate change on different mussel life stages, a semi-mechanistic integrated modeling cascade was implemented for the Aist catchment in Austria (630 km<sup>2</sup>), including two climate models, a hydrological model, hydraulic models, Random Forest models for FBMDs accumulation risk, Species Distribution Models for physical habitat requirements, and a graph-based assessment of the structural connectivity for the probability of successful glochidia dispersal. Results show a future reduction of peak discharge that cascades into a reduction in shear stresses during high flow. Overall, the mussel's hydraulics requirements are expected to be met also in the future. However, the pressure of FBMDs over suitable habitat patches is predicted to increase due to the reduced sediment transport capacity in most reaches, leading to a reduction of up to 25% of the available habitats in 2090 for RCP 8.5. Consequently, the dispersal probability decreases down to 44.3 - 75.6% of the maximum theoretical value. Arguably, conservation plans that are resilient to climate change in the studied area should consider the future FBMD dynamics. The use of integrated models could increase understanding of cascading effects of climate change on catchment hydrology, reach hydraulics, and local habitats and support the identification of management options e.g. soil erosion control, and increase in stream transport capacity.

## Macrozoobenthos assemblage patterns in European carp (*Cyprinus carpio*) ponds

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Qualitative and quantitative differences in benthic macrozoobenthos distribution in carp pond littoral zones (macrophyte areas; LM) and pelagic zones (macrophyte-free areas; MF) were assessed in four commercial carp (*Cyprinus carpio*) grow-out ponds in Czechia (semi-intensive management) and Austria (organic management) monthly over the growing season (June–September) of 2016 and 2017. While differences in environmental parameters and granulometric composition between LM and MF were insignificant ( $p > 0.05$ ), organic matter content was significantly higher ( $p < 0.05$ ) in LM. Average macrozoobenthos density and biomass in LM (mean 431 ind.m<sup>2</sup> and 6.78 g.m<sup>2</sup>) was usually significantly higher ( $p > 0.05$ ) than MF (371 ind.m<sup>2</sup> and 3.17 g.m<sup>2</sup>). A similar trend was observed for zoobenthos diversity, with LM having a higher diversity (76 taxa) than MF (47 taxa). At the start of the growing season, chironomid density was higher ( $p < 0.05$ ) in muddy MF zones, regardless of management type, while oligochaete density was higher in muddy LM. The density of both groups later declined, such that density was significantly higher ( $p > 0.05$ ) in sandy substrates, regardless of habitat or management type. Our data suggest a significant drop in macrozoobenthos density and biomass compared with historical data, mainly due to new management techniques (fertilisation, supplementary feeding) and intensification (higher stock densities), suggesting that pond management is crucial as regards benthic invertebrate development and diversity. Our results indicate that emerged LM beds positively influence macrozoobenthos performance in carp ponds, potentially making them biodiversity hotspots. Further, LM beds can be regarded as invertebrate harbours, and hence should be protected and encouraged.

## Translocation of the giant freshwater pearl mussel: first results

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*Pseudunio auricularius* is one of the most threatened freshwater mussel species worldwide and is classified as Critically Endangered in the IUCN Red List. The artificial Canal Imperial de Aragón (CIA) in the Ebro basin (Aragón - Spain) presents the largest census colony in the world (around 6000 tagged specimens), but since 2013 it has suffered a sharp decline. The aim of this study was to evaluate the recovery and survival of adult mussels of this species translocated from CIA to the Ebro River main channel. A first emergency translocation plan was scheduled in 2016, when various localities were characterized in the middle Ebro River to this aim. Environmental parameters were measured and, based on previous data on the ecology of this species, an index was designed giving a higher score to habitats more suitable for *P. auricularius*. A total of 638 specimens were then translocated (291 specimens in 2017, 291 in 2018 and 56 in 2019) to six different locations. The minimum first-year survival in 2017 was 41.6%. After the second year 95% of these specimens were found alive, suggesting a successful establishment. In those individuals translocated in 2018 and 2019 and checked one year later the survival was c. 69% and 49%, respectively. In contrast, the control group left in CIA had only a 19.7% survival after one year. Currently, the conditions in the river seem to allow a higher survival for *P. auricularius*. Future studies should be secured to confirm the long-term success of these translocation works.

## 9F\_SS04 Citizen science and public participation in freshwaters: engaging citizens to research and management of freshwater ecosystems & RS11 Fundamental and applied freshwater ecology

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### Engaging communities into ecosystem services - Innovating with nature towards an integrated aquatic ecosystems management

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The changes on Ecosystems composition, structure and dynamic produced by anthropogenic and natural factors can be described as part of the global change process. These threats can cause losses of biodiversity and Ecosystem Services (ES) supply. The implementation of Nature based Solutions (NbS) have been studied as a landscape planning instrument to optimize the spatial arrangement of ecosystems to promote nature conservation, while delivering ES to populations. NbS reduce vulnerability and exposure to climate variability, improve human health, social and economic wellbeing, environmental quality, and livelihoods. The implementation of NbS will depend primarily on the needs and potentialities of each territory, acting accordingly the stakeholders' interests. ALICE is a project with partners from Portugal, Spain, France, Northern Ireland and United Kingdom which aims to promote sustainable investments in NbS through identification of the benefits of ES delivered at the terrestrial-aquatic and land-sea interface in the Atlantic Region. To assess the major environmental issues in Paiva River (Portuguese case study), a participatory process involving national to local stakeholders was developed. Through a process of collaborative mapping, the identification and prioritization of the Paiva catchment major problems and ES delivery, were structured towards the aim of the project. This approach also involved the development of participatory scenarios to identify the barriers and benefits of the BGINs implementation to promote ES and biodiversity. Overall, this study aimed to develop participatory learning approaches to engage local stakeholders for valuing NbS in Atlantic landscapes towards a smart, sustainable and integrated co-management.

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## Freshwater research in tertiary education of pre-service teachers – a Croatian example

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Croatian primary and secondary education system is undergoing a comprehensive reform, in order to shift the focus from the syllabi-based teaching content to learning outcomes and development of life competencies. The actual curriculum changes are also supported by tertiary teacher education, e.g., Department of biology (Faculty of Science, University of Zagreb) educates future biology and chemistry teachers following the trends of curricular reform. Within an elective course Sustainable Development in Science Teaching (SD), pre-service biology and chemistry teachers go through an extensive training in freshwater research (including field work and e-training), using the GLOBE-protocols. These protocols are provided by the GLOBE (The Global Learning and Observations to Benefit the Environment) Program - international science and education program aimed at understanding functioning of global environment. Among other teaching resources, the Program offers detailed user-friendly protocols for hydrological measurements of relevant abiotic factors and macrozoobenthos. In the winter semester of 2020/21, 23 students elected the SD course consisting of 30 lecture and 30 seminar hours (4 ECTS), 20 of which were dedicated to the GLOBE activities, including freshwater research. At the end of the SD course, students (pre-service teachers) completed an online survey expressing their views on the benefits of applying the GLOBE approach (including the extensive training in freshwater research) in teaching and learning process. Most students pointed out the benefits in terms of implementing experiential learning and learning by discovery through out-of-the classroom teaching and practical work (19%), and development of sensitivity to environmental problems (13%) and science literacy (13%).

## Bloomin' Algae: public engagement in monitoring harmful algal blooms

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Cyanobacteria (blue-green algae) produce toxins that present risks to human and animal health. This is a concern, as blooms of cyanobacteria are a widespread and increasing problem in fresh waters across the world. Furthermore, models of climate change impacts predict the future may well be blue-green. Providing early warning of these risks requires high frequency monitoring across thousands of waterbodies to enable rapid management actions to minimise risks to public and animal health. The Bloomin' Algae citizen science app is used to help monitor Harmful Algal Blooms (HABs) in freshwaters, mainly across the UK. Since it was launched in June 2017, the numbers of records submitted to the app have grown each year with about 200 records in both 2019 and 2020. The app has been used most across Scotland, where local authority environmental health officers and the Scottish Environment Protection Agency use it routinely to get notifications from the public and rapid confirmation of suspected HABs. In addition to providing an overview of the app's usage in the UK, we will discuss the reasons behind correct and incorrect records and describe stories from different user groups who have benefitted from using the app (wild swimmers, dog walkers). We will discuss strategies for sustaining public engagement and the plans to expand app usage across Europe.



## Response of benthic diatoms to hydromorphological changes in streams

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Protecting stream integrity represents a fundamental condition underpinning the supply of essential ecosystem services vital to sustaining well-being and future economic and social development. To date, a variety of approaches, mainly associated with legislation and enforcement of government policies, are used to assess streams' ecological state. They aim to quantify impairment, identify the influencing factors and assist the managerial decision. As an important part of stream ecosystems, benthic algae communities play essential roles in energy flow and nutrient cycling. Being able to respond quickly to the deteriorated conditions, they are frequently included in biomonitoring schemes. Most often, diatoms are used as proxies for the whole benthic algae community. However, our knowledge about benthic algae communities' response to different human-induced changes to the aquatic ecosystem is very limited. Our research assesses the diatom community's response to hydromorphological modifications associated with the construction of micro-hydropower plants. Results highlight the diatoms community attributes upstream and downstream of 33 intake points of 17 hydropower plants across the Carpathians in Romania. The spatial and temporal variation of diatoms, uni-criterial and multimetric indices and their accuracy in revealing the streams' hydromorphological impairment are discussed. Our research contributes new knowledge about diatoms' response to hydromorphological changes and underlines the need to further develop the benthic algal assessment system.

## Stimulation of terrestrial carbon degradation in stream hyporheic zones by phosphorus addition

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The hyporheic zone (HZ) is a hot spot of carbon processing in stream ecosystems due to the mixing of organic matter and nutrients from groundwater and surface waters. However, major knowledge gaps exist regarding the drivers of microbial activity and carbon processing in the HZ among stream ecosystems with different carbon sources and sediment properties. We investigated the impact of algal dissolved organic matter (DOM<sub>algal</sub>) and phosphorus (P) on the degradation of soil DOM (DOM<sub>soil</sub>) by hyporheic microorganisms. First, we explored the influence of different ratios of DOM<sub>algal</sub> to DOM<sub>soil</sub> on microbial respiration and changes in DOM optical properties in microcosms mimicking a HZ. One batch was incubated at ambient and another at P concentrations adapted to the pure DOM<sub>algal</sub>. Secondly, we determined microbial respiration of HZ-sediments from 20 streams in Austria incubated with DOM<sub>soil</sub> with and without P additions. Microbial respiration in HZ-microcosms decreased with increasing DOM<sub>soil</sub> fractions. When P levels were adjusted to DOM<sub>algal</sub>, microbial respiration was comparable between the different DOM mixtures and DOM<sub>soil</sub> was degraded in the microcosms. However, only in one out of 20 natural HZ-sediments did P additions cause a significant increase in microbial respiration, suggesting that microbial respiration rates are not solely controlled by P availability. We conclude that P pulses can, but do not necessarily stimulate microbial activity and terrestrial carbon degradation in the HZ and the trophic status of a stream might influence the role of intrinsic versus extrinsic factors in HZ carbon degradation and CO<sub>2</sub> outgassing.

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### Remote sensing the impacts of dam developments on downstream aquatic ecosystems

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10A\_SS13 Remote sensing for inland waters, July 30, 2021, 10:30 - 12:00

Since 2015, the Gibe III hydropower dam in Ethiopia has permanently dampened the seasonal cycle of Omo River discharge, bringing an end to the annual floods. This has profound implications for downstream aquatic ecosystems which were well adapted to seasonal fluctuations in environmental flows. Using satellite Earth Observation, we evaluated the impacts of altered hydrological patterns on riparian wetlands and on Lake Turkana in Kenya, the terminus of the Omo River. Analysis of Landsat imagery using Google Earth Engine highlighted a significant decrease in seasonally flooded area after the dam and the desiccation of river-adjacent lakes and wetlands. Radar altimetry data showed that seasonal fluctuations in Lake Turkana's water levels have been severely dampened, reducing the connectivity of the lake with its flood plain. MERIS imagery was used to generate a historical baseline of Lake Turkana's water quality. Prior to dam completion, strong seasonal cycles in chlorophyll-a and TSS were observed, and mean lake-wide chlorophyll-a, an indicator of phytoplankton concentrations, showed a strong relationship with Omo inflows. An empirical model was derived to predict chlorophyll-a from Omo River discharge. Application of this model to future discharge scenarios based on Gibe III operations predicted reductions in both the magnitude and seasonal variability of chlorophyll-a. Together these changes represent severe threats to the lake's ecology and fisheries. Sentinels-2 and -3 are currently being used to investigate more recent changes in the lake. Our remote sensing approach can be easily adapted for investigating the impacts of changing environmental flows in other freshwater systems.

## Primary productivity monitoring in Swiss lakes using Sentinel-3

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10A\_SS13 Remote sensing for inland waters, July 30, 2021, 10:30 - 12:00

Eutrophication of inland waters is a widespread environmental issue. In Switzerland most lakes experienced eutrophication during the past century. Phosphorous emission reduction measures were implemented in the 1970, but primary productivity remains elevated in many lakes. Because phytoplankton communities adapted to the reduced nutrient supply and optimized carbon assimilation, resulting in a 2.5-fold increase in C:P ratio. Estimating primary production is thus key to monitoring the recovery of lakes. However, the ex-situ incubation of water samples is circuitous and laborious, and hence chlorophyll-a became a popular proxy for the productivity of lakes. Today, automated oxygen sensors and operational Earth observation satellite missions enable efficient primary productivity estimates based on diel oxygen variations and using bio-optical models for remote sensing data. Initial results suggest that remote sensing of primary productivity may even be more robust than the chlorophyll-a concentration estimates it uses as an input. Because on one hand, the productivity model uses phytoplankton absorption as input, rather than requiring a conversion from optical to gravimetric units. On the other hand, the phytoplankton absorption obtained from water-leaving radiance might be more representative of area primary productivity than of the pigment concentration in a discrete volume. We present a Sentinel-3 processing chain for primary productivity estimates in lakes, which is validated using automated sensors for oxygen, reflectance and inherent optical properties in Lake Geneva. We compare the results to monitoring data for more than 20 Swiss lakes, and discuss the improved potential of novel Earth observation techniques for lake eutrophication monitoring.

## The Essential Climate Variable ‘Lakes’: exploring satellite-products from global to local scale

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10A\_SS13 Remote sensing for inland waters, July 30, 2021, 10:30 - 12:00

Lakes are integrators of environmental and climatic changes occurring within their contributing basins. Understanding the complex behavior of lakes in a changing environment is essential to effective water resource management and mitigation of climate change. The ESA CCI Lakes is a multi-disciplinary project (<https://climate.esa.int/en/projects/lakes/>) creating the largest and longest consistent global record of five lake climate variables: lake water level, extent, temperature, surface-leaving reflectance, and ice cover. Phase 1 covered 250 lakes and phase 2 will cover up to 2000 globally. The distribution of the global dataset will be presented followed by a focus on Lake Trasimeno, a shallow eutrophic lake in central Italy included in the Long-Term Ecosystem Research (LTER) network. We used AI and Non-Parametric Multiplicative Regression (NPMR) to analyze the data. Chlorophyll-a in lake Trasimeno was dominated by a summer bloom initiating in July and peaking in early September and was largely predicted by the time variable - accounting for 87% of feature importance. The North Atlantic Oscillation was the next most important variable (4% feature importance) corroborated by NPMR and shown to be largely important during early to mid-September when a positive NAO, associated with high pressure and warm sunny weather, led to an increase in chlorophyll-a concentrations. Regional climatic indices as well as the more obvious nutrient drivers of algal blooms should therefore be considered in lake management. High Frequency chlorophyll-a and phycocyanin data from a WISP station showed that rapid fluctuations visible in the satellite record are supported by in situ data.

## Exploring hydrological patterns in the landscape from remote sensing data

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10A\_SS13 Remote sensing for inland waters, July 30, 2021, 10:30 - 12:00

Freshwater Pearl Mussel (*Margaritifera margaritifera*; LINNAEUS 1758) populations continue to diminish in Ireland and elsewhere, despite ongoing conservation and management measures. Anthropogenic impairments to the hydrological regime remain a major threat to their survival and successful reproduction. As relict populations are frequently confined to smaller, remote catchments, hydrological gauging data is rare. To overcome this constraint, we explore how remote sensing data, such as soil moisture and vegetation indices, may help to derive hydrological patterns critical for mussel survival. Applying these indices to the dominating land-cover types across several years sheds insights on the role they play at the catchment scale. Preliminary results show the importance of accounting for the specific phenology of different land-cover types throughout the seasons and during extreme events. Our main aim is to assist environmental managers and conservation practitioners to better manage and support the recovery of Irish Freshwater Pearl Mussel populations.

## Optimisation of water quality algorithms for monitoring of lakes in Ireland.

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10A\_SS13 Remote sensing for inland waters, July 30, 2021, 10:30 - 12:00

There are over 12,000 lakes and ponds in Ireland. Management of these waterbodies requires an integrative and adaptive approach that can provide a comprehensive and reliable overview of current status. This requires reliable and cost-effective monitoring programmes. Currently in Ireland, however, only approximately 225 of these lakes are monitored regularly as part of the EU Water Framework Directive (2000/60/EC) monitoring programme. Consequently, there are a large number of water bodies which are only sampled infrequently or not at all. The use of satellite remote sensing is one option that can be used to address spatial and temporal limitations of traditional monitoring approaches. Here we investigate the potential for using Sentinel-2 imagery for monitoring lakes in Ireland, given the high cloud cover and relatively small sizes of the water bodies involved. Two processors, C2RCC and ACOLITE, were selected and used to compute chlorophyll a concentrations from a number of case study lakes. Field radiometry measurements were taken alongside water quality data to coincide with satellite imagery, which allowed glint free reflectance from the water bodies to be calculated. Based on the validation with this field data, a coupled technique was developed to atmospherically correct and estimate chlorophyll a. This optimised approach has the potential to offer many benefits for water quality monitoring programmes in Ireland, but nevertheless, challenges remain regarding the frequency with which cloud free scenes can be obtained.

## 10B\_SS10 Management of climatic extreme events in lakes and reservoirs for the protection of ecosystem services

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### In-lake based definitions of extreme events are more relevant for lake science

Harriet Wilson<sup>1</sup>, Prof. Eleanor Jennings<sup>1</sup>, Prof. Dr Hans-Peter Grossart<sup>2,3</sup>, Ana Ayala<sup>4</sup>, Dr Don Pierson<sup>4</sup>, Dr Elvira de Eyto<sup>5</sup>, Dr Eleanor Mackay<sup>6</sup>, Dr Mikkel Andersen<sup>1</sup>, Dr Seán Kelly<sup>1,7</sup>, Dr Ian Jones<sup>2</sup>

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10B\_SS10 Management of climatic extreme events in lakes and reservoirs for the protection of ecosystem services, July 30, 2021, 10:30 - 12:00

Extreme weather events, such as storms, are of great concern worldwide, notably due to their potential to have profound consequences for ecosystem functioning. Sudden and intense physical perturbations of lakes, referred to as mixing events, can have important biogeochemical and ecological consequences. Currently, weather-based approaches to extreme event analysis have dominated limnology, with the implicit assumption that extreme weather events inevitably lead to extreme in-lake events. This assumption, however, has yet to be tested. Here, we compared the frequency of concurrent extreme weather-related and extreme in-lake events using long-term high frequency datasets from two European lakes. Weather-related events were defined as the 5% greatest daily conditions for precipitation, wind-energy and surface heat-flux losses to the atmosphere. In-lake events were defined as the 5% largest day-to-day surface water temperature decline, surface mixed layer deepening and loss of water column stability. The majority of extreme weather-related events were not concurrent with extreme in-lake events and vice versa. Allowing for a 1-2 day lag in the in-lake response made little difference to this result. The timing and magnitude of extreme in-lake events was highly dependent on the in-lake variable used, and for surface mixed layer deepening events, were sensitive to the precise calculation method used. Our results indicate that weather-based approaches may lead to a misrepresentation of the connections between extreme weather and lake functioning.



## A chimney for peatland GHGs; CH<sub>4</sub> dynamics of peatland rivers and lakes

Truls Hveem Hansson, Emma Drohan, Alexa Hoke, Joseph Cooney, Elvira De Eyoto, Hans-Peter Grossart, Eleanor Jennings

10B\_SS10 Management of climatic extreme events in lakes and reservoirs for the protection of ecosystem services, July 30, 2021, 10:30 - 12:00

Peatlands are known reservoirs of methane (CH<sub>4</sub>) and as such play an important role in the global CH<sub>4</sub> budget. In this 6-month study, we show that dissolved CH<sub>4</sub> originated from peatland catchment soils was siphoned into the downstream lake. Transects in the lake showed however that virtually all CH<sub>4</sub> was persistently lost before reaching the centre of the lake, Lough Feeagh, in the west of Ireland. This loss of CH<sub>4</sub> was most pronounced during dry periods, when low flow rates resulted in the accumulation of CH<sub>4</sub> in the lower catchment and the immediate inflow area of the lake. Preceding heavy rainfall events strongly reduced concentrations in both inflow and lake. While some of the reduction in CH<sub>4</sub> could be attributed to oxidation, we found that the vast majority was rapidly lost to the atmosphere. These findings suggest that peatland associated water bodies may function as a “chimney” for peat-derived CH<sub>4</sub> loss to the atmosphere. Furthermore, we also show that external catchment input of CH<sub>4</sub> can be a main source of lake CH<sub>4</sub> emissions. This study demonstrates the importance of taking the catchment area into consideration when looking at lake carbon cycling and atmospheric CH<sub>4</sub> contribution.

## Storm events oppose atypically high stability induced by climate warming in lakes

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10B\_SS10 Management of climatic extreme events in lakes and reservoirs for the protection of ecosystem services, July 30, 2021, 10:30 - 12:00

Impacts of climate warming include long term increases in surface water temperature, stronger and longer thermal stratification, and changes in surface mixing in many lakes. The magnitude and frequency of extreme events such as storms is also expected to increase. High thermal stability and destabilising storms act in opposition on thermal dynamics, yet we know very little about how they will interact and impact lake ecosystems. Changes in meteorological variables during a storm destabilise thermal stability via different mechanisms which are difficult to disentangle. This study uses high-frequency data, long-term monitoring data, and a numerical lake physics model to investigate the physical and hydrological impact of a storm event in a small monomictic lake in the UK Lake District. The storm occurred during a period of atypically high summer thermal stability, likely to be characteristic of summer conditions in a climate-altered future. Analyses show that a storm event occurring at a time of atypically high thermal stability can return stability to levels more typical for the time of year, and a storm event following very stable conditions show bigger reductions in stability compared to a storm event following less stable conditions. Disentangling the meteorological impacts during the storm demonstrated that, despite often being overlooked, the reduction in solar radiation from increased cloud cover had the largest impact on stability. The study implies that, though storms are seen as extreme events, as climate warms storms may have the effect of returning lakes towards current conditions.

## Dissolved organic carbon: changes following extreme weather events in a humic system

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10B\_SS10 Management of climatic extreme events in lakes and reservoirs for the protection of ecosystem services, July 30, 2021, 10:30 - 12:00

The concentration of dissolved organic carbon (DOC) in surface waters has implications for both the carbon cycle in downstream lakes and for drinking water supplies. Concentrations have been shown to both increase and decrease in streams and rivers following high flow events. DOC concentrations are also strongly influenced by droughts within the catchment. Here we used high frequency fluorescence data, a proxy for DOC, to investigate changes in DOC in a river and downstream lake following storms and drought periods. Concentrations in streams showed a distinct seasonal cycle with highest values in late summer and autumn. They also were lowest during summer droughts but increased immediately after. In comparison to the highly variable DOC concentrations in the stream, concentrations in the downstream lake were damped and lagged. Responses within the lake to high flow events were a function of both riverine concentration and discharge volume. Replicating these patterns in DOC models is essential to simulate short- and longer-term changes in climate and thus inform future catchment and lake management.

## A global dataset on weather, lake physics, and phytoplankton dynamics

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10B\_SS10 Management of climatic extreme events in lakes and reservoirs for the protection of ecosystem services, July 30, 2021, 10:30 - 12:00

We compiled data from over 30 lakes across the globe to address how storms influence thermal structure and phytoplankton community dynamics mediated by lake conditions and functional traits. In addition to (generally) fortnightly phytoplankton samples (mean  $\pm$  SD temporal coverage across all lakes =  $20 \pm 13$  years), the dataset includes limnological variables from standard long-term monitoring programs ( $24 \pm 15$  years coverage), daily weather observations ( $16 \pm 10$  years coverage) and, when available, high-frequency lake water temperature and water chemistry profiles ( $12 \pm 7$  years coverage). All data have been standardized to similar formats and include complete metadata. We used the dataset to develop an R-package (“algaeClassify”), which assigns phytoplankton genus/species information to multiple functional trait groups, and here we provide a summary of ongoing research using the dataset to investigate: 1) the influence of storm events on seasonal phytoplankton succession, 2) the impact of storms on lake thermal structure, and 3) whether lake phytoplankton communities are shaped by long-term patterns in disturbance frequency and intensity. We give an overview on how to access these data, and we further highlight the opportunities the dataset provides for asking both basic and applied questions in limnology, ecology, climate change, and lake management.

## Phytoplankton responses to meteorological and hydrological forcing at decadal to seasonal timescales

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10B\_SS10 Management of climatic extreme events in lakes and reservoirs for the protection of ecosystem services, July 30, 2021, 10:30 - 12:00

We aim to quantify the effects of recent and potential future change in hydro-meteorological forcing in phytoplankton dynamics at time scales from days to decades. Using a 54-year monthly phytoplankton time series, we apply the following statistical methods to a large, shallow, polymictic Lake, Võrtsjärv (58°16'N, 26°02'E) in Estonia, combined with daily data on forcing factors – thermal, wind, light, and water level regimes: Nonmetric multidimensional scaling (NMDS) of Bray-Curtis similarity between phytoplankton samples, K-means clustering of NMDS scores for periodizing the changes, Variance partitioning with linear mixed effect modeling (LME) to analyze variance partitioning in variables among different time scales.

Comparing correlation results between phytoplankton and hydrometeorological variables with applying general additive method (GAM model) and other statistical analysis. By using LME, we revealed a continuum from the major dominant K-selected filamentous cyanobacteria with the most robust decadal-scale variation (8-30%) to r-selected phytoflagellates with large stochastic variability (80-96%). Despite water level and wind speed with a substantial decadal variation (8% and 20%, respectively), other external forcing detected remarkable seasonal variation (up to 80%). We detected that the effect of external variables was proportionally distributed in the time scales of phytoplankton variation. With an evident variation of temperature at the seasonal scale, it had no impact on the dominant cold-tolerant filamentous cyanobacteria in Lake Võrtsjärv. We presented the LME as a unique method for eliminating the temporal cross-scale problem. It yielded excellent agreement with quantitative results and our intuitive understanding of the dynamics of different hydro-meteorological forces.

Keywords: phytoplankton dynamics

## 10C\_RS03 Catchment management from policy to practice

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### Weaving together diverse values for managing Lake Wānaka in Aotearoa/New Zealand

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10C\_RS03 Catchment management from policy to practice, July 30, 2021, 10:30 - 12:00

Managing fresh waters for good ecological and human health and wellbeing is one of the great challenges of the UN Decade on Ecosystem Restoration. The inadequate successes of decades-long attempts to restore freshwater ecosystems casts doubt on the effectiveness of common top-down driven management based on ecological and socio-economic objectives alone. Public participation taking into account cultural values and knowledge of communities is a way forward to enhance environmental management and people's wellbeing, but little guidance on integrating diverse values is provided in respective directives. We demonstrate a framework based on Multi-Criteria Decision Analysis (MCDA) to integrate diverse values in the development of a catchment management plan for Lake Wānaka in Aotearoa/New Zealand, one of the few countries that mandates action plans to be developed based on community water visions. The MCDA-framework successfully wove together diverse cultural, ecological, and socio-economic values in a collaborative management plan. In particular, clearly translating values into objectives and structuring them allowed identifying potential management strategies that target current system deficits and ranking potential management actions based on the objective assessment of their performance against all objectives. Stakeholder-specific preferences did not lead to rank reversals of alternatives, underpinning the community's unity in their water vision, which is an optimal basis to agree on a collective action plan. Based on this case study, we recommend values-based approaches such as MCDA as a way forward to develop inclusive freshwater co-management not only in Aotearoa/New Zealand where community input to management is mandated, but elsewhere as well.

## Hydrological modelling with SWAT+ for catchment management: the Tagus River case study.

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10C\_RS03 Catchment management from policy to practice, July 30, 2021, 10:30 - 12:00

The European Water Framework Directive establishes that water management policies must be planned at a basin scale. One of the main threats for this management is climate change, which might bring decreases in water availability and quality to many regions, including the Iberian Peninsula. In order to adapt water policies to the potential effects of this change, it is necessary to acquire knowledge about its future dimensions. Hydrological models are useful tools to achieve it, allowing also simulating the impacts of plausible actions to be taken. In this work, we present a highly detailed hydrological model for the upper third of the Tagus River Basin, the most populated in the Iberian Peninsula. The renovated version of the Soil and Water Assessment Tool, SWAT+, has been used. Inputs to the model include detailed geographical, hydrological and meteorological datasets, with a special emphasis representing the agriculture and its operations due to their relevance in hydrological and water quality processes. As a result, a model with 129 subbasins, 2843 landscape units and 29256 hydrological response units was created. Further work includes multi-site model calibration and scenarios simulation. However, soft calibration has been already done for the entire basin and daily flow calibration has been performed in key subbasins with satisfactory results, serving as experience to achieve the full calibration. Results of this research could aid in decision-making related to water management policies in the Tagus River basin, reinforcing the suitability of hydrological modelling for water management in the present context of climate change.

## Cluster analysis reveals surprising community preferences for managing New Zealand's Blueskin estuary

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10C\_RS03 Catchment management from policy to practice, July 30, 2021, 10:30 - 12:00

Community participation has been increasingly embedded into environmental policy with the aim to accelerate transformative change towards sustainable management. When performed effectively, participatory processes integrate local preferences and knowledge with scientific evidence, which leads to more effective management powered by community buy-in. A common way of engaging the community is the collaboration with local stakeholders; a relatively cost-/time-efficient approach based on the often vaguely-met assumption that each stakeholder represents a shared interest of the respective key community group. The selection of representatives, despite well planned, also often ends up being done ad-hoc due to availability constraints of participation favorites. We tested a more analytical approach based on cluster analysis to identify community interests to feed into the development of a collaborative management plan for the Blueskin estuary in Otago, New Zealand. We interviewed a total of 36 community members to elicit their preferences of management objectives, which we had co-designed in previous workshops. We found distinct preference clusters comprising stakeholders with different backgrounds for the main and the more specific sub-objectives, with the defining objectives being catchment/estuary health and sustainable economic activities (main objectives) and recreational activities, and sustainable agriculture and forestry (sub-objectives). Our results indicate that the assumption that participants with certain economic interests are primarily concerned with objectives directly relating to their industry may not hold. Consequently, cluster analysis helps map community preferences more accurately, while likely facilitating collaborative decision making as stakeholders from diverging backgrounds could view themselves clustered with stakeholders previously assumed to have differing preferences.



## Duhallow Farming for Blue Dot Catchments (Results-Based Integrated Agricultural Catchment Management)

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<sup>1</sup>IRD Duhallow (*Duhallow Farming for Blue Dot Catchments EIP*)

10C\_RS03 Catchment management from policy to practice, July 30, 2021, 10:30 - 12:00

The intensification of agriculture in Ireland has played a major role in declining water quality trends throughout the country. The number of rivers achieving high biological status (Q5) has dwindled in recent decades with only 20 sites achieving highest status in 2016-2018 compared to 575 for the 1987-1990 period. Measures under existing agri-environmental schemes are not sufficient to protect high status waterbodies from agricultural practices and hydromorphological impacts associated with farming, particularly in vulnerable areas such as upland farms with heavy soils. The Duhallow Farming for Blue Dots Catchments project is a five-year (2019-2023) EIP-Agri project that aims to restore and maintain the high status of the Allow river catchment. Working closely with farmers in the catchment, an innovative results-based payment scheme rewards sustainable agricultural practices that enhance freshwater and wetland ecosystem services. Farmers select a number of catchment-specific actions designed to enhance the river ecosystem and reduce greenhouse gas emissions, and are financially rewarded to reflect the success of their efforts. Knowledge exchange and community initiatives form a key component of the project and ensure a truly integrated approach. The outcomes of the project will carry a range of environmental, economic and social benefits associated with high water quality to the catchment. However, it is anticipated that the project impact will have a far wider reach as project learnings will inform future agricultural policy and agri-environmental schemes that will be essential to reverse declining river water quality trends and restore Irish river catchments to highest ecological status.

## A multi-agency approach to management of channelised waterways

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10C\_RS03 Catchment management from policy to practice, July 30, 2021, 10:30 - 12:00

The maintenance of waterways by dredging is an ongoing concern for catchment managers in many European countries. The rationale for adopting this management approach has varied over time according to societal need, and various reasons behind it include navigable access, land drainage and providing flood relief. In Ireland, the Office of Public Works is statutorily obliged to maintain 11,500 kilometres of river channel. From a fisheries perspective, this legal obligation underpinned by national legislation can be challenging to reconcile with European and national objectives and obligations under the Water Framework Directive and the Habitats Directive. An ongoing collaboration between the OPW and Inland Fisheries Ireland, namely the Environmental River Enhancement Programme, aims to address this gap and provide applied management advice for reducing the environmental impact of channel maintenance on riverine habitats. Previously established protocols for environmental drainage maintenance outline ten steps that can be followed to ensure maintenance is implemented in an environmentally-sensitive manner. Moreover, under EREP, these procedures are twinned with either hard or soft engineering measures to promote natural fluvial processes at long-term study sites, thereby enhancing habitat quality for salmonids and other aquatic fauna. Arising from these long-term studies, the effectiveness of site-specific measures is assessed and management recommendations made with regards to riverine canopy cover, retention or restoration of instream physical features, and overall hydromorphological quality within previously channelised or dredged rivers.

## Blue Dot Catchments Programme

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<sup>1</sup>*Local Authority Waters Programme*

10C\_RS03 Catchment management from policy to practice, July 30, 2021, 10:30 - 12:00

Ireland has a high percentage of its waters achieving high status relative to many European countries. However, there has been a large decline in the numbers of high status water bodies in recent decades. To address this decline as part of the implementation phase of the River Basin Management Plan for Ireland 2018 – 2021, a set of principal actions were outlined which included the development and coordination of a Blue Dot Catchments Programme to protect and restore Irelands high-status waters. This programme is novel and aims to ensure that high status waters are prioritised for the implementation of supporting measures and for available funding. The presentation will give an overview of this programme, water bodies with a high ecological status objective in Ireland and outline significant pressures impacting on these waters. An overview of work which is being undertaken by the Local Authority Waters Programme in Prioritised Areas for Action with high status objective water bodies will also be presented. The Blue Dot Catchments Programme represents an opportunity to inform policy and practice in order to protect and restore these sensitive water bodies.

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### Can changes in connectivity reduce climate change impacts on lakes?

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10D\_RS10 Freshwater restoration: challenges, innovation and achievements, July 30, 2021, 10:30 - 12:00

Climate change is already affecting many lakes and reservoirs, causing changes in water temperature, hydrological regimes and biogeochemical cycles. Increases in water temperature can cause unexpectedly high levels of algal blooms even when nutrient inputs from the catchment have remained relatively stable. These algal blooms affect the sustainable use of these waterbodies for recreation, tourism and water supply, and as a suitable habitat for plants and wildlife that are of conservation importance. Using a lake response model, PROTECH, we explored whether small changes in water retention time could help to mitigate these impacts in Loch Leven, a large, shallow, and well monitored lowland lake in Scotland, UK. We examined the effects of 30 different water release scenarios on the timing and maxima of cyanobacterial blooms, using data from a warm year (2019) as a baseline. Our results suggested that the peaks in chlorophyll a levels associated with these blooms could be reduced by up to 39% if relatively small changes in water retention times were implemented. These changes appeared to have little effect on the timing of the chlorophyll a maxima or the lake water levels. We concluded that making small changes to the connectivity of lakes has the potential to reduce the size of climate change induced algal blooms where options to reduce nutrient inputs further are limited.

## Long-term responses of an iconic macrophyte to hydrological and local environmental controls

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<sup>1</sup>*River Restoration Centre*

10D\_RS10 Freshwater restoration: challenges, innovation and achievements, July 30, 2021, 10:30 - 12:00

The flow regime of lotic environments is widely regarded as a primary control shaping the integrity of riverine ecosystems. Macrophyte responses to hydrological controls have been understudied relative to other trophic groups (e.g. macroinvertebrates, fish). Moreover, how reach-scale environmental conditions (e.g. shading and gradient) mediate macrophyte responses to flow regime controls remains poorly understood. In this study, we examine the catchment-wide and long-term (1997-2017) variations of a nationally iconic macrophyte ('water crowfoot' – *Ranunculus* sp.), which is integral to wider ecosystem health and functionality. Population patterns *Ranunculus* sp. were then statistically examined against a suite of hydrological controls and their interactive effect with various local environmental conditions (gradient, shading extent and algal coverage). *Ranunculus* sp. populations displayed significant temporal and spatial variations, notably peaking after high-flow periods. *Ranunculus* sp. populations were most responsive to the timing of flow conditions and the duration of minimum and maximum discharges. All hydrological indices identified within our statistical analyses yielded significant interactive effects with the gradient, shading extent or algal coverage. Findings from this study can help inform environment regulators and regional water companies how *Ranunculus* sp. populations can be most effectively managed through a combination of large-scale water resource management operations and reach-scale management interventions.

## Vertical slot fishways: incremental knowledge to find perfect solutions

**Dr Paulo Branco**<sup>1</sup>, Ana Margarida Mascarenhas<sup>1</sup>, Duarte Gonçalo<sup>1</sup>, Filipe Romão<sup>2</sup>, Professor José Maria Santos<sup>1</sup>, Prof Teresa Ferreira<sup>1</sup>, António Pinheiro<sup>2</sup>

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10D\_RS10 Freshwater restoration: challenges, innovation and achievements, July 30, 2021, 10:30 - 12:00

Rivers are affected by a multitude of instream barriers that prevent several freshwater fish species from completing their life cycle. As they become secluded to river sections between barriers, that not always grant them access to all habitats needed during their life. This will promote within population genetic homogenization, density reduction and potential extirpation, affecting meta –population, and -community unbalance and disappearance, contributing to species extinction and loss of community functional resilience, affecting ecosystems processes. The most common way to enhance connectivity is to install fish transposition devices – the most common are the pool-type fishways installed at small instream barriers. Vertical slot fishways have the benefit of being able to be navigated at the fish's desired depth to be less selective than other fishway types. In this work, we have conducted a meta-analysis of published data on Vertical slot fishways for cyprinids. We followed a Bayesian inference since it allows having multiple well-defined hypotheses and calculating their probability of being true, while benefiting from joint analyses of datasets with inherent data dependencies. The results demonstrate that it is possible to integrate outputs for different experiments, conducted in different years and seasons, and for different fish species. This allows for a more informed determination of the best management solutions for barrier connectivity based on fishways. Future design guidelines for holistic fishways will benefit from this integrative approach leading to more effective connectivity solutions.

## River fragmentation in Brazil: impacts of dam construction

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10D\_RS10 Freshwater restoration: challenges, innovation and achievements, July 30, 2021, 10:30 - 12:00

Worldwide dams have been built to provide valuable services, such as irrigation, hydropower and water supply. In addition to increasing fragmentation, these disruptions affect the habitats of several riverine species since they impact the flow regime and modify discharge, water velocity, water temperature, sediment transport. This seriously impacts river connectivity, since physical (dams) and behavioural barriers (large reservoirs) are one of the major threats to fish migration. The consequences are dramatic for the migratory fish fauna, as barriers increase system fragmentation and block fish species to reach feeding and breeding grounds, sheltering and refuge, and limiting longitudinal and lateral dispersal. The objective of this work is to assess structural connectivity of watersheds in Brazil, as well as to evaluate, chronologically, the impact of dams' construction on the systems' capacity to support fish populations. Using the construction date and the foreseen dam development allowed the evaluation of the chronological impact of dams on the fragmentation of freshwater fish (potamodromous and resident) minimum functional areas (MFA). MFAs and related river network characteristics were calculated using the River Network Toolkit. Results from this work show the continuous reduction of long free stretches of rivers have affected fish populations by diminishing their available habitat. They also suggest that construction of new dams, especially in rivers with higher Strahler order, will have significant impact on structural and functional connectivity. The assessment of river fragmentation evolution allows a global perspective of the state of rivers' connectivity in the country, along with dams' impacts on fish populations.

## Floodplain restoration: a new approach how to prioritize and quantify.

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10D\_RS10 Freshwater restoration: challenges, innovation and achievements, July 30, 2021, 10:30 - 12:00

In the face of the global decline of biodiversity, floodplains take a key role in nature conservation. and have become a focus of protection and restoration efforts. In conservation planning the selection of target species and the quantification of the outcome are regarded as crucial elements of an effective design. We developed a new index for the identification of conservation priorities as well as a modelling approach to quantify long-term restoration success and tested our design in a case study on the Lech River in Austria. Characteristic species of the river-floodplain system of the Lech were assessed using a multi-score evaluation matrix with ten categories, whereby each category reflects an attribute of the species with relevance for its conservation importance. Based on the final score, we generated a hierarchical structuring of the species according to their priority for conservation activities. Habitats of the priority species were modelled in ArcGIS and aerial balances of the modelled habitats in pre- and post-restoration state of the fluvial system indicate to which degree priority species potentially benefitted from previously implemented measures. A comparison of historic and present habitat availabilities shows an overall increase of the habitats for the priority species of the river-floodplain system after the river restoration but also highlights deficits for some of the priority species as well as discrepancies from the historical reference condition.



## Estimating timescales for reduction of legacy P in a shallow eutrophic lake

**James Thompson**<sup>1</sup>, Dr Yvonne Mcelarney<sup>1</sup>, Prof. Brian Rippey<sup>2</sup>, Dr Julie Campbell<sup>2</sup>, Dr Mary Gallagher<sup>3</sup>

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10D\_RS10 Freshwater restoration: challenges, innovation and achievements, July 30, 2021, 10:30 - 12:00

Internal loading of legacy phosphorus (P) from lake sediment can negatively influence water quality and delay recovery from eutrophication following reductions in external loading. In Lough Neagh, a large, shallow eutrophic lake situated in the north-east of Ireland, internally released P is significant. Within-lake measures to control P are not feasible owing to its large surface area (383 km<sup>2</sup>). Therefore, to set realistic management goals it is necessary to account for this legacy P and provide an estimate of the time required flush excess sediment P out of the system via natural processes. P profiles and chronologies were obtained for multiple sediment cores collected from the lake's depositional basin. Utilizing a condensed model consisting of two major purging factors, diagenesis (transformation of particulate P to soluble P) and burial of P from the active layer, an estimate of the time required for the sediment P inventory to diminish to an insignificant amount was established. Lake recovery was determined as the point when the sediment P inventory in the active layer became reduced by 75%. The model predicts that it will take approximately 40 years before sufficient excess P is purged from the active layer. This reinforces the need for lake managers to consider the extent of the internal load and subsequent multi-decadal hysteresis following the implementation of external loading control measures.

### Vulnerability of Irish Freshwater Fish Species to Climate Change

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10E\_RS07 Fish & Fisheries, July 30, 2021, 10:30 - 12:00

As the impacts of climate change become more frequent (e.g. increasing temperatures, storms, flooding, droughts) and the subject of both scientific and public concern a greater understanding of the impacts on biodiversity in Ireland and elsewhere is required. Climate change has been identified as a significant threat to fish populations in the medium to long term. The impacts on fish species may manifest directly (e.g. physiological stress) or indirectly (e.g. species interactions or habitat degradation). It is predicted that cold water salmonids will likely shift towards higher latitudes and may become locally extinct at the warmest edge of their current distribution ranges. However considerable uncertainties and research gaps remain in relation to the impacts of climate change on Irish fish species, populations, and habitats. This study investigated the vulnerability of freshwater fish species present in Ireland using two methods, i.e. expert questionnaire and a species trait analysis. The expert group analysis showed that two species (3%) were assigned the rank of high, seven species (20%) were of medium to high vulnerability, 17 species (49%) were of medium vulnerability, ten species (29%) were of low to medium vulnerability. Analysis of the results supported claims that native cold-water species were relatively more vulnerable to climate change with indirect effects through interactions with other species or in combination with other pressures. The result provides insight into the factors that drive vulnerability of freshwater fish in Ireland, this information is significant to decision-makers and other stakeholders engaged in managing freshwater fish resources in Ireland.

## Assessment ecological potential of dam reservoirs based on Lake Fish Index (LFI\_CEN)

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10E\_RS07 Fish & Fisheries, July 30, 2021, 10:30 - 12:00

Water Framework Directive obliges the EU Member States to monitor and assess the quality of surface waters. Ichthyofauna is one of the assessed biological elements in dam reservoirs featuring both the river and lake environment characteristics. Research was carried out on the methods for ecological potential assessment based on dam reservoirs ichthyofauna. The feasibility of ichthyological index recommended for lakes was also tested. So far 6 dam reservoirs have been investigated. The modified ichthyofauna monitoring method used in Poland to assess the ecological condition of lakes, using the Nordic-Lake multi-panel gill nets in accordance with the EN 14757 standard, was used for catches. The similarities between studied reservoirs were analysed on the basis of the relative abundance of individual fish species and their relative biomass using the Bray-Curtis method. Data were entered into the calculation application used in Poland to assess the ichthyofauna of lakes: "LFI.exe", in order to obtain the result of the "Lake Fish Index LFI-CEN" value. Altogether 17 species of fish were found in the catches; 7 of them had the highest frequency. These were: perch, bream, silver bream, perch, ruffle, zander and bleak, which accounted for 99.2% -99.9% of the total abundance of fish found in each reservoir. No correlation was found between the level of similarity of individual reservoirs (0.460-0.700) and the results of the LFI-CEN index (0.27-0.58). Therefore, it seems doubtful to use the index dedicated to lakes to assess dam reservoirs ichthyofauna and a dedicated index should be developed.

## Examining the diversity of lacustrine fish species in Ontario and Europe

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10E\_RS07 Fish & Fisheries, July 30, 2021, 10:30 - 12:00

One of the primary goals in ecology is to be able to explain patterns of biodiversity. Specifically, species richness is a primary measure of biodiversity in any community. In our study we are 1) examining the important predictors of fish species richness in lakes in Ontario and Europe, and 2) comparing these results to disentangle patterns at local and intercontinental scales. For the 9435 lakes in Ontario, we use fish species richness data collected from the Aquatic Habitat Inventory Program in lakes around 1985. For the European lakes we use comparable data collected from 1903 lakes across 15 countries. In addition, we have measurements of physical, chemical, watershed, and climate variables. Analyses of the Ontario dataset reveal increases in species richness with increases in area, conductivity, and depth, and decreases in elevation, distance to the main outlet, latitude, longitude, and Secchi depth. The watershed in which a lake is located also has implication for richness. We hypothesize that we will see similar patterns in Europe since these lakes have experience similar glacial history and fall into a similar climate envelope. Comparisons with patterns evident in the European dataset will be discussed. Overall, freshwater fish are an invaluable part of the economy, culture, and ecosystems in temperate and tropical regions. As a result, it is imperative that we understand these patterns of ecological diversity, especially in our current climate of anthropogenic stressors and climate change.

## Effect of retrofitting ramped weirs on passage performance of potamodromous cyprinids fish

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10E\_RS07 Fish & Fisheries, July 30, 2021, 10:30 - 12:00

Portuguese rivers have more than 8000 small weirs (< 5 m high), of which low-head ramped weirs are one of the most common designs. The negotiation of these weirs, where water passes over the ramp and does not generate a waterfall, is usually site- and species-specific, being often insurmountable for fish due excessive velocity and/or insufficient depth along the ramp. The addition of substrates (retrofitting) to make them more friendly for fish passage, is an issue that has captured attention during the late years. Despite some studies highlighted their usefulness for aiding fish passage through technical fishways, few studies are available on how retrofitting and discharge affect the negotiation of low-head ramped weirs. The aim of this study was to assess the performance of an experimental ramped weir to enhance passage of a cyprinid species, the Iberian barbel (*Luciobarbus bocagei*), a medium-sized potamodromous cyprinids. Special attention was given to testing the effects of substrate (i.e. cobble) placement and discharge (Q) on fish passage performance. Results showed that the addition of cobbles proved to be an effective retrofitting measure, generally increasing fish movements, successful upstream passages, and, overall, enhancing fish passage performance by enabling faster negotiations of the obstacle. Regarding physiological parameters assessed on blood samples of tested fish, glucose (generally associated with responses to stress) and lactate (used as a proxy to characterize fish effort and fatigue), results revealed that they were only Q influenced. These outcomes may help to design more efficient passage structures for potamodromous fish.

## Environmental influence on fish behaviour in thermally and hydraulically contrasted river sections

**Dr Dominique Lamonica**<sup>1</sup>, Dr Hervé Capra<sup>1</sup>, Dr Hilaire Drouineau<sup>2</sup>, Hervé Pella<sup>1</sup>, Jérémy Piffady<sup>1</sup>, Anthony Maire<sup>3</sup>  
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10E\_RS07 Fish & Fisheries, July 30, 2021, 10:30 - 12:00

Understanding the variations in habitat use by aquatic animals can provide insights for managing hydrosystems, in particular those subject to strong anthropogenic pressures where the environment can be spatially and temporally variable (e.g. hydropeaking, thermal effluents). Movement ecology is an appropriate framework to investigate habitat use by animals as it allows studying the interplay between individuals and environmental conditions in their movement through the analysis of observed trajectories of individuals (e.g. velocity, orientation, direction changes). In this study, we investigated habitat use by three fish species (European chub, barbel and wels catfish) in a 2 km long section of the Rhône River. For this purpose, we developed a state-space model to link fish behaviour (namely a static behaviour and a moving one) and local environmental conditions (flow speed, water depth and temperature) through fish movement. We estimated model parameters using individual telemetry data recorded over three months at a very fine temporal resolution (3 secs). We were able to disentangle the effect of each environmental variable on behavioural change probabilities and found that water depth and flow speed have overall a stronger effect than temperature. Yet, the effect of environmental factors on behavioural change probabilities was highly variable between individuals, and the variability between species was similar to the variability between individuals of the same species. The model was finally used to predict the probabilities of individual behavioural change and to map the probable habitat use based on local environmental conditions in the river section.

## Native-invasive forage fish species interaction revealed by long-term, spatially-explicit monitoring data

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10E\_RS07 Fish & Fisheries, July 30, 2021, 10:30 - 12:00

Invasive species can cause major disruptions on native food webs, yet the impact of species introductions appears to be context-dependent. Rainbow smelt (*Osmerus mordax*) and alewife (*Alosa pseudoharengus*) co-exist as invasive species in the Laurentian Great Lakes and as native species on the Atlantic coast of North America, but in Lake Champlain rainbow smelt is the dominant native forage fish and alewife are invasive. We used data from a 31-year forage fish survey to compare demographics of rainbow smelt populations in three basins of Lake Champlain with different volumes, nutrient levels, food resources, and predator abundances. Rainbow smelt catch-per-unit-effort (CPUE) remained constant in the large, deep Main Lake before and after alewife invaded, but decreased in the two smaller basins. Declines were primarily a result of increased age-0 and age-1 mortality. Predation by top piscivores, system productivity, and competition for resources alone could not explain the patterns in CPUE across the basins. The mechanisms that allow alewife and rainbow smelt to co-exist could be related to system volume and oxythermal habitat availability, and may explain why the two species do not negatively affect each other in the Great Lakes. Summer hypoxia in the smaller basins of Lake Champlain could force individuals of both species into smaller habitat volumes with higher densities of competitors and cannibalistic adult rainbow smelt. Long-term datasets for different trophic levels helped to clarify the complex potential mechanisms behind species coexistence, and revealed that habitat availability may mediate the impact of invasive alewife on native rainbow smelt.

### Fine sediment impact assessment of high status Irish rivers

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10F\_RS11 Fundamental and applied freshwater ecology, July 30, 2021, 10:30 - 12:00

Under the European Union (EU) Water Framework Directive (WFD), rivers, lakes, transitional and coastal waters that are close to natural status and relatively un-impacted by anthropogenic activities are designated as “high status”. These high status water-bodies (HSWs) are sensitive areas that require special attention. While Ireland had a relatively large number of HSWs compared to other EU countries, in recent years these numbers have declined extensively, with sediment pressures being cited as one potential reason for these declines. Using macro-invertebrate sediment metrics and physical sediment variables, this relationship between sediment as a pressure and HSWs that were determined to have either: “Lost” their high status (e.g. gone from high to good, moderate, poor or bad); consistently “Maintained” their high status; or “Gained” in status (e.g. from good to high) was assessed. While macro-invertebrate taxa occurring in HSWs were typically sediment sensitive taxa, for two sediment specific metrics, the Proportion of Sediment-sensitive Index (PSI) and the Empirically-weighted PSI (E-PSI), significant differences were observed between sites that Lost status and those that Maintained status. This indicates that at some sites, sedimentation is impacting on macro-invertebrates. However, the lack of difference between sites classified as having Lost and Gained in status, leaves an important caveat. Additionally, while weak to moderate relationships were observed between the sediment metrics and the physical sediment variables, no difference between status categories for any of the physical sediment variables was observed, although this may be related to the sampling resolution.



## Ecological and Evolutionary Change in Phytoplankton Competitive Ability for Essential Resources

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10F\_RS11 Fundamental and applied freshwater ecology, July 30, 2021, 10:30 - 12:00

Competition for essential limiting resources is known as one of the major forces structuring ecological communities, in particular phytoplankton communities. Studies of competition in phytoplankton show that competitive traits of various species measured in isolation can be used to predict the outcomes of competition. How competitive traits evolve and influence the outcome of competition is relevant for phytoplankton populations with high genetic and species diversity. Our experiment, with natural phytoplankton communities, aims to estimate ecological and evolutionary changes in competitive ability traits (Tilman's  $R^*$ ) in response to resource limitation. We isolated 23 species from the natural communities, before and after being grown under different limiting resources (N, P or light) in mesocosms over 10 weeks. We then performed a laboratory experiment where we exposed the species to a gradient of 10 levels of an essential resource to calculate their  $R^*$ , to test community-level responses to resource limitation. As expected, species'  $R^*$ s changed in response to the selection environment, reducing their requirements for resources under long-term limitation in some cases.

## Occurrence of antibiotic resistance genes and their relationship with water quality

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10F\_RS11 Fundamental and applied freshwater ecology, July 30, 2021, 10:30 - 12:00

Recent studies showed rivers could be possible reservoirs of antibiotic-resistant bacteria. Also, water can facilitate the spread of antibiotic resistance, given that bacteria travel through water to different ecosystems and regions. The aim of this study was to better understand the distribution of antibiotic-resistant bacteria in freshwater ecosystems. We analyzed the presence of antibiotic resistance genes (ARGs) and facultative pathogenic bacteria (FPB) with qPCR in sampling sites upstream and downstream of a small WWTP in southern Germany. Five sampling campaigns were conducted from February to June 2019. Surface water, sediment, and biofilm samples were analyzed. Several ARGs and FPB were detected in water samples. The number of ARGs and FPB detected in the biofilm samples was lower, but abundance was very high. Few ARGs and FPB were detected in sediment, with low abundances. Genes related to resistance against tetracycline, erythromycin, ampicillin, and sulfamethoxazole were detected in all the samples analyzed, showing the prevalence of antibiotic resistance even in the environment. The occurrence of ARGs conferring resistance to strong or last-resort antibiotics and the abundance of all genes were influenced by the presence of WWTP effluent and water quality parameters. Downstream of the WWTP, the occurrence of ARG and FPB correlated with ammoniacal nitrogen concentrations and therefore, with the effluent, while ARG and FPB upstream of the WWTP correlated with turbidity, suspended solids, and seasonal factors such as UVA radiation indicating a relation to the transport conditions from upstream.

## Abiotic factors driving cyanobacterial composition under perennial bloom conditions in tropical latitudes

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10F\_RS11 Fundamental and applied freshwater ecology, July 30, 2021, 10:30 - 12:00

While warming and eutrophication have increased the frequency and magnitude of harmful cyanobacterial blooms globally, the scenario for many eutrophic tropical freshwaters is a perennial year-round bloom. Yet, the drivers of persistent blooms are less understood when conditions such as light, temperature, and nutrients favor cyanobacteria growth year-round, and especially in regions facing recurrent periods of drought. In order to understand the drive of cyanobacteria dominance, we assessed the abiotic conditions related to the abundance and dominance of the two dominant bloom-forming genera *Raphidiopsis* and *Microcystis*, in six shallow, man-made lakes located in the semiarid Northeastern region of Brazil during a prolonged regional drought. Lower water level corresponded to increased phosphorous and nitrogen concentration and, consequently, phytoplankton biomass. Cyanobacterial biomass was also proportional to phosphorus concentrations during year-round blooms. Yet, the two dominant cyanobacterial genera, *Raphidiopsis* and *Microcystis*, seldom co-occurred temporally and the switch between them was driven by water transparency. Our results illustrate the effects of drought induced water level reductions on the biomass and composition of cyanobacterial blooms in tropical shallow man-made lakes. Given the ideal year-round conditions (i.e., high light and temperature), droughts may be expected to intensify the risk and multitude of problems associated with eutrophication.

## Natural freshwater biofilms: a potential nature-based solution for sewage waters treatment

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10F\_RS11 Fundamental and applied freshwater ecology, July 30, 2021, 10:30 - 12:00

The efficiency of a bioreactor based on river biofilms activity (BioSolar) has been tested at a pilot-plant located in a wastewater treatment plant (WWTP). Through this presentation the results of different experiments will be presented and compared. In the first experiment, the BioSolar received the treated water from the conventional secondary treatment of the WWTP whereas in the second one the incoming water come from the earthworm's reactor (Lumbrifilter) which received raw untreated water from the WWTP inlet. Different parameters have been measured once per week during 4-12 weeks to assess the BioSolar reactor efficiency. At the same time, biofilms have been characterized measuring the abundances of the main phototrophic groups (green algae, diatoms and cyanobacteria) and the biomass (chlorophyll-a and ash free dry mass). The preliminary results obtained indicate that: a) overall the quality of water released by lumbrifilter is significantly better than from the secondary treatment of the WWTP; b) the overall BioSolar efficiency is greater when the incoming water arrives from Lumbrifilter compared to secondary treatment (average reduction of all parameters considered of 64% and 47%, respectively); c) the BioSolar showed the best efficiency of reduction (>50%) for total suspended solids, turbidity, biological oxygen demand and fecal bacteria indicators in both experiments; d) the greater efficiency of the BioSolar could be related with the higher abundances of green algae within biofilm communities. This study demonstrated the great potential of nature-based solutions grounded on the purifying capacity of biological organisms for wastewater treatment.

## Resistome and microbiome dynamics of an interconnected eutrophic lake-river-oligotrophic lake system

**Dr Tomasa Sbuffi<sup>1</sup>**, Daniela Trinchi<sup>2</sup>, Dr Andrea Di Cesare<sup>1</sup>, Dr Raffaella Sabatino<sup>1</sup>, Dr Gianluca Corno<sup>1</sup>  
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10F\_RS11 Fundamental and applied freshwater ecology, July 30, 2021, 10:30 - 12:00

Subalpine lakes are natural reservoirs for antibiotic resistant genes (ARGs) due to agriculture, wastewater treatment plant (WWTP) effluents and aquaculture. The Bardello River, an emissary of the eutrophic Lake Varese flows into the oligotrophic Lake Maggiore (Italy). We investigated the impact of Lake Varese and its emissary on the microbiome and resistome of Lake Maggiore. During August, October and December (2019) seven metagenomes were analysed: the hypolimnion and epilimnion of both lakes, two WWTP inflows along river Bardello course, and its mouth. The microbiome and resistome of the system show seasonal variability in the surface, whereas the hypolimnion of Lake Varese is stable. Taxa distribution highlights the divergence of the river samples especially at the WWTP inflows, mainly in the summer, possibly due to the variation in temperature and water regime. The bacitracin is the most abundant ARG family in the system followed by the macrolide-lincosamide-streptogramin, and multidrug families, predominantly in the Lake Varese and the river. The quinolones characterize the WWTPs inflows while the polymyxin and trimethoprim families denote the Lake Varese hypolimnion. Most abundant ARG families in the system are more abundant in Lake Varese and Bardello river than in Lake Maggiore. However, a cluster of 14 scarce ARG families exclusively and homogeneously characterize the Lake Maggiore waters along the seasons and is almost absent in the polluted Lake Varese-emissary system, suggesting a different origin of such genes pool. We find that Lake Maggiore microbiome and resistome are not impacted by the Varese-Bardello system, especially in the hypolimnion.



# Poster Presentations

## Extreme events and ice cover determine dissolved oxygen in a mountain lake

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Poster Session 1, July 29, 2021, 17:00 - 17:45

Climate change often leads to a decrease in hypolimnetic dissolved oxygen (DO). However, annual mean DO (% saturation) has increased from near anoxia to >20% in the bottom layer (35–39 m) of oligotrophic Lake Tovel (Italy), a deep mountain lake. We analysed long-term patterns of DO (1937–2019) using correlation and trend analysis and identification of extreme events to link dissolved oxygen to drivers and indices of mixing. While spring mixing remained temporally limited, delayed ice-in (5.1 days/decade) and the positive relationship between ice-in and DO the following year indicated autumn mixing as the main driver for hypolimnetic DO increase. Using DO and conductivity (1995–2019), we identified 14 deep mixing events with hypolimnetic DO > 40% indicating that extreme meteorological events also replenished hypolimnetic DO. These events were only partially captured by density-based indices of mixing (Schmidt stability, relative thermal resistance, Lake Number, and Wedderburn Number) and were related to snowmelt, flooding, and cold spells during spring and autumn, with a carryover effect sometimes lasting >1 year. Recently, annual mean DO in the upper layer decreased beyond temperature-dependent solubility. Statistical tests did not comprehensively confirm this decrease but it was possibly linked to atmospheric stilling. We suggest that the observed shift from meromixis to dimixis was driven by climate warming (i.e., increasing air temperature 0.6°C/decade) that delayed ice-in and increased autumn mixing in Lake Tovel. Our work emphasises the vulnerability of mountain lakes and their different response to climate change with respect to more studied lowland lakes.

## Macroinvertebrates and fish of a piedmont stream in the developing city context

Dr Aneta Bylak<sup>1</sup>, Dr Bernadetta Ortyl<sup>1</sup>, Elżbieta Hałoń<sup>1</sup>, Dr Ewa Kukuła<sup>1</sup>, Prof. Krzysztof Kukuła<sup>1</sup>

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Poster Session 1, July 29, 2021, 17:00 - 17:45

Rapid expansion of cities, transformation of rural areas into suburban areas, and increasing human pressure completely alter the natural character of watercourses. Urbanisation leads to profound changes in the environment, and affects the biocenosis. Urban streams are sometimes canalised and hidden under the ground surface, with simple geometry, impermeable banks, and usually concrete bottom. In urban areas, higher than average surface runoff occurs as a result of an increase in tight, impermeable surfaces such as pavements, parking lots, or compact building development. Interactions between surface water and groundwater are highly disturbed. Nonetheless, in most cases, the expanding city boundaries are not occupied by wild land, but by rural areas, and the changes occurring in the catchments of rivers and streams primarily involve transformation of arable land, orchards, and greenhouses into urban development. Therefore, the aim of our study was to trace and analyse changes in stream basins and aquatic biological communities resulting from the transformation from agricultural to urban land use. Our research was based on GIS analyses, hydro-morphological parameters of streams, macrozoobenthos and fish fauna. It was conducted over three decades (1993-2017). %EPT (percent of Ephemeroptera, Plecoptera, and Trichoptera) and richness metrics slightly increased with urbanisation. On the other hand, %OP (percent of Oligochaeta and Psychodidae) decreased with urbanisation. The disappearance of agricultural sources of pesticides and nutrients, and the sewage system of the former village are probably responsible for the rather unusual response of aquatic fauna to urbanisation.



## Impact of replacement of culverts on fish fauna in a mountain stream

**Dr Aneta Bylak<sup>1</sup>**, Joanna Szmuc<sup>1</sup>, Prof. Krzysztof Kukuła<sup>1</sup>

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Poster Session 1, July 29, 2021, 17:00 - 17:45

Stream fish fauna is highly altered by human impacts. Transverse barriers in stream channels, both large dams and smaller weirs, lead to dramatic changes in fish fauna. Small road infrastructure objects also have a negative effect on the ecosystem of streams, particularly at a local scale. Moreover, in small streams, the combined impact of several such structures may multiply. In the Carpathian part of the Vistula River basin (Poland), the number of concrete culverts is high and difficult to estimate. Concrete culverts can hinder movement of fish and invertebrates, particularly in places with low water levels. Although the impact of culverts on aquatic fauna appears evident, not much data is available on this topic. The aim of the study was the assessment of effects of spectacled culverts on the structure of stream ichthyofauna. A decrease in the abundance, or even disappearance of fish was caused by the presence of concrete culverts in the stream bed. These structures were impassable obstacles preventing upstream fish migration. Replacing concrete spectacled culverts with arch structures restored the ecological continuity of the stream. It was the first stage in the re-colonisation of the stream by fish moving upstream from the mainstem river. By providing spawning grounds and fry growing habitats, the restored stream also became a source of new generations of fish populations. The process of restoring the ichthyofauna structure was slow. Nonetheless, less than 10 years after replacing the culverts, the fish fauna was found to be approximate to its natural state.

## Distribution and structure of functional groups phytoplanktonic in a shallow tropical reservoir

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Poster Session 1, July 29, 2021, 17:00 - 17:45

The community phytoplanktonic found in the prey the Rodeo, Been of Morelos, Mexico, conformed it 96 morphospecies, being the division Chlorophyta the dominant group regarding diversity. Cyanobacteria Was the most important group in terms of biomass along with the study. And concerning the functional groups recognized 15 associations. This work pretends to characterize the structure of the community phytoplanktonic in a tropical reservoir shallow along an annual cycle, in terms of functional groups like indicators of the hydrological variations and the state trophic of the body of water. The functional groups that report are dependent on the diet of the mix of the column of water like M (*Microcystis botrys*), P (*Fragilaria* sp., *Cosmarium bioculatum*), and F (*Botryococcus* sp., *Dictyosphaerium* sp.), which presented like the most notable in this study. And in a lower proportion, together with the previous groups J (*Coelastrum*, *Pediastrum duplex*, *P. simplex*), Lm (*Coeleomoron* sp.) And the W (*Trachelomonas* sp.). The hydrological variations in the system marked the apparition of some functional groups, specifically in the phase of a greater volume of water as they went through it and (*Cryptomonas* sp.), X2 (*Rhodomonas* sp.), D (*Achnanthisidium* sp.), and (*Mallomonas* sp.) And The (*Merismopedia tenuissima*). The community algal of the Detour reflects a marked heterogeneity in his structure through the time and although the reservoir presents variations cyclic environmental and hydrological along the year, the functional groups observed in this body of water do not describe any pattern of clear succession.

## Community zooplanktonic of the Dam Madín, Estado de Mexico, Mexico

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Poster Session 1, July 29, 2021, 17:00 - 17:45

Within groups of organisms in aquatic systems epicontinental, there is the zooplankton community, responsible for secondary productivity and therefore its importance for all higher trophic levels. This body, due to the urbanization that has grown to its around it presents a problem of direct discharges, without any previous treatment, knowing that the water from the dam is used to supply some nearby towns. During this study, two stations were established in the limnetic zone within the dam, in which collected 64 samples, as a result of 8 months of sampling; obtaining a wealth of 14 different species among which the cladocerans stood out, who named 8 species different species and 57% density, followed by copepods with 5 species and 36% of density and a kind of throwing this only 7% density. The lakes and reservoir, represent optimal models for the study of specific richness in relation to environmental gradients, since they form ecological entities that are well delimited in the landscape, and the development of zooplankton populations will not only depends on the quantity of food available but also it's quality and the characteristics of the photosynthetic communities that depend on them, favoring a variability in zooplankton populations, as well as concentrations of available nutrients and OM that will allow the use of these as a basis for the energy flow of these aquatic systems, thereby determining the presence or absence of these fundamental organisms in the dynamic equilibrium of systems aquatic systems, their conservation, and sustainable anthropic use.

## Extremophile cyanobacteria from thermo-mineral springs in Galicia (NW Spain)

**Laura García Abad**<sup>1</sup>, Antonia Dolores Asencio<sup>1</sup>, M<sup>a</sup> Carmen López-Rodríguez<sup>2</sup>, Rosa Mejide<sup>3</sup>, Enrique Torres<sup>4</sup>

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Poster Session 1, July 29, 2021, 17:00 - 17:45

Cyanobacteria are photosynthetic prokaryotic organisms found in very diverse aquatic and terrestrial habitats. In aquatic environments, they develop in marine and fresh water where we can find them from ice to hot springs. To survive in such varied and sometimes extreme environments, they have a wide range of secondary metabolites to compete successfully in the different habitats of the planet. This has an enormous importance from a biotechnological and industrial point of view. We were studied the species composition of cyanobacteria assemblages in six thermo-mineral springs in Galicia (NW Spain). Four are considered hot and two cold, and some contain hydrogen sulphide. A total of 21 taxa have been recorded. Of the species identified, the most diverse genus is *Leptolyngbya* with four species, followed by *Chroococcus* with three species and *Aphanocapsa*, *Phormidium* and *Lyngbya* with two species. The most abundant species was *Jaaginema angustissimum*, followed by *Leptolyngbya laminosa* and *Symploca thermalis*. One of the most important parameters for cyanobacteria species diversity in hot springs is temperature. In the two cold springs, 7 different species were found, and only *Aphanocapsa conferta* was common to both springs. Cyanobacterial species were more numerous in the four hot springs, with 15 different species and only *Calothrix thermalis* common to these hot springs. It is difficult to establish a characteristic cyanobacterial flora for the thermal waters of the Galician springs since there are significant differences in the communities from the six sites studied.

## Scuba divers to address the invasion issue of *Hemimysis anomala* in lakes

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Poster Session 2, July 29, 2021, 17:45 - 18:30

Lake Geneva has been recently colonised by the small and invasive blood-red shrimp (*Hemimysis anomala*). This 15 mm maximum in size Mysidacea is native from the Ponto-Caspian region and it recently settled in some large peri-alpine lakes while it is paradoxically considered "endangered" in its original area. As there is still very little scientific evidence on the magnitude of its impact in these ecosystems, we began a survey in 2020, referred to as the MYSILAC program, with the help of nonprofessional scuba divers. The implication of both scientific and recreational divers offers a unique opportunity to study the ecology of this invasive shrimp. Diving is indeed the only way to obtain valuable information on swarms (volumes, preferential habitats) and to collect individuals for further analyses regarding feeding behavior (using stable isotopes, DNA metabarcoding on stomach contents). Here, we highlight the seasonally-evolving behavior of this shrimp at one reference site on Lake Geneva (Saint Disdille, France) and summarize a global survey of its colonization in 2020 and 2021 among this lake and others. This study provides a nice illustration of how civil stakeholders can be involved in a research program and highlight once more that citizen science may be an efficient mean for the monitoring of such biological invasion.

## Can picocyanobacteria be considered a functional bio-indicator of ecosystem health?

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Most of the work done in recent years in the field of lake bio-indication (and more broadly on aquatic ecosystems) has focused on developing tools to characterize ecological status in order to identify degraded environments to be restored. These bioindicators have only offered a partial view of biodiversity that supports the functioning of aquatic environments and they do not concern some biological compartments that are functionally important. This is the case, for example, of small unicellular organisms, between 0.2 and 2-3  $\mu\text{m}$  in size, referred to as the picoplankton, which are still largely ignored while they play a very important role in food webs as primary producers, recyclers of the material or as prey for the upper trophic levels. The PICOMIL project aims to examine that picophytoplankton (i.e. the plant fraction of picoplankton and in particular picocyanobacteria) through its abundance, diversity (pigmentary and/or genetic), biomass and/or relative production can be a good candidate of ecosystem health, and/or a marker of natural or anthropogenic changes, vulnerability and/or ecosystem restoration trajectory.

## Fish responses to the Highland Water restoration – a success or failure?

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Freshwater ecosystems around the world are threatened by anthropogenic activity and the law and government has so far been unsuccessful in preventing further damage. Restoration projects are often implemented as a means to improve the ecological status though the success of the project regarding this is often poorly assessed if at all. The study uses fish survey data from 1996 to 2019 to assess the success of the EU funded LIFE 3 restoration project, with respect to fish species, that took place between 2004 and 2005. The study implemented a MBACI study design – a fairly robust design suitable for measuring the effectiveness of a restoration project. The study found the fish had recovered within ten years following the restoration project and there was little change to the species composition among sites. However, the restoration was unable to produce any ecological or biological improvements in respect to fish. Despite this, the restoration may be deemed a success given that more habitat was created by increasing stream length which likely caused an increase in fish population. The project also had the added benefit of delayed flood peaks. These results may therefore question the true motives of the project.

## Limnological features of small, intermittent, brownish lakes in Hungary

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Intermittent, brownish lakes are very special aquatic ecosystems of Hungary, their distribution are scattered, island-like even in relation to world. These closed basin lakes are very shallow (depth <1m) with specifically little surface area (<50m<sup>2</sup>). They can be found in hilly forests; their high humic acid content (due to the bedrock and the allochton leaf litter input) provide exceptional brown colour. These ecosystems are very important from biodiversity perspective, and they are very sensitive for extreme weather events caused by climate change. Water and phytobenthos samples were collected from 137 lakes of 12 regions in Hungary, during the spring periods of 2014-2018. Water chemical parameters were measured in the field and in laboratory. Pyhtobenthos samples were treated by hot hydrogen-peroxide method, diatoms were analysed with light microscope. PCA analyses was run to determine the limnological patterns of these lakes. Mean value of the main variables were the next: conductivity 220.31  $\mu$ S/cm, pH 7, Cl- 27.38mg/l, NO<sub>3</sub>- 2.58 $\mu$ g/l, TP 334.019  $\mu$ g/l,). On the basis of the PCA lakes can be separated into three groups. The main features of the first group were the high shading ( $r = -0.543$ ) and turbidity ( $r = 0.443$ ). The second group can be characterized by higher DO ( $r = 0.774$ ) and irradiance ( $r = 0.601$ ). The third group can be specified by high HCO<sub>3</sub><sup>-</sup> ( $r = -0.605$ ), conductivity ( $r = 0.599$ ), Cl- ( $r = -0.576$ ) and SRP ( $r = 0.562$ ) concentrations. The most common diatom species were Pinnularia, Gomphonema, Eunotia and Nitzschia spp.



## What is a river? Impact of RiuNet app on students' mental models.

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Rivers are complex ecosystems from a structural and functional perspective. However, the general public still has a simplified notion of them, which may act as a sociocultural barrier for a sustainable river management leading to further river degradation. Therefore, it is urgent to develop and evaluate pedagogical tools that promote a change in people's mental models of rivers. This study aimed to assess the RiuNet app as a pedagogical tool to improve students' mental models of river ecosystems. The RiuNet app is a citizen science application that guides citizens to determine the hydrological (water abstractions), hydromorphological (riparian forest and river habitat heterogeneity) and biological quality (using macroinvertebrate communities) of rivers in a simple way, and collects data that can be available for scientific and management purposes. Here, we analysed river mental models of High School students before and after performing a hands-on activity guided by a RiuNet instructor. According to the students' drawings and definitions of a river, ten mental models were subsequently defined. Our results showed that the model's complexity increased significantly before and after the activity towards a better characterisation of river ecosystems. After the activity, students included new elements such as hard substrates, organic matter, living organisms or the riparian forest. This study demonstrates the usefulness of RiuNet app to carry out environmental education activities related to river ecosystems.

## How animals make use of plastic

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Plastic is a material which is widely used in everyday products. Yet, it is frequently mismanaged and enters the environment where it accumulates and persists. It is well known that microplastics (plastic particles < 5 mm) are ingested by aquatic animals and can be found in both terrestrial and aquatic ecosystems. Besides ingestion, however, only very few interactions between animals and plastics have been described. Here, we provide an overview on plastic usage by animals. While birds and bees use plastic as nesting material, marine polychaetes use microplastics for tube-building. Furthermore, we recently showed that caddisfly larvae use microplastics of different shapes (spheres, films, fragments, fibres) and polymer types as case building material in a German stream. Following that study, microplastic fibres were reported from caddisfly cases in an Italian river. Moreover, we recently found a red polyethylene and a red polyester urethane plastic fragment in caddisfly cases in a Spanish stream. We verified polymer types using state-of-the-art Fourier-transform infrared spectroscopy (FTIR). These findings from Germany, Italy and Spain show that plastic in caddisfly cases is not a local phenomenon. Since plastics can leach toxic additives, organisms using (micro)plastics for their nests or cases could be exposed to harmful substances. Among such substances are endocrine disruptors, which might affect nestlings and caddisfly larval development. As plastic is found in freshwater, marine and terrestrial habitats worldwide, more studies have to be conducted on how animals are using plastic and potential effects of such plastic usage should be examined.

## Annual patterns of litter decomposition in an intermittent stream

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Intermittent streams, dominant in arid and semi-arid regions, are considered to be more representative of global river networks than perennial rivers. The impacts of constant changes in hydrological regime on the functioning of these streams and associated riparian areas does, however, remain to be elucidated. In this study, litter derived from two deciduous tree species (chestnut and oak) was used to compare microbial–decomposition patterns between an intermittent stream channel and its riparian area over a 1-year period. The stream channel exhibited higher decomposition rates than the riparian area for litter from both species, and higher fungal biomass only for chestnut. Despite a prolonged absence of streambed surface water (254 days), differences in hydrological conditions in the wetter seasons (autumn and winter) shape the decomposition dynamics in both zones throughout the whole hydrological cycle. The results point out the importance of the “hydrological imprint” for the leaves’ degradation; long-term studies are advisable over short-term ones to better understand the functioning of intermittent streams.

## Ecological and ecotoxicological assessment of freshwater quality: reservoirs as study cases

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Toxic effects associated with exposures to the surface waters may not only be attributed to compounds regularly imposed in the analysis for the chemical water quality according to the Water Framework Directive (WFD). Hence, there is an urgent need for an effect-based evaluation strategy that employs ecotoxicological parameters to identify environmental hazards. This study aims to determine the physical and chemical parameters and evaluate the functionality and sensitivity of ecotoxicological tools in the assessment of water quality of Miranda, Pocinho and Alqueva reservoirs. One sampling site was defined in Miranda and Pocinho reservoirs, and three sites in Alqueva. Samplings were conducted in autumn 2018 and spring 2019. A set of ecotoxicological assays (growth inhibition of *Raphidocelis subcapitata* and *Lemna minor*, and feeding rate of *Daphnia longispina*) were performed, using three natural water treatments. *R. subcapitata* was the most sensitive species, indicating an environmental risk that is not detected by chemical analysis, nor by organisms of different trophic levels. *L. minor* assay and physiological parameters measured (total chlorophyll, lipid peroxidation, and proline content) did not show effects or sensitivity to discriminate the water treatments. *D. longispina* assay showed low sensitivity, mainly in the sampling sites of Alqueva, due to the difficulty in establishing relationships between the biological responses and the water treatments. Hence, it is important to increase the number of research studies to decrease the gap of knowledge in this type of water bodies and identify the most sensitive indicators that can be used for their management and restoration.

## Deleterious effects of salinization on litter decomposition are independent of litter quality

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Freshwater salinization is a matter of major global concern due to its consequences on the aquatic biota and ecosystems functioning. Salt contamination negatively affects the leaf litter decomposition process, a key ecosystem-level process in forested streams that contributes to the recycling of nutrients and carbon storage. However, information on how additional factors may influence the magnitude of the response to salinization is scarce. In this microcosm study we assessed the importance of leaf (*Castanea sativa*; *Quercus robur*) traits, on aquatic hyphomycetes-mediated leaf litter decomposition and associated variables, in salt-contaminated (0, 1, 3 and 6 g/l NaCl) environments. The leaves were incubated individually, and in a mixture, for 28 days, under each tested salt concentration. Salinity depressed leaf mass loss, fungal biomass, respiration and sporulation rates, particularly at the highest salt concentration. Differences across leaf categories were observed in all parameters but fungal biomass, although the effects were not consistent across descriptors. All leaf categories responded with a similar intensity to salt contamination for all measured variables but sporulation rate. These results suggest that the deleterious influence of salt on litter decomposition occurs independently of the traits of the stream riparian subsidies.

## Monitoring of chlorophyll-a concentrations in high mountain lakes using Sentinel-2 imagery

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Continuous and regular monitoring of water bodies is an essential tool for studying their ecological status and their correct management. This monitoring would be possible using methods based on satellite images which, once optimised, would also allow the study of inaccessible water bodies and an easier and faster study of the accessible ones. One of the most studied parameters through this method is chlorophyll-a (chl-a), as a proxy of the phytoplankton biomass and the trophic status of the system. Dozens of chl-a spectral indexes, such as NDBI, 2BDA, 3BDA or FLH, have been used for this purpose. However, further validations with field values are still needed. One of the satellites with the greatest potential is the Sentinel-2 Multispectral Instrument (MSI), due to its high spatio-temporal resolution. Its spatial resolution of up to 10 m allows the analysis of small water masses, and its revisit time of five days allows the characterisation of temporal dynamics. The aim of this work is to explore the potential of remote sensing for monitoring the trophic status of small high mountain lakes. These systems are excellent sentinels of global change due to their high sensitivity to environmental changes. Chl-a concentrations of 60 lakes in Sierra Nevada (Spain), sampled in July 2020, were related to several spectral indices derived from Sentinel-2 images with and without atmospheric corrections. The evaluated spectral indexes were obtained from a comprehensive literature review of 560 articles obtained from Scopus and WoS.

## Transfer of environmental stress across ecosystems through emerging aquatic insects

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Freshwater ecosystems are under anthropogenic stressors which can co-occur and interact in many ways. Moreover, these stressors cross ecosystem boundaries and propagate to adjacent terrestrial habitats. Emerging aquatic insects play a crucial role in these environments, transferring resources and energy, as well as subsidies to higher trophic levels in both aquatic and terrestrial habitats. Accordingly, the aim of the current study was to investigate the single and combined effects of emerging contaminants (ECs); pharmaceuticals (PhACs) and endocrine disrupting compounds (EDCs) and elevated water temperature (as a proxy for climate change effects) on aquatic insects at the aquatic-terrestrial habitat linkage. A laboratory (microcosm) experiment was conducted with a simplified freshwater food web containing nonvascular macrophytes and Trichoptera larvae feeding mainly as shredders. Sampling included initial sampling and several consecutive collections including both, aquatic and terrestrial life stages (larvae, pupae and adult stage). Analyses enabling assessment of the response of non-model aquatic insects to the selected stressors at molecular level are being conducted, such as metabolite profiling, total protein content, total lipid content and fatty acids composition. As expected, increased water temperature caused earlier emergence of male and female adults, however, there were no changes in sex ratios due to exposure to EDCs. Furthermore, negative correlation between body weight and protein concentration was observed in larvae and pupae in treatments with ECs mixture, irrespective of the water temperature. The current study will provide important insights on propagation of in-stream environmental stress across ecosystem boundaries through emerging aquatic insects.

## On the hydrology of the Albufera of Valencia lagoon (Spain)

**Prof. Dr Juan Soria**<sup>1</sup>, Lucía Vera-Herrera<sup>1</sup>, Sara Calvo<sup>1</sup>, Dr Xavier Sòria-Perpinyà<sup>2</sup>, Prof. Dr Susana Romo<sup>1</sup>

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Wetlands are among the most vulnerable freshwater aquatic ecosystems on the planet due to the overexploitation of their resources and the continuous anthropogenic pressure to which they are subjected. Mediterranean coastal wetlands are examples of the fragility of these areas, where agriculture is the main factor in relation to intensive land use. The Natural Park of the Albufera (Valencia, Spain) is an important Mediterranean coastal wetland (RAMSAR and NATURA 2000 site), that includes the largest Iberian coastal lagoon. It has an area of 23.1 km<sup>2</sup> and an average depth of only 1 m, with a maximum depth of 1.6 m. This lagoon is the remnant of an original and more extensive wetland of about 220 km<sup>2</sup> which is now mostly dedicated to rice cultivation. Surface water is supplied through several main and many secondary canals for a total of 64 water entry points and three exit points to the sea. Between 1988 and 2018, several procedures were used to estimate the water inflow. Overall, a decrease in the inflow during these thirty years was observed and, therefore, it can be concluded that the residence time is increasing. There is a temporal variation during the year due to rainfall and cultivation periods. Likewise, the results found that the natural hydrological zoning of the lagoon causes a spatial heterogeneity with small Northern areas with low residence time of 4.7 days, almost on a weekly basis and large Western extensions with high residence time of 222.9 days.



## Characterization of synthetic microbial communities by flow cytometry combined with viSNE

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Aquatic biofilms serve essential ecosystem functions. Controlling community composition for effects assessment and for understanding functions is essential for integrating biofilm ecology in environmental protection. Thus, tools are needed to efficiently analyse community composition. A high-throughput method to assess optical properties based on cellular structure and composition is stain-free flow cytometry (FC). Automated extraction of relevant information from high-dimensional FC data and clustering cells into phenotype-based groups is challenging. We present a method based on FC and single-cell visualization by viSNE (visual stochastic network embedding) to analyse microbial communities. 30 reference species grown under identical conditions were characterized by a common FC protocol (12 optical parameters). Four species representing similar and dissimilar fluorescence profiles (*Achnanthes minutissimum* (A), *Nitzschia palea* (N), *Botryococcus braunii* (B) and *Chamaesiphon polonicus* (C)) were selected to track temporal phenotypic shifts in simple communities (AN and ANBC) analysed by FC&viSNE and light microscopy (LM). Single-species cultures served as control. After a week, phenotypes moderately changed in the planktonic fractions and strongly changed in the biofilm fractions. Sedimentation of decaying cells was tracked. In (AN) mixtures, (A) became dominant in both planktonic and biofilm fractions, while in (ANBC) mixtures, (B) and (C) dominated the planktonic fraction, while (A) and (N) dominated the biofilm fraction. Combinations of microbial and protozoan species are likewise possible. In preliminary experiments, three out of six common model protozoa were detectable. The method has also been successfully applied to stream biofilms and abiotic particles like microplastics.

## Predicting methane production in sediments from particular organic matter supply and reactivity

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The highest CH<sub>4</sub> production rates can be found in anoxic surface inland water sediments however no model quantifies CH<sub>4</sub> production following fresh particular organic matter (POM) deposition on anoxic sediments. This limits our capability of modeling CH<sub>4</sub> emissions from inland waters to the atmosphere. To generate such a model, we quantified how the POM supply rate and POM reactivity control CH<sub>4</sub> production in anoxic surface sediment, by amending sediment at different frequencies with different quantities of aquatic and terrestrial POM. From the modeled CH<sub>4</sub> production, we derived parameters related to the kinetics and the extent of CH<sub>4</sub> production. We show that the extent of CH<sub>4</sub> production can be well predicted by the quality (i.e. C/N ratio) and the quantity of POM supplied to an anoxic sediment. In particular, within the range of sedimentation rates that can be found in aquatic systems, we show that CH<sub>4</sub> production increases linearly with the quantity of phytoplankton-derived and terrestrially-derived POM. A high frequency of POM addition, which is a common situation in natural systems, resulted in elevated CH<sub>4</sub> production rates. This suggests that relationships derived from earlier incubation experiments that added POM only once, may result in underestimation of sediment CH<sub>4</sub> production. Our results quantitatively couple CH<sub>4</sub> production in anoxic surface sediment to POM sedimentation flux, and are therefore useful for the further development of mechanistic models of inland water CH<sub>4</sub> emission.

## Total Suspended Matter during westerly winds in Albufera of Valencia lagoon (Spain)

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Wind is the factor with greatest influence on Total Suspended Matter (TSM) in shallow lagoons. Albufera of Valencia is a shallow lagoon on the Mediterranean coast of the Iberian Peninsula (Europe). It has an area of 23.1 km<sup>2</sup> and an average depth of only 1 m, with a maximum depth of 1.6 m. The lagoon is affected by easterly breezes and winds that increase the turbidity of the water and decrease the transparency. Meteorological data have been correlated with the reflectance obtained by processing Sentinel-2 satellite images with C2RCC (Case 2 regional processor), Acolite and iCOR (image correction for atmospheric effects) processing systems. The most suitable processor to monitor changes in concentration of TSM was evaluated. The results obtained show significant correlations between the measured variables and those obtained from the satellite images for TSM and water transparency and with the average daily wind speed. Moderate to fresh breezes resuspend the fine sediment and it is possible to improve the management of the lagoon by taking advantage of the westerly wind days to discharge the turbid waters towards the Mediterranean Sea. If this management system is implemented, it is possible to reduce the sedimentary material in the lagoon and also help to relocate these materials on the adjacent beaches by taking advantage of the natural processes.

## Zooplankton diversity patterns in lakes and ponds along an altitudinal gradient

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Unravelling the mechanisms underlying community organization and diversity patterns along altitudinal gradients is a modern issue in community ecology that has attracted growing interest in recent years. However, most studies on altitudinal gradients available to date tend to focus on terrestrial systems. The aim of our study was to examine the environmental and spatial drivers of zooplankton communities in 78 lakes and ponds distributed across a large and heterogeneous region from northern Spain that covered a wide altitudinal range. We tested if the beta diversity of zooplankton communities and the relative contribution of species replacement and nestedness changed predictable in relation to the altitude. Finally, we assessed the roles of local environmental drivers and the geographical template on patterns of community organization. Our results showed a consistent shift in community composition and diversity patterns between lowland and mountain ponds. This shift was mediated by concomitant changes in water chemistry, including conductivity and nutrient concentrations. Interestingly, we found that mountain ponds were environmentally less heterogeneous than their lowland counterparts; yet, there was no difference within-group dispersions between these two pond groups. Species turnover drove beta diversity patterns along the altitudinal gradient, whereas variation in community composition was slightly more likely to be correlated with changes in local environmental conditions. However, the minor influence of both niche-based and spatial-based mechanisms in our models suggests that the organization of zooplankton communities remains highly unpredictable.

## Intra-specific leaf trait variability controls in-stream decomposition of *Vitis vinifera* cultivars

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Understanding the ecological consequences of alteration of the plant species composition and distribution of leaf traits has recently been a main concern of freshwater ecologists. *Vitis vinifera* vineyards are the most valuable horticultural crop in the world. It frequently occurs near small watercourses replacing, total or partially, the native riparian trees. This study aims to assess the importance of intra-specific variability of four *Vitis vinifera* cultivars (Aragonez, Baga, Bical and Fernão Pires) on leaf litter mass loss and microbial and detritivore associated activities, in a low order stream. All cultivars presented fast decay rates. Leaf trait variability among cultivars was a main driver of litter mass loss and microbial decomposer descriptors (i.e. respiration and sporulation; fine mesh bags) as well as of the density of shredders and invertebrates' structure (coarse mesh bags). Bical and Baga globally presented the highest and lower values, respectively, in all microbial parameters; Bical leaf litter also presented a higher density of associated shredders in relation to the other cultivars. Results seem to be related with Bical leaf litter higher softness, lower leaf mass, trichomes density, and C:N. Vineyards with multiple cultivars seem to be able to provide a gradient of fast decomposition leaves to the streams that, if intermingled with deciduous riparian trees, may constitute an additional autumnal, easily processed, food source to aquatic food chains. These findings support that the intra-specific differences in leaf traits affect, a priori, the litter decomposition process in streams, potentially determining cascading impacts across the ecosystems.

## Model-based response of Mediterranean freshwater macroinvertebrates to climate warming scenarios

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Mediterranean-climate rivers are projected to warm by 0.5-4°C by 2071-2100. We modelled average taxonomic, metric and trait responses of macroinvertebrates from 191 Greek streams/rivers to increasing water temperature scenarios projected for the 2071-2100 period, to identify critical thermal limits beyond which potential irreversible responses might be triggered. Overall, total assemblage abundance was not projected to change but assemblages will be less diverse, with fewer, mostly limnophilic, warm-dwelling taxa. Ephemeroptera, Plecoptera, Trichoptera and some Diptera will be gradually replaced by Odonata, Amphipoda, Gastropoda and Heteroptera. Moderate warming (1-1.8°C) was not projected to significantly affect assemblage abundance and richness, but our models indicated a warming threshold (3-5°C), beyond which critical responses are triggered, eventually becoming irreversible at  $\geq 5^\circ\text{C}$  warming. Limnephillidae, Potamanthidae, Brachycentridae, Nemouridae, Taeniopterygidae, Glossosomatidae and Leptophlebiidae were the most thermal-sensitive taxa, projected to decrease in abundance by 29%, 29%, 26%, 17%, 16% and 12% for every 1°C of warming, respectively. This suggests 87% average loss of Limnephillidae and Potamanthidae populations (near-extinction levels) at 3°C of warming. In the assemblage level, these losses will be mostly replaced by relevant increases in the abundance of Physidae (42%), Coenagrionidae (32%), Hydrachnidae (26%), Helophoridae (23%), Dryopidae (15%) and Dytiscidae (13%). Our models indicate that, on average, the structure of macroinvertebrate assemblages will change by 2071–2100. Action needs to be taken for protecting thermal-sensitive taxa from extinction, which, based on our models will not likely occur before the 2071-2100 period, but might as well be highly accelerated due to the extreme hydro-thermal variability characterizing mediterranean-climate rivers.

## In-situ monitoring of chemical mixtures and biological effects in Albufera Natural Park

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Mediterranean coastal wetlands are highly impacted by intensive agriculture and WWTP discharges. The extent to which chemical mixtures contribute to biodiversity loss and the specific pollutants that are contributing to it is yet unknown. We implemented a set of novel chemical and biological monitoring approaches to assess the occurrence of contaminant mixtures and to assess bioconcentration and toxic effects on selected organisms of the Albufera Natural Park (Valencia, Spain). Grab water and sediment samples were taken and compared to passive sampling devices (POCIS) to assess (mixture) chemical exposure dynamics over 14 days in 12 sampling sites, including drainage ditches and the Albufera lagoon. Moreover, cages with animals (*Procambarus clarkii*, *Lepomis gibossus*, *Corbicula fluminea* and *Anodonta* sp.) were deployed to assess biological effects and bioconcentration of chemical pollutants. Analysis of 89 pharmaceuticals, 62 pesticides, 25 perfluoroalkoxy alkanes, and 9 flame retardants was performed by liquid chromatography tandem mass spectrometry (LC-MS/MS) and high-resolution mass spectrometry Q-Exactive Orbitrap system and data independent acquisition following established methods at the IDAEA and CIDE-UV laboratories. Pesticides, such as azoxystrobin, prochloraz, tebuconazole and terbuthylazine were found at concentrations >100 ng L<sup>-1</sup>. Preliminary results show complex pesticide and pharmaceutical mixtures potentially contributing to a biodiversity loss in the study region. Mortality of the caged animals was directly related to oxygen availability, whereas relation to pollution status was less evident. We discuss the use of biomonitoring (caged organisms) as a tool to replace and/or complement traditional chemical monitoring in Mediterranean coastal wetlands with significant anthropogenic impact.

## Recolonization processes and dispersal modes of three cyprinids in an intermittent river

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The recolonization processes and dispersal modes of fish inhabiting Mediterranean intermittent rivers are poorly studied. To address this, seven ichthyological campaigns were conducted at the main stem of an intermittent river (Evrotas River, Greece), from October 2018 to June 2019, at five sites; a perennial refugium site (P1) located near the river source and four intermittent sites downstream of P1 (I2 -3.5 km, I3 – 5 km, I4 – 6.6 km and I5 – 13.8 km). The native fish community includes the rheophilic Evrotas chub (*Squalius keadicus*), and the limnophilic Spartian minnowroach (*Tropidophoxinellus spartiaticus*) and Evrotas minnow (*Pelagus laconicus*). Recolonisation was rapid, within 12 days upon flow resumption, as all three species were collected from all intermittent sites, with the exception of the most downstream site (I5), where only a few minnows were collected; these either survived in a disconnected pool at I5 or rapidly colonized the I5 site from P1. Species composition was similar in P1 and the adjacent intermittent site (I2), with minnows and chubs prevailing. Sites I3 and I4 were mainly dominated by chubs, while the most downstream site (I5) was dominated by minnows.. Higher percentages of juveniles were observed in intermittent sites during our 1st sampling, indicating that the classification of fish to dispersion modes based on body size (i.e. larger sized species are also the strongest dispersers) is not always valid, especially in intermittent rivers. Our results suggest that species abundances at perennial refugia are the main factor modulating fish species distribution at intermittent sites.



## Groundwater cirolanids from the Iberian Peninsula, and establishment of two new genera

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Cirolanidae Dana, 1852 is the second most diverse isopod family, formed by a heterogeneous group of peracarid crustaceans that is present in practically all aquatic ecosystems, from deep sea waters to continental groundwater. Three endemic species of stygobiont Cirolanidae are known from the Iberian Peninsula: *Kensleylana briani* Bruce & Herrando-Pérez, 2005, *Typhlocirolana margalefi* Pretus, 1986 and *T. troglobia* De Grave & Herrando-Pérez, 2003. Our team has carried out multiple samplings across different localities of the Valencian Community, Aragón and Balearic Islands. Freshly collected specimens were obtained from a cave located at sea level in the Valencian coast and the hyporeic zones of the Martín river and the Turia river. The specimens were compared with type material of *T. troglobia* from the Zoological Collection of the Oxford University Museum of Natural History and freshly sampled specimens of the *Typhlocirolana* type species (*T. moraguesi* Racovitza, 1905) collected from Mallorca. A combined morphological and molecular analysis confirms the presence of two new genera in the Valencian Community and Aragón regions. In addition, each genus prefers slightly different habitats, as estimated from ecological data and physicochemical parameters of water. Historical sea level changes and plate tectonics could explain the significant diversity of stygobiont cirolanids in the Iberian Peninsula.

## Crustacean zooplankton metrics in the assessment of water quality in reservoirs

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At the European scale, the Water Framework Directive (WFD) bioassessment protocol relies on phytoplankton as the main biological element to assess the ecological potential of heavily modified artificial waterbodies. Crustacean zooplankton remains overlooked within the WFD scope, despite its bioindicator value, strategic intermediate position in the food web, and cost-effective assessment. In this study, we evaluated the potential of structural and functional metrics of the crustacean zooplankton community in four Portuguese reservoirs (differing in morphology, hydrology, climate and anthropogenic pressures) to test their value as indicators of water quality and ecosystem functioning. A total of 11 sampling stations were sampled at four distinct periods: autumn 2018, spring 2019, autumn 2019 and spring 2020. Zooplankton samples were collected with oblique trawls using a 150- $\mu$ m plankton net, along with water samples for general physical and chemical parameters and phytoplankton. The latter descriptors were used to calculate Ecological Quality Ratios (in the case of phytoplankton) and ecological potential according to WFD, which were compared with zooplankton metrics (functional feeding groups, average body size, biomass, and various ratios). Overall, there was agreement between zooplankton and WFD metrics. However, the rapid turnover of phytoplankton communities and the presence of cyanobacterial blooms worked as confounding factors and occasionally caused divergence between zooplankton and phytoplankton indicator value. Such mismatch deserves further research. Nonetheless, our data support the idea that the use of crustacean zooplankton metrics is, at least, complementary to the current WFD bioassessment approach.

## Blooming blanket weed: managing nuisance algae in UK freshwater bodies

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Across the UK, many standing freshwater ecosystems are experiencing increasingly frequent and widespread blooms of blanket weed, particularly genera such as *Cladophora*, *Ulva*, *Hydrodictyon* and *Spirogyra*. The formation of thick mats at the lake surface cause major ecological damage by harbouring pathogens and decreasing aquatic plant diversity. Blooms also reduce the amenity value of freshwater bodies by looking unsightly, preventing water-based activities and negatively impacting conservation work. Currently the extent, cause and consequences of these prolific blooms are largely unknown. This PhD project employs (1) Questionnaire surveys gathered from freshwater sites across the UK to formulate a better understanding of the extent of the problem; and (2) Limnological monitoring and experiments with macroalgae cultures to assess spatial and temporal patterns and identify the main environmental drivers of the blooms. Laboratory experiments include nutrient amendment bioassays to investigate seasonal nutrient limitation in different macroalgae genera sampled from shallow UK lakes. Nutrient limitation will be determined by measuring the rate of change in algae biomass and photosynthetic yield potential using chlorophyll fluorescence. Results from the entirety of this project will inform effective and sustainable management techniques, using the National Trust's lake at Clumber Park, Nottinghamshire as a model for application elsewhere.

## An HPLC-UV method for the determination of pharmaceuticals in surface water environments.

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The continually increasing consumption of small molecule pharmaceuticals has led to the contamination of global surface water ecosystems from  $\mu\text{g/L}$  to  $\text{ng/L}$  concentrations. The concentrations, fate and toxicological implications of pharmaceuticals and their residues remain generally unknown. The continual release, stability and biological activity of these “micro-pollutants” can lead to chronic environmental exposure, with ensuing behavioural and health-related effects to wildlife and potentially to humans. The objective of this project is to determine the presence and concentrations of pharmaceuticals in surface water and relate it to potential environmental effects on aquatic ecosystems. 11 pharmaceuticals are investigated in this study, including diclofenac, trimethoprim, ciprofloxacin, sulfamethoxazole, amoxicillin, gemfibrozil, venlafaxine, carbamazepine, Estrone,  $17\alpha$ -ethylene estradiol,  $17\beta$ -estradiol. These pharmaceuticals were selected from the water framework directives “Watch List” or are recognised as contaminants of emerging concern. 1L Surface-water grab samples were collected from the Tolka river and further underwent pre-treatment and concentrated using solid-phase extraction (SPE) with OASIS HLB cartridges. Detection was performed by high-performance liquid chromatography coupled with a UV detector (HPLC-UV). Outcomes from this research will aim to provide a robust method too systematically monitor pharmaceuticals in surface waters at environmentally relevant concentrations.

## A new Sphaeromicolinae (Ostracoda) commensal on a cirrolanid isopod from Iberian Peninsula

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Sphaeromicolinae (Crustacea: Entocytheridae) are ostracods that live mostly as commensals on other crustaceans, usually in cave environments. The subfamily is composed of two genera: *Sphaeromicola* Paris, 1916, present in Europe, and *Hobbsiella* Danielopol & Hart, 1985, distributed in southern North America. The genus *Sphaeromicola* includes 5 species, all of them described from cave environments in France, Northern Italy, Croatia, Herzegovina and Slovenia. This survey reports on the first record of a Sphaeromicolinae species from the Iberian Peninsula. It was found living commensal on an undescribed species of a troglobitic cirrolanid isopod, each individual hosting up to eight ostracods, placed under coxal plates and pleopods. These entocytherid ostracods are tentatively assigned to *Sphaeromicola*, although they present some unique morphological traits that suggest the erection of a new genus. The new species holds five setae on the 5th segment of the antennule, a primitive character corresponding shared with *Hobbsiella* and used to distinguish it from *Sphaeromicola*, which has four setae only. However, the new species presents unfused 4th and 5th antennular segments, a diagnostic character of the genus *Sphaeromicola*. In addition, unlike other entocytherids but one (i.e. *Sphaeromicola sphaeromicola* Hubault, 1938), the new species has an extra seta on the maxillula, arising not from the maxillular palp, but from a more proximal bulk suggesting a small endite, what can be considered a putative ancient character. Both *S. sphaeromicola* and the new species are living in coastal caves, which could explain their closer affinities to marine entocytherids, compared to more inland European Sphaeromicolinae.

## Sedimentary phosphorus: a perspective on climate and anthropic activity as eutrophication drivers.

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Lakes with varved sediments are especially well suited to bridge the gap between modern and past limnological studies, because they provide high resolution, continuous and reliable records. Temporally integrated information is of central importance to tackle eutrophication problems and allows investigating long-term (decadal, centennial), progressive nutrient enrichment processes in lakes. It also helps identifying long-term drivers of eutrophication like climate variability. Lake Montcortès (Central Pyrenees, Iberian Peninsula) has well preserved biogenic varves. Its current trophic status is meso-oligotrophic with poor nutrient turnover due to meromixis. Paleoecological studies revealed the importance of human activities around the lake between the mid-17th to late 19th centuries. Hence, we investigated eutrophication processes that impacted the lake since 1500 CE. To go deep in the knowledge of the dynamic of eutrophication, we determined the concentration of several forms of sedimentary inorganic phosphorus - exchangeable, iron-bound, authigenic carbonatefluorapatite (CFAPaut) and detritic carbonatefluorapatite (CFAPdet)- by using the SEDEX method. Here we focus mainly on the detrital fraction, since it probably is the main source of P to the lake. In fact, it was correlated with Titanium ( $r=0.636$ ), a geochemical indicator of erosion. CFAPdet maxima were associated with periods of extreme (1847, 1899) or moderate (1516, 1558, 1740, 1756, 1780, 1833 1847) precipitation frequency and intensity. Concurrent erosion could also have contributed to CFAPdet inputs to the lake, mainly associated to forest clearing (1500-1550), intense forest burning (1740-1760) and intensive hemp retting (1830-1850). Noticeable is also the opposite pattern between CFAPdet and CFAPaut, possible related to changes in turbidity and in carbonate precipitation.

## The redclaw crayfish: A prominent aquaculture and pet-traded species with invasive potential

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The redclaw crayfish (*Cherax quadricarinatus*), native to northern Australia and southern New Guinea, is among the largest freshwater decapods. It matures early and is considered highly prolific as females may lay over one thousand eggs in a single clutch. Despite generally preferring slow-moving streams in its native range, it has a wide environmental tolerance, making it capable of establishing populations when introduced to a wide range of other conditions and habitats. These biological and ecological features render it a highly suitable and popular species for aquaculture worldwide, being the second most important crayfish species economically (after the red swamp crayfish *Procambarus clarkii*). Adding to that, its unique coloration fuels demand and value among aquarium enthusiasts, making it attractive for the aquarium pet trade. Today, redclaw is widely translocated (67 countries/territories) and various established wild populations (22 countries) have been reported on every continent except Antarctica. Information on its potential or observed impacts, however, is sparse and often anecdotal. To address this gap, this comprehensive review compiles all available information on this species, covering its taxonomy and description, biology and ecology, native and non-native ranges accompanied with documented introduction pathways. Built upon these, we conducted biological and socio-economic classification and species distribution modelling. We reveal a lack of thorough impact assessments for this species despite sufficient indications of major observable impacts at local scales. We call attention to the importance of managing the use of this prominent introduced species in aquaculture and aquarium pet trade.

## Chemical pollution levels explain site-specific sensitivities of genetically-homogeneous freshwater amphipods to micropollutants

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Anthropogenic micropollutants alter chemical and ecological conditions of freshwater ecosystems and impact aquatic species that live along the pollution gradient of a river. Species sensitivity to micropollutants depends on the site-specific exposure, however, it remains unclear to what degree this sensitivity relates to species' genetic structure. Here, we explored the relationship between toxic sensitivity and genetic structure of the amphipod species *Gammarus pulex* (Linnaeus, 1758) along an organic micropollutant gradient in the Holtemme River in central Germany. We determined the river's site-specific micropollutant patterns and analyzed the genetic structure of *G. pulex* using nuclear and mitochondrial genetic markers. Furthermore, we examined the exposure sensitivities and bioaccumulation of the commonly detected insecticide imidacloprid in *G. pulex* from different sites. Our results show that throughout the Holtemme River, *G. pulex* forms a well-connected and homogenous population with no observable pollution-related differences in genetic structure. However, *G. pulex* from polluted sites responded more sensitively to imidacloprid; survival times for half of the amphipods were up to 54% shorter, the percentage of immobile individuals increased up to 65%, and the modeled imidacloprid depuration rate was lower in comparison to amphipods from non-polluted sites. Altogether, these results suggest that the level of sensitivity of *G. pulex* amphipods to micropollutants in the river depends on the degree of pollution: amphipods may thrive in food-rich but polluted habitats, yet their sensitivity is increased when chronically exposed to organic micropollutants.



## On two new species of the subfamily Cypridopsinae (Ostracoda) from southern Africa

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We present two new species of the subfamily Cypridopsinae, *Potamocypris* sp. nov. and *Sarscypridopsis* sp. nov., both found only as asexual (all-female) populations in temporary waters of southern Africa. *Potamocypris* sp. nov., collected from a small pan in the North-West Province of South Africa, is 0.5 mm long, presents the main diagnostic features of the genus and belongs to the species group with long swimming setae on the second antennae. It holds, however, somewhat isolated position in *Potamocypris* owing to conspicuously reticulate carapace densely covered by prominent conuli of normal pores with extending sensillae and to wide anterior and posterior flanges on the left valve. Because of this characteristic ornamentation and form of the carapace it resembles *Potamocypris deflexa* and *P. humilis*, which were originally described from South Africa as belonging to the separate genus *Cyprilla*, later regarded as a junior synonym of *Potamocypris*. However, South African ornamented species assigned to *Potamocypris* seem to represent a separate lineage which might well deserve to be recognised as a genus of its own. The genus *Sarscypridopsis* is mostly Afrotropical with only few species occurring in other regions. *Sarscypridopsis* sp. nov. was collected from floodplains of the outskirts of the Okavango Delta in Botswana. It is 0.4 mm long and can be distinguished from its congeners mainly by the unique shape of the valves which are smaller and more oval than in other species. We conclude that South African Cypridopsinae urgently need revision by means of both morphological characters and DNA-sequence data.

## Physico-chemical characterisation of protected oligotrophic lakes in Ireland

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Both oligotrophic isoetid (3110) and acid oligotrophic (3160) lake habitats are protected under Annex I of the EU Habitat Directive. Despite this, their conservation status in the Republic of Ireland is bad, declining, and unfavourable, inadequate, respectively. Failure to meet conservation status assessments is driven by a lack of baseline knowledge on their structure and function characteristics including distribution, characterisation, environmental drivers and conditions. The current research aims to evaluate the use of water chemistry analysis as a key conservation assessment monitoring method for these lakes, and distinguish and characterise subtle changes in water chemistry between these lake habitat types. A 12-month water sampling campaign, conducted on 24 lakes and pools in Connemara Bog Complex Special Area of Conservation (SAC), Co Galway (n=12) and Owenduff/Nephin SAC, Co Mayo (n=12), examines over ten water chemistry parameters. Preliminary findings indicate that both lake habitat types are mildly acidic with low levels of conductivity, alkalinity, chlorophyll-a and nutrients. However, parameters such as colour, dissolved organic carbon, turbidity and suspended solids vary between lake habitat types and sampling sites, possibly reflecting catchment management practices rather than distinct characteristics between the lake habitats. This water sampling campaign is an important first-step towards a better understanding of these protected lake habitats and the creation of monitoring methods and assessment tools which will deepen our knowledge of their conservation status and requirements for restoration.

## Riverine damselfly as a model system for personality studies in the wild

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Although, animal personality studies have received high interest over the last two decades, several areas remain to be still developed. For instance, more field studies of invertebrates are needed. Also, more surveys on animal personality should be directed towards increasing the number of traits measured and species tested. We propose *Calopteryx splendens* and its habitat which is a lowland river as a promising model system in animal personality studies in the wild. We measured repeatability of nine behavioural traits from an array of three experiments: (i) courtship, (ii) aggressiveness and (iii) boldness. The repeatability was assessed by measuring the behaviours twice, in two different contexts: (i) an undisturbed territory and (ii) a partially disturbed territory that is a floating vegetation raft. All of the behavioural traits, but two, were consistent throughout the two bouts, showing on the one hand the presence of personality in the studied damselfly, and on the other hand, indicating that caution is needed in developing personality metrics for different species. This work demonstrates, for the first time, the presence of individual personality differences in an adult damselfly in the wild population.

## Periphyton as a tool for monitoring stream revitalization at tufa barriers

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Tufa barriers provide great microhabitat complexity and are therefore colonized by various periphytic organisms. The metabolic activity of the periphyton alters the microenvironment and may affect the physicochemical conditions of calcite precipitation in tufa-precipitating hydrosystems. Because the invasive plant *Ailanthus altissima* (Mill.) Swinge was identified as the cause of stream drying at the Skradinski buk barrier (Krka National Park, Croatia), it was removed. Its removal resulted in hydromorphological changes at the barrier and reactivation (revitalization) of dry streams. The aim of this study was to compare the annual dynamics of control (permanently flowing) and revitalized (reactivated) streams at the Skradinski buk barrier using periphyton (i.e. abundance and diversity of periphytic phagotrophic protists and micro-metazoans) and environmental parameters as proxies for evaluating the efficiency of the applied revitalization measure. Compared to control streams, revitalized sites exhibited lower flow velocity, conductivity, pH, alkalinity, and total water hardness, but higher dissolved organic matter, nitrite, and orthophosphate concentrations due to the presence of soil-derived organic material and intensive soil drainage. They also showed higher periphyton abundance and diversity, dominated by bacterivorous and omnivorous ciliates and cercozoans, which may be attributed to the abundant food resources of the soil. Our results demonstrate that ecosystem responses to stream revitalization can be efficiently detected and monitored at the microscale (i.e., periphyton scale). This study provides data and guidelines for future management plans applicable to various tufa-depositing systems facing the spread of invasive species, allowing for better understanding and protection of these unique and vulnerable karstic features.

## Size structure and biomass of Chironomid larvae in the regulated-subalpine Lake Maggiore (Italy)

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An appropriate water management strategy could contribute to solve problems of water availability both from a biodiversity and a socio-economic point of view. Further, water level manipulation (WLM) may well mitigate the adverse impact of extreme events on the distribution and ecology of macroinvertebrates. This is particularly true for chironomids, the largest family of aquatic insects dominating lakes, where their assemblages seemed to be influenced by amplified water level fluctuations. However, knowledge of how the distribution, diversity and size structure of chironomids change under different water level regimes is still fragmentary. Here, we report our preliminary results of the chironomid assemblage obtained from a study within the INTERREG Project “Parchi Verbano Ticino” aimed to understand the impact of water level fluctuations on the macroinvertebrate community structure in the littoral zone of Lake Maggiore, the second largest lake in Italy regulated from mid-March to mid-September through the Miorina Dam placed at the lake’s outflow (River Ticino). Samples were collected in 2019 and 2020, from July to September, in three sampling sites following the north-south axis of the lake and characterised by different WLMs (high/low) and depths (deep/intermediate/shallow). Biometry, biomass and relative abundance of each detected chironomid species are presented here, and for the most common species, length-mass regression models were developed to predict the dry mass. Alterations in the size structure and length-mass relationships for populations of the same species relative to different WLMs and depths are investigated as potential consequences of the impact of water level regulation in Lake Maggiore.

## Biodiversity as barrier against ARGs diffusion: a first look into ANTIVERSA project

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Does microbial biodiversity of the receiving environment play a role in the dissemination of antimicrobial resistance (A) from anthropogenic sources? The ANTIVERSA project aims to answer this question, evaluating whether biologically diverse ecosystems have a greater capacity to prevent or delay the spread of A compared to low-diversity environments. To study the link between biodiversity and environmental A a dual approach of field observations and laboratory experiments will be employed. In the laboratory, river-grown biofilm communities and soil microbial communities of contrasting diversity will be exposed to different sources of antimicrobial resistance in flume microcosms and pot experiments, respectively. The first phase of the project consisted of a field sampling campaign to acquire prior knowledge over the diversity present in aquatic (river biofilms) and terrestrial (forest and agricultural soils) habitats in the seven European countries participating in the project, providing a geographic gradient from NW to SE Europe. The field survey was conducted in parallel in all countries in the fall season of 2020 using standardized sampling protocols and methods. The respective samples were analyzed with molecular approaches (e.g., DNA extraction, 16S rRNA gene and ITS2 amplicon sequencing and qPCR) to assess microbial diversity and to explore potential correlations between species diversity and the abundance and diversity of ARG/ARB. In this poster, we detail the ANTIVERSA project and present preliminary results from the characterization of bacterial and fungal biodiversity.

## Monitoring of macrophytes in the context of the work of renaturalisation

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The research was carried out in the years 2019-2020 on Lake Łajskie in the north-eastern part of Poland. It is a relatively small (46.9 ha) and shallow (7.7 max. depth) reservoir located within the Natura 2000 area (PLB280007). Through its hydrographic location affects the state of the waters of Lake Kośno (Kośno Reserve PLH280052). Unfortunately, as a result of many years of uncontrolled pollution of the reservoir with untreated sewage, there was an accumulation of nitrogen and phosphorus compounds in the bottom sediments of the lake, which over time began to adversely affect the nearby protected areas. In 2014, a decision was made to reclaim the reservoir by improving the oxygen conditions in the bottom layers of the lake, through chemical precipitation and inactivation of phosphorus from the water column into bottom. The recultivation progress was monitored by analyzing the macrophyte communities and assessing the ecological condition of Lake Łajskie. The lake's ecological status was assessed using the Ecological State Macrophyte Index (ESMI) method. The results of which confirmed the improvement of the ecological condition of Lake Łajskie from moderate (2019 – 15 taxa) to good (2020 – 17 taxa).

## Combined effect of elevated temperature and hypoxia on the interspecific-competition of *Daphnia*

Marcin Żebrowski<sup>1</sup>, Ewa Babkiewicz<sup>1</sup>, Kamil Dąbrowski<sup>1</sup>, Karol Krajewski<sup>1</sup>, Szymon Pukos<sup>1</sup>, Julia Wawrzeńczak<sup>1</sup>, Wojciech Wilczynski<sup>1</sup>, Dr Piotr Maszczyk<sup>1</sup>

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Numerous studies have revealed an apparent decrease in individual body size among a variety of aquatic ectotherms as well as the mean body size of their populations and communities either spatially or temporally at an elevated temperature. In the case of zooplankton communities, one of the most likely explanations of these patterns is the relative decrease of the competitive abilities of larger- over smaller-bodied species because the production (i.e. growth and reproduction) of individuals of larger species is more limited due to their greater susceptibility to decreased oxygen at an elevated temperature either through a decreased oxygen concentration or increased oxygen demands (due to an accelerated metabolism). To test this, we performed competitive experiments at two oxygen concentrations (8.0 and 3.0 mg O<sub>2</sub>\*L<sup>-1</sup>) at two temperatures (23 and 13 °C) with two pairs of zooplankton species differing in body size: *D.longispina* (smaller-bodied) and *D.pulex* (larger-bodied), as well as *D.pulex* (smaller-bodied) and *D.magna* (larger-bodied).

In the case of *D.longispina* and *D.pulex*, our hypothesis was not confirmed, since larger-bodied species competitively excluded the smaller one in all of the experimental treatments. Although in the case of *D.pulex* and *D.magna*, both species successfully coexisted for a very long period of time in all of the treatments, their relative densities were affected by both experimental variables. According to our hypothesis, temperature favoured smaller-bodied species. Contrary to the hypothesis, low oxygen concentration had the opposite effect, which may be attributed to a greater concentration of hemoglobin in the body tissues of *D.magna* than in *D.pulex*.



## Variation of the valve shape asymmetry of a halophile ostracod *Heterocypris salina*

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Geometric morphometric-based methods are increasingly used in ostracod valve shape studies and have also become important approach for the analysis of morphological asymmetry in left and right sides of bilaterally symmetric organisms. Asymmetry of left-right sides of carapace in freshwater ostracods is a common phenomenon manifested by unequally-sized and/or differently-shaped valves. It is not known, however, how variable the asymmetry between left and right valve really is within and among populations. Partitioning the total shape variation into components or genetic basis of asymmetry are also only little explored at present in ostracods. In this study we used geometric morphometrics towards assessment of intra- and inter-population variation of asymmetry in the left-right valve outline (independent of size) based on 135 female individuals of a morphospecies *Heterocypris salina*, an ostracod which prefers brackish coastal and inland waters. Seven asexual (all-female) populations from Italy, Morocco and Poland were examined. After the valve outline approximation according to the B-spline algorithm, computation of morphological difference between left and right valves of a given specimen was performed and expressed as Mean Delta Square values (MDS). Intrapopulation distribution of MDS values were then studied and differences among populations tested by ANOVA followed by the post-hoc Student-Newman-Keuls method. The results support heterogeneity of the valve asymmetry among the studied populations, showing both directional and fluctuating asymmetry, though without any consistent geographical pattern. Further studies are needed to clarify taxonomic importance and to provide more data on factors that affects components of valve asymmetry in ostracods.

## Local and landscape impacts of land-use on lotic macroinvertebrate functional diversity

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Freshwater macroinvertebrates play essential functional roles within lotic ecosystems. However, there is a lack of knowledge on how functional diversity changes with habitats disturbance at the local and landscape scale. The aim of this study was to compare the taxonomic and functional diversity of the macroinvertebrates found adjacent to urban and rural land-use types across four rivers in South Wales. Macroinvertebrates were kick-sampled in accordance with the RIVPACS guidance and river and bankside modification were assessed using a modified version of the River Habitat Survey at three urban and three rural sites for each river (N = 24). Shannon-Weiner was calculated to determine the taxonomic diversity of each sample site and Rao's coefficient was used to provide an index of functional diversity. A multivariate DECORANA was employed to assess variation in community structure between sites. No significant differences were found in the taxonomic or functional diversity of freshwater macroinvertebrate communities between urban or rural land-use types, in addition to no differences found across the four rivers sampled. Community assemblages however differed in accordance with landscape factors as oppose to microhabitat scale with compositions being more consistent within-river, than between-rivers. These outcomes suggest that a catchment approach to conservation management that identifies unique species compositions is a more pragmatic approach compared to relying on taxonomic and functional diversity traits alone, as details in compositions are omitted. More analysis is needed to interpret and investigate this relationship between communities, functional structure and anthropogenic impacts, to ensure effective mitigation of freshwater systems.

## Combine modeling approaches to gain knowledge about community assembly of stream macroinvertebrates

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Climate and environmental changes raise many new challenges, including the need to better understand ecosystems with a focus on reducing human impact on them. In particular, good management of streams requires an understanding and predictions how the community assembly of stream macroinvertebrates reacts to changing conditions. Different modeling approaches have been proposed for this purpose: machine learning algorithms, interpretable statistical models, and mechanistic models. They differ in their use of prior knowledge, interpretability, computational requirements, and amount of data needed for calibration. To identify the strength and weaknesses of the approaches we will apply the different types of models to a macroinvertebrate biomonitoring data set covering whole Switzerland. We will compare their quality of fit and predictive performance, and, while carefully accounting for uncertainties, identifying the most important influence factors. With the acquired knowledge we will develop a simple and efficient model that is optimized for predictions while considering the most important mechanisms. Such a model will allow us to run simulations to identify macroinvertebrates metrics that are sensitive to future environmental changes. This will hopefully bring new insights for predicting community assembly and inform the management of aquatic ecosystems in response to future environmental changes. In this poster, we will outline the methodological approach and provide first results of the model comparison.

## Functional traits differences of the heterophyllous plant *Luronium natans*

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The rare aquatic plants *Luronium natans* (L.) Raf is an endangered species endemic to Europe. Many studies have shown high phenotypic plasticity and occurrence under variable environmental conditions. The heterophyllous plant *Luronium natans* produces two types of leaves. We aimed at determining functional trait differences in floating and submerged leaves of *Luronium natans*. Leaves were collected in July 2020 in five soft-water lakes situated in NW Poland. We measured leaf morphological traits (leaf area, leaf dry weight, specific leaf area and leaf dry matter content) and shape traits in a group of floating leaves and submerged leaves. In investigated lakes *Luronium natans* grows in shallow littoral, mainly in acidic water (pH from 5.1 to 7.36), low conductivity (23.0 – 52.3  $\mu\text{S cm}^{-1}$ ) and low calcium concentration (1.7 – 5.2 mg L<sup>-1</sup>). We found significant functional differences in types of leaves. The submerged leaves in comparison with floating leaves were more elongated, usually thinner, with higher specific leaf area and leaf area. Moreover, functional leaf type distinctness was linked to carbon acquisition strategies. The studies were partly financed by Polish National Science Centre, under project No 2019/32/C/NZ8/00147.

## Residual pools and dry streambeds as refugia for macroinvertebrates of intermittent streams

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Since stream intermittency is becoming more frequent, species need to either survive stranded in moist stream bed sediment, or retreat into remnant pools and hope for the best. We assessed the role of these two refuge types by comparing their community composition with spring and autumn communities on 6 different streams. Results indicate, that taxonomic composition of summer dry streambed and residual pool samples are much more diversified than spring or autumn samples. Probably in reaction to diverse and changing environmental conditions. Mean number of species surviving from all taxa of each stream in remnant pools was around 10 % and similarly 10 % in dry streambed. Around 15 % of species were found during flowing phase and in one or both of our refuge type samples. As we see, the role of residual pools and dry streambed as refuges for macroinvertebrates in intermittent streams should not be overlooked in river management and can serve to argue for their protection, even during dry phase. This research was supported by INTER-EXCELLENCE COST project INTERSTREAM (LTC17017), Czech Science Foundation (P505-20-17305S) and university specific research MUNI/A/1581/2020.

## Integrating satellite and high-frequency data on episodic weather events in Lake Maggiore

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Weather-related episodic events have increased in frequency and intensity in many regions around the globe. Their impacts on lake structure and function include abrupt changes in the physical, chemical, and biological parameters relative to previous background levels. However, both abiotic and biological responses are often missed in routine monitoring. Integrating data from a diverse range of spatial and temporal scales is important for advancing the understanding of the impact of episodic events on lakes. We present data from a high-frequency monitoring station from the oligotrophic deep subalpine Lake Maggiore, Northern Italy, during periods of sudden changes in weather conditions with extremes in precipitation and/or wind. To investigate the implications at spatial scale, HFM data have been combined with Sentinel-3 satellite data (OLCI and SLSTR sensors) from images taken at a timescale of 1-3 days before and after the selected events. Satellite images captured surface chlorophyll-a, total suspended matter (TSM) and temperature in the whole lake area and in the zone close to the buoy. Water temperature, dissolved oxygen and pH all decreased following episodic weather events. Conductivity and TSM dropped after heavy rainfall. Chlorophyll, registered in-situ by a fluorescent sensor, showed varied responses to episodic events depending on the type of event (rain, wind or combination of both) and antecedent lake conditions (extended period of warm or windy weather, thermal condition-stratification, vegetative season). Overall there was a fair agreement between in situ and satellite data, even though the relationships were highly dependent on the timing of satellite overpass.

## Heavy metals in pristine mountains: an emerging ecological stressor for aquatic biodiversity?

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Climate change affects the availability and quality of Alpine freshwaters, as the diminishing hydrological contribution from receding glaciers is paralleled by the increasing influence from mountain permafrost. In particular, rock glaciers (i.e., bodies of rock fragments with internal ice) have been addressed as significant water reservoirs, as their subsurface ice melts much more slowly than that of glaciers. As springs emerging from rockglaciers are quite cold even in glacier-free areas, they may also represent “climate refugia” for cold-adapted biodiversity within a context of global warming. Nonetheless, this crucial ecosystem service may be negatively affected by the release of trace metals/metalloids, which is enhanced by the permafrost thawing. In this study, we describe the physical and chemical conditions of a set of springs emerging from rock glaciers in deglaciating catchments of the Central European Alps. Concentrations of solutes and trace elements (As, U, Ni, Al, Mn) by far exceeded the environmental quality standards at several springs, in particular during late-summer. A detailed seasonal analysis on two of these springs revealed that the rise of solute concentrations can reach either a plateau during autumn, or peak during late-summer before declining towards winter. We suggest that the seasonal behaviour of solute export from rock glacier springs might be relevant for their potential ecological effects, and should be taken into account in future studies.

## Shifts in diatom assemblages in Lake Maggiore: insights from 20 years monitoring data

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Lake Maggiore is a deep subalpine lake in Northern Italy belonging to the Long Term Ecological Research (LTER) network. The lake underwent eutrophication from the 1960s to mid-1980s and a recovery process from mesotrophy since the early 1990s. Over the last decades, climate-driven events became prominent and overlapped the long-term oligotrophication pattern. Recent studies demonstrated that shifts in diatoms assemblages can be considered robust indicators both of climate and trophic changes.

Here, we report the results of our study on variations in diatom community structure and diversity in Lake Maggiore as possible response to hydrometeorological and chemical conditions over the last 20 years. We used phytoplankton monthly and fortnightly data for the period 1999- 2019 collected within the research programs funded by the International Commission for the Protection of Swiss-Italian Waters (CIPAIS). The results suggest shifts in diatom assemblages. Pennate diatoms such as *Synedra* spp. declined during the oligotrophication period but increased recently. Similarly, *Fragilaria crotonensis* showed an increase during the last few years. It has been accounted in the number of significant and dominant species as competes to form minimum 80% of the total community biovolume at least once per year. Shifts in *Tabellaria flocculosa* dynamics is also evident. This species has contributed mostly to phytoplankton biomass in 2007-2008, while it has completely disappeared nowadays. Further analyses are performed to investigate the role of climate drivers, including change in lake hydrodynamic, and nutrient concentrations as driving factors for the observed shifts in diatom assemblages in Lake Maggiore.



## Diat.barcode: a DNA reference library to identify diatom taxa

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Diatoms are ubiquitous microalgae, which present a huge taxonomic diversity, changing in correlation with differing environmental conditions. This makes them excellent ecological indicators for various ecosystems and ecological problematics (ecotoxicology, biomonitoring, paleo-environmental reconstruction ...). Current standardized methodologies for diatoms are based on microscopic determinations, which is time consuming and prone to identification uncertainties. DNA metabarcoding has been proposed as a way to avoid these flaws, enabling the sequencing of a large quantity of barcodes from natural samples. However, to identify environmental sequences correctly, the reference database should contain a representative number of reference sequences to ensure a good coverage of diatom diversity. Moreover, the reference database needs to be carefully taxonomically curated by experts, as its content has an obvious impact on species detection. Diat.barcode is an open-access library for diatoms linking diatom taxonomic identities to rbcl barcode sequences (a chloroplast marker suitable for species-level identification of diatoms), which has been maintained since 2012. The last version of the database (version 9.2), includes 8066 entries that correspond to more than 280 different genera and 1490 different species. In addition to the taxonomic information, morphological features, life-forms and ecological features are given. Ready-to-use files for metabarcoding pipelines (Mothur and DADA2) are also available.

Database download: [www6.inrae.fr/carrtel-collection/Barcoding-database/](http://www6.inrae.fr/carrtel-collection/Barcoding-database/)  
R package diatbarcode: <https://github.com/fkeck/diatbarcode>

## Citizens' assessment of river biological quality: a comparison with official data.

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Citizen science data have the potential to be used for research and management purposes. However, data reliability is always an important concern because these data are often collected by non-experienced people and using simplified methods. In this context, there is a need to assess the reliability of citizen science data before their use. Currently, there are two citizen science programs on river bioassessment in Catalonia that involve thousands of students, teachers, NGOs, and citizens: RiuNet ([www.riunet.net](http://www.riunet.net), since 2014) and Projecte Rius ([www.projecterius.cat](http://www.projecterius.cat), since 1997). Both have clear educational purposes and have introduced many people to river ecology, bioassessment and management. Altogether, these programs have generated 3057 data records on macroinvertebrates and the corresponding values for simplified biological indices. Our main objective was to assess whether RiuNet and Projecte Rius data on biological indices are reliable and can provide additional information to improve decision-making on river management. Since 2000, official data gathered by water authorities are available following the Water Framework Directive. Our study compared information on biological indices obtained from 269 water bodies where data were collected by non-experts (i.e. citizens through RiuNet and Projecte Rius) and experts (i.e. managers at the Catalan Water Agency and the Ebro Hydrographic Confederation) Results showed that non-expert assessments tend to underestimate the biological quality compared to official data, which is explained by the use of a simplified methodology. To improve the matching between non-experts and experts, methods used to calculate the biological quality in these citizen science programs need to be reconsidered.

## A new methodological approach for assessing riparian zones in the Czech Republic

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Riparian habitats represent an important ecosystem providing a range of functions and services important to humans – e.g. biodiversity support, reduction of erosion risk, or transport of pollutants from the surrounding landscape to watercourses. At the same time, it is, unfortunately, an environment that has been very often subjected to significant pressure during the agricultural cultivation of the landscape or the development of industrial and residential activities of human society. Thus, a large number of riparian ecosystems have disappeared or have been degraded. The assessment of the overall ecological status of riparian habitats thus constitutes an important source of information for the needs of watercourse management and landscape planning in the riparian landscape, the aim of which should be to maintain good status or to improve the current unsatisfactory state of these habitats. In the Czech Republic, there is not yet a comprehensive assessment procedure that would take into account not only the important partial variables affecting the current state (e.g. morphological state of watercourses or prevailing categories of land-use in the surrounding) but also the potential reference state. For this reason, a methodology for evaluation of the ecological status of riparian habitats is currently being developed. Our contribution describes the evaluation procedures and preliminary results of the methodology applied to the selected model area (small stream catchment).

## Biomonitoring survey of the hydrographical network in a MAB UNESCO Biosphere Reserve

Dr Adriano Boscaini<sup>1</sup>, Dr Leonardo Cerasino<sup>1</sup>, Dr Nico Salmaso<sup>1</sup>

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The knowledge of microbial biodiversity (bacteria and protists) in aquatic ecosystems is far from complete. This is mainly due to the inadequacy of conventional taxonomic identifications, which are based on the discrimination of diacritical morphological traits. Further, investigations are mainly focused on specific lake and river typologies that are usually also of interest for economic exploitation, often disregarding the small and/or ephemeral water bodies. Nevertheless, due to their physiographical complexity and temporal dynamics, these neglected hydrographical elements can host a vast microbial diversity. In order to fill the gap in the biodiversity estimates in the Alpine region, we carried out a survey using high throughput sequencing (HTS) of 16S and 18S rDNA markers from water and sediments collected in the MAB UNESCO Alpi Ledrensi and Judicaria Biosphere Reserve (Project Acqua Viva). The study sites are located between Lake Garda and the Brenta Dolomites, and include natural environments in a semi- anthropized Alpine context with agricultural and tourist vocation. The survey was carried out during the summer 2019, covering 20 sites of different sizes and characteristics, including lakes, alpine pasture ponds and wetlands. The results allowed disclosing a high number of amplicon sequence variants (ASVs) belonging to a wide variety of bacterial and protists groups, and significant differences linked to lake and sample typologies. Despite a wide presence of potentially toxigenic cyanobacteria, microcystins and anatoxin-a were detected only in a few water bodies, including Lake Ledro, which showed the presence of both *Planktothrix rubescens* and *Tychonema bourrellyi* in the pelagic samples.

## Is the UK a global hotspot of aquatic-terrestrial specialists of temporary streams?

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Temporary rivers and streams are dynamic habitats that shift between flowing, ponded and dry states to support high invertebrate biodiversity, with their species spanning a continuum from aquatic to terrestrial. Although the communities inhabiting temporary streams are often dominated by generalist species, where drying events are frequent and predictable enough – but not too severe – adapted specialist species can occur. In particular, many insects have evolved carefully timed life cycles that allow aquatic and terrestrial life stages to cope with seasonal changes in habitat availability. We present emerging evidence that the cool, mild climate of south England allows their ‘winterbourne’ chalk streams to support a globally notable range of temporary-stream specialists: species reliant on shifts between wet and dry instream conditions to complete their life cycles. These species include the mayflies *Paraleptophlebia wernerii* and *Siphonurus armatus*; the stonefly *Nemoura lacustris*; the caddisfly *Isonychia dubia*; the beetle *Agabus brunneus*; and the blackflies *Metacnephia amphora* and *Simulium latipes* – a fauna which includes some of the UK’s rarest species. Their reliance on the availability of different habitats in different seasons puts these species at particular risk from interacting stressors including over-abstraction and drought, which may disrupt life cycles by changing where and when shifts between wet and dry states occur. As temporary streams increase in extent due to global change, we call for management actions that protect the habitats required by their specialist species, thus safeguarding their contribution to the biodiversity of these dynamic aquatic–terrestrial ecosystems.

## Important drivers of zooplankton diversity and composition in shallow lentic ecosystems

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Shallow lentic ecosystems (SLEs) encompass various waterbodies that represent a valuable source of freshwater biodiversity and provide important ecosystem services. They are distributed across different landscapes, and thus can be exposed to a wide range of simultaneous stressors. Zooplankton diversity has been recommended for assessing the water quality of SLEs, but it is not well resolved how zooplankton diversity and community composition respond to anthropogenic pressure and environmental factors. Using the data from 28 sampling sites of nine SLEs (seven ponds, one channel, and one shallow lake) we tested the effects of anthropogenic pressure, system size (area, depth), trophic state, connectivity, fish abundance, and macrophyte biomass on zooplankton abundance and species richness (by using generalised linear mixed models and linear mixed models, respectively) and taxonomic and functional composition (by using PERMANOVAs and non-metric multidimensional scaling). Abundance and species richness were positively related to anthropogenic pressure ( $\chi^2=134.4$ ,  $P<0.005$ ;  $F=11.97$ ,  $P=0.004$ , respectively), and negatively related to fish abundance ( $\chi^2=43.03$ ,  $P<0.005$ ;  $F=7.67$ ,  $P=0.01$ , respectively). Abundance was positively related to the depth ( $\chi^2=39.9$ ,  $P<0.005$ ), trophic state ( $\chi^2=1125.1$ ,  $P<0.005$ ) and macrophyte biomass ( $\chi^2=72.4$ ,  $P<0.005$ ). Only a few rotifer species were abundant in systems with high fish abundance. Non-predatory rotifers were the most abundant in large and deep systems with high connectivity. Predator species richness was higher in connected systems and increased with macrophyte biomass but decreased with fish abundance. Overall our results suggest that small SLEs can sustain high zooplankton diversity even in human-degraded landscapes, while top-down control by fishes is an important limiting factor.

## An aggressive aquatic invader? The ecological effects of *Crassula helmsii* invasion

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Freshwater ecosystems are increasingly threatened by the proliferation of invasive species. Acting on often-incomplete evidence regarding the ecological impact of new arrivals, land managers adopt a 'guilty until proven innocent' mindset, seeking to eradicate new arrivals before they become established in the landscape. Whilst this approach prevents harmful invasive species from gaining a foothold, it may also result in the misallocation of finite resources towards the control of benign non-natives, and cause unnecessary collateral harm to native biota. *Crassula helmsii* is an aquatic macrophyte native to Australasia. First found naturalised in Essex in 1956, the pondweed has since spread through lentic systems across the UK and continental Europe. The shallow fluctuating waterbodies typically invaded by *C. helmsii* harbour much of the freshwater biodiversity of Northern Europe, making its rapid spread particularly alarming to conservationists. In conservation literature, *C. helmsii* has been portrayed as a destructive threat to European freshwater biodiversity, and considerable resources have been devoted to the study and implementation of eradication techniques. However, studies investigating *C. helmsii*'s ecological impacts have so far been inconclusive. We're addressing this knowledge gap through field study, assessing the effects of *C. helmsii* invasion on invertebrate assemblage structure and function. In addition, we're conducting mesocosm trials to assess the palatability and toxicity of *C. helmsii* to generalist herbivores, and biochemical tests to determine the basis of this putative toxicity. This research will provide invaluable information to land managers, aiding the development of an evidence-based management strategy for *C. helmsii* in European freshwaters.

## Does size matter? Synthesis of environmental impacts of a small hydropower plant

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The increasing incentives stemming from numerous initiatives promoting sustainable energy production have led to a global success of small hydropower plants. Nonetheless, the debate about the actual environmental impact of these kinds of structures on the riverine ecosystems has been growing, up to the point that some authors argue that their impact might be greater than that of large hydropower plants. However, a thorough evaluation of a case study following a “Before-After-Control-Impact” (BACI) design has not yet been conducted. Using aquatic macroinvertebrates as a proxy of changes in running-water environments and combining generalized linear mixed model (GLMMs), spatial and temporal  $\beta$ - diversity quantification and variability assessments, we show that a small “run-of-river” hydropower plant located on a glacier-fed stream in the Italian Alps had no impact on the riverine ecosystem. Our results underline the importance of an unbiased approach to strategic energetic planning, but also the need for decision-makers to pursue informed and empirically based trade-off policies concerning water management issues.



## Inter- and intraspecific variability of aquatic hyphomycetes and freshwater ecosystem processes

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Research dedicated to ecosystem functioning has focused mainly on species diversity. Leaf litter breakdown is a key ecosystem-level process in forested streams, mainly driven by aquatic hyphomycetes and mediating energy transfer to invertebrate detritivores. In this study, we investigated the influence of inter- and intraspecific functional variabilities across a set of ten isolates each belonging to five different widespread aquatic hyphomycete species namely *Articulospora tetracladia*, *Anguillospora crassa*, *Lemonniera terrestris*, *Neonectria lugdunensis* and *Tetracladium marchalianum*. The aquatic hypomycetes used originated from streams undisturbed by land use or land cover changes. We addressed inter- and intraspecies variability on fungal growth and sporulation rates and leaf litter decomposition. Besides, we assessed whether consumption rates of a leaf-shredding invertebrate species varied when fed with leaves colonized by different fungal isolates. Significant differences were seen within the fungal species in growth rates, sporulation rates and leaf litter decomposition. The relative consumption rates of the shredder significantly differed when fed with leaves colonized by different isolates of *L. terrestris* and *N. lugdunensis*, however differences were not observed when fed with leaves conditioned by different species. Overall, the results point towards considerable intraspecific functional variability within the aquatic hyphomycete isolates. In addition, our work also provides a novel information that intraspecific functional variability naturally occurs even in undisturbed habitats.

## Multi-model projections of evaporation in a subtropical lake

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Evaporation of surface water is critical to the basic functioning of lakes. It modifies the hydrologic, chemical, and energy budgets, making evaporation one of the most important physical controls on lake ecosystems. Predicting lake evaporation response to climate change is, therefore, of paramount importance. Most studies on lake evaporation have utilised only a single mechanistic model. Whilst such studies have merit, the advantage of applying an ensemble approach, is that some of the inherent uncertainties in individual lake models can be reduced, thus enabling increased robustness of historic and future projections. In this study, we present results from the Inter-Sectoral Impact Model Intercomparison Project phase 2b (ISIMIP) Lake Sector, where lake evaporation responses to 20th and 21st century (1901-2099) climate change has been simulated with a suite of independently developed lake models under different climate change scenarios (Representative Concentration Pathways, RCP, 2.6, 6.0 and 8.5). Our study focuses on Lake Kinneret (Israel), a sub-tropical lake of socioeconomic importance. Simulations are validated during the historic period with bulk evaporation estimates calculated from high frequency meteorological and in-lake observations. Our results demonstrate that the lake models provide an accurate representation of historical variability in lake evaporation, with promising comparisons of the magnitude, timing and seasonality. Future evaporation projections at Lake Kinneret show that evaporation will increase by the end of the century. We show that multi-model projections of lake evaporation can accurately represent the historic period and hence provide reliable future projections that will be vital for water management.

## Lough Feeagh: A sentinel for long-term catchment change

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As part of the BEYOND 2020 project funded by the Marine Institute, an 8m long sediment core was taken from the Burrishoole Catchment's largest lake, Lough Feeagh. Palaeolimnological methods are being applied to examine the authochthonous (in-lake) and allochthonous (catchment) derived deposits. Stratigraphic, organic matter content, wet density, dry weight and <sup>14</sup>C AMS Radiocarbon measurements have been conducted, providing an initial outline for the Holocene history of Lough Feeagh. These sediment reconstructions along with another study on environmental DNA (eDNA) are providing a long term temporal geoscience context for ongoing high frequency monitoring and ecological and carbon cycling studies in the catchment.

## Metabarcoding vs. morphological identification for aquatic ecosystem biomonitoring: a case study

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Phytoplankton and benthic diatoms are frequently used as biological quality indicators. However, conventional methods for species identification (light microscopy) are time-consuming and require a high level of taxonomic expertise. The Interreg Alpine Space Eco-AlpsWater project (EAW) has the aim of overcoming these limits, exploring the application of high throughput sequencing (HTS)-based DNA metabarcoding for water quality assessment in the Alpine region. Here, preliminary results obtained from Lake Lugano (CH-IT) are used to evaluate the potential of DNA based approaches. For this purpose, in 2019, 10 littoral sites were sampled for the study of benthic diatoms and one pelagic site was sampled monthly for the study of eukaryotic phytoplankton and cyanobacteria. The HTS sequences of 16S rRNA (V3-V4), 18S rRNA (V4), and rbcL marker genes obtained from eDNA extracted from water and biofilm samples was compared with conventional identification by light microscopy. The genetic approach showed a good consistency with conventional methods, in particular for dominant taxa, although the correspondence between approaches was lower at the genus and, especially, the species level. Moreover, the HTS led to the identification of a higher number of indicator taxa and was found to be a sensitive tool for the detection of rare or invasive species. Therefore, the approach proposed within the EAW project, and HTS methods in general, can be effective in the study of the biodiversity and in the improvement of the ecological quality assessment of waterbodies.

Molecular insight into taxonomy of the genus *Typhlocypris* Vejdovský, 1882 (Ostracoda: Candoninae)

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Representatives of the widely distributed non-marine subfamily Candoninae are one of the most taxonomically difficult and species-rich lineage of freshwater ostracods. In the last decades several new Candoninae species has been described, and currently the subfamily comprises 49 genera with 548 species, diagnosed almost exclusively by morphological characters. Due to a number of homoplasies, however, phylogenetic relationships within the subfamily remain ambiguous. The genus *Typhlocypris*, which has been recently reviewed using morphological characters, includes 15 nominal species inhabiting exclusively subterranean waters in Europe and Anatolia. Morphological criteria clearly differentiate *Typhlocypris* from the most closely related genera *Pseudocandona* Kaufmann, 1900 and *Marmocandona* Danielopol et al. 2012. To verify the morphology-based taxonomy of the genus *Typhlocypris*, two molecular markers were analyzed. First one was the fragment of mitochondrial gene cytochrome oxidase subunit I (COI mtDNA), which is commonly used as a molecular barcode, due to its uniparental inheritance, high mutation rate and copy number. Second one was nuclear region (28S rDNA nDNA), which is characterized by a lower mutation rate, compared to the mitochondrial marker. The data set consisted of over fifty 28S rDNA and COI sequences from representatives of five species of *Typhlocypris* (including one new to science) and over a dozen other species belonging to different Candoninae genera. The genetic results confirm morphological separation of the genus *Typhlocypris* from *Pseudocandona* nevertheless maintaining their close relationships. Phylogenetic analyses indicated, however, incomplete correspondence between morphology-based and molecular-based affinities within the subfamily

## Species' traits and taxonomic distance can predict the ostracod resting eggs hatching

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Freshwater ostracods are commonly found in temporary ponds and lakes, surviving the drought periods by the production of resting eggs. We investigated the hatching phenology of ostracod resting eggs from the sediments of temporary floodplain lakes (Upper Paraná River, Brazil), considering both the taxonomic distance between species and their functional traits, such as carapace size (length and height) and shape, valve ornamentation, locomotion and reproductive mode. The experiment was conducted for 91 days in the laboratory with controlled temperature and photoperiod, and the microcosms were monitored weekly. The first hatching of an ostracod was recorded during the second week of incubation after hydration of the sediments. A total of twelve ostracod species hatched, belonging to the families Cyprididae and Candonidae. Generalized Linear Model (GLM) showed that the time between inundation and first hatching was mostly similar between congeneric species in the genera *Chlamydotheca* Saussure, 1858 and *Strandesia* Stuhlmann, 1888, but was different between some *Strandesia* species, which might be owing to some differences in functional traits. The Principal Coordinate Analysis (PCoA) showed that the species composition and functional traits composition of ostracods were significantly different over the 14 weeks of incubation. Our results furthermore showed that both taxonomic distance and functional traits can have an effect on the hatching time of ostracod resting eggs from temporary floodplain lakes. Thus, future studies addressing the hatching phenology of ostracod resting eggs (and resting stages from other invertebrates) should also emphasize the use of functional traits.

Key-words: Ostracoda, hatching time, functional traits, neotropical.

## Dried aquatic macrophytes are potential dispersal vectors of ostracod (Crustacea) resting eggs

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*Eichhornia crassipes* (Mart.) Solms is a common floating plant in the Neotropics and shelters a high diversity of ostracods in the pleuston of its root system. During the dry season, many plants remain dried along the water courses. We evaluate the potential of dried *E. crassipes* as a dispersal vector of ostracod resting eggs by assessing the richness, abundance, and beta diversity of the associated fauna. Dried plants were collected at the edge of two connected lakes in the Upper Paraná River floodplain (Brazil) and were hydrated with distilled water in the lab. The microcosms were kept in germinating chambers with controlled temperature and photoperiod during 147 days. The first hatching of an ostracod was recorded during the fourth week of incubation after hydration of the roots. A total of 397 ostracods representing seven species hatched from the resting eggs adhered to dried macrophyte roots. A generalized linear mixed model (GLMM) was used to determine the relationship between the incubation time (weeks) and the richness, abundance and beta diversity of the hatched ostracods. An increase in richness and a decrease in abundance were observed over the weeks, although these trends were not significant. However, the beta diversity increased significantly over the incubation time. Our results indicate that the complex root systems of *E. crassipes* have the potential for storage and transport of the ostracod resting eggs. Hatching of resting eggs can contribute to the recolonization of the floodplain environments and to wide dispersal after drought periods.

Key-word: Egg banks, floodplain.

## Biological Tools to Monitor Impacts of Flow on Ecology in Irish Rivers

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Flow plays an important role in determining how river ecosystems establish and function. In Ireland, hydromorphology has been identified as a significant pressure for 24% of the nation's waterbodies. This project aims to develop a set of tools for Irish river biomonitoring programmes that will improve our understanding of river flow impacts on Irish river ecosystems. Here we examine existing river biomonitoring tools, which measure benthic macroinvertebrates, fish, and macrophytes relative to flow, for application in Ireland. Benthic macroinvertebrate-based indices will incorporate data for assessing impacts of flow velocity, drought, and sedimentation, while fish indices will explore measures of fish habitat suitability to further develop our understanding of optimal flows within Irish rivers. Finally, further development of existing macrophyte metrics and emphasising morphological traits of these communities in relation to flow will improve the utility of macrophytes for meeting biomonitoring objectives. New data collected throughout this project, in combination with available historical data, will allow for the detailed assessment and adaptation of these tools for Irish rivers. These new tools will allow for the development of enhanced strategies to restore and manage Ireland's river ecosystems while working towards meeting the European Union Water Framework Directive standards for water quality.



## Climate change will reduce ostracod richness in South America's Southern Cone

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Many studies predict changes in the distribution of individual species by climate change, while few of them have assessed such changes at community levels, especially for aquatic invertebrates. We used 61 ostracod species and a set of climatic and hydrological predictors to identify areas with richness gain and loss across river basins of the Southern Cone of South America, using six ecological niche modelling algorithms, and based on two hypotheses of increased carbon emissions in 2080: the moderate-optimistic (4.5) and the pessimistic (8.5) scenario. In both scenarios, there were losses of species throughout the study area, with the highest losses (up to 30) concentrated in the north and along the Paraguay River (La Plata basin, LPLA). Losses up to 25 species were observed in the north of the Brazil-South Atlantic Coast basin, the tributaries of the east margin of the Paraguay River and the west margin of Paraná River (LPLA). The southeast part of the LPLA will gain species (up to 15), in a larger area in the 2080-8.5 than in the 2080-4.5 scenario, demonstrating a possible trend for migration of ostracods. LPLA will preserve sympatric species, since ostracods are good regional dispersers. However, the dispersion of allopatric species might be lower, owing to the lack of connectivity between basins. Ostracod communities of the Patagonian basins have a risk of extinction, owing to the scarcity of suitable areas in this region in the future, as cold-stenothermal species tend to migrate to higher latitudes or altitudes with global warming.

Keyword: Macroecology

## Impacts of macrophyte removal on phytoplankton, zooplankton, and macroinvertebrates

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Mass development of exotic and native macrophytes in rivers and lakes occurs worldwide. It is often considered to have negative impacts on the ecosystem, with oxygen depletion and its corresponding negative effects on biodiversity as one example. Therefore, most water management strategies are based solely on this prevailing negative perception about macrophytes, and substantial amounts of resources are invested in removing the macrophytes. Though largely overlooked, macrophytes also have positive impacts on aquatic ecosystems. For example, the presence of macrophytes provides new habitats, shelter against predators, and new food resources for a diverse aquatic flora and fauna. In the framework of the international collaborative project MadMacs, we aim to provide a balanced view on the effects of macrophyte removal on biodiversity (phytoplankton, zooplankton, and macroinvertebrates) based on a Before-After-Control-Impact (BACI) sampling design in six study sites across three continents. Here we present results from our first study site in France (Lac Grand-Lieu). Preliminary analysis showed: 1) A temporary reduction of zooplankton diversity and evenness following the macrophyte removal; 2) Only small shifts in the phytoplankton community; 3) A delayed and small increase in macroinvertebrate abundance in the impacted site. This work is the first step towards a global approach to the effect of macrophyte removal on biodiversity and therefore provides a more balanced knowledge base for further water management programs.

## The influence of macrophyte life forms on beta-diversity of associated ostracod communities

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Beta-diversity measures have been used to understand patterns of community distribution in natural ecosystems. We used ostracod communities to evaluate the influence of environmental and spatial factors structuring different facets (species-, trait- and phylogeny-based) of beta-diversity of ostracod communities associated with different macrophyte life forms. We test the following hypotheses: (1) that the influence of environmental factors is higher for ostracod beta-diversity facets of communities associated with submerged plants compared to emergent and floating plants and (2) that the influence of spatial factors is higher in communities associated to fixed, compared to non-fixed plants. Ostracods were sampled from five life forms of macrophytes, including emergent, rooted floating, rooted submerged, free submerged and free floating in 25 lakes of the Upper Paraná River floodplain, Brazil. We used distance-based redundancy analysis, as well as variation partitioning procedures to evaluate the influence of environmental and spatial factors on ostracod communities. Our results showed that the environmental factors turned out to be important for all beta-diversity facets of ostracod communities, but mainly for those associated with submerged macrophytes, thus corroborating the first hypothesis. We found that spatial factors' influence on ostracod beta-diversity was not related to the fact that plants are fixed or not, thus refuting our second hypothesis. We showed the importance of including these three approaches in ecological surveys. Finally, we highlight the importance of different macrophyte life forms in biodiversity surveys for the preservation and management of the diversity of these plants and their associated communities.

Keyword: environmental and spatial factors

## Intraspecific differences of *Alnus lusitanica* traits between Mediterranean and Atlantic riparian populations

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Atlantic and Mediterranean climatic conditions shape vegetation traits in riparian ecosystems. By studying the variation in morphological and physiological traits along the climatic conditions we can gain insight into the populations local adaptation strategies. This insight is particularly valuable when inferring riparian vegetation responses to projected climate change. This work aims to study local adaptation of *Alnus lusitanica* Vít, Douda & Mandák, to Atlantic and Mediterranean conditions, which is present at the warmer limit of alder genus distribution - Iberian Peninsula and Northern Morocco. One Mediterranean population from Extremadura in SW Spain and one Atlantic population from Ponte de Lima in NW Portugal, were grown for 2 years in controlled conditions. Phenological (bud burst) and morphological (height, diameter) traits were seasonally compared for 2 years between populations. Seedling destruction allowed assessing dry biomass and plant physiology (chlorophyll fluorescence, photosynthesis). Linear regressions were applied on allometric ratios for biomass allocation analysis. One-way ANOVA and Pearson's correlation were calculated on all traits to assess differences in growth strategies. The Mediterranean population showed earlier bud burst, higher stem increment and higher aboveground biomass allocation. Populations showed little difference in growth strategies and no pattern of local adaptation to environmental conditions. Future research should focus on the analysis of adult trees and include more populations from the Atlantic-Mediterranean gradient.

## Two new genera and three new species of Cypridopsinae from Brazil

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The subfamily Cypridopsinae Kaufmann, 1900 comprises 20 genera and occurs on all continents, except for Antarctica. The main characteristics of this subfamily are the small carapace size (c. 0.3-0.9 mm length) and the caudal ramus which is reduced to flagellar structures. Here, we describe one new tribe, two new genera and three new species of Cypridopsinae from Brazilian floodplains. The ostracods were collected associated with aquatic macrophytes and benthic sediments in several environments in the Amazon, Araguaia, Pantanal, and Paraná floodplains. The first new genus belongs in the nominal tribe Cypridopsini, and both new species in this new genus were found in both sexual and asexual populations. The first species in this genus has a wide distribution and was found in three of the four major Brazilian floodplains. It has a subtriangular shape in lateral view. The second species in this genus was recorded from the Amazon floodplain only. It is more elongated and has more rounded dorsal margins in both valves, as well as more pronounced external valve ornamentation. The second new genus comprises a single new species, which was found in asexual populations in the Upper Paraná River floodplain and differs from other Cypridopsinae in the more elongated carapace without marginal valve structures, an A1 with strongly reduced chaetotaxy and the total absence of caudal rami in females. Because of these strong reductions in valve and limb morphology, the new tribe Paranadopsini trib. nov. is created within the Cypridopsinae for this second new genus and species.

Keyword: Taxonomy

## On a new species of *Pseudocypretta* (Ostracoda, Crustacea) from the Neotropical region

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The genus *Pseudocypretta* Klie, 1932 presently comprises only the type species *P. maculata* Klie 1932 and *P. lineata* Ma & Yu 2020, both from the Oriental region and inhabiting mainly rice fields, pools, and streams. This genus shares some similarities with the genus *Cypretta* Vavra, 1895, both in the presence of septae along the anterior margins of the valves as in the rounded shape of the carapace. Here, we present a new species of the genus *Pseudocypretta* from the four main Brazilian floodplains (Amazônia, Araguaia, Pantanal, and Paraná), and thus extend the range of the genus to a new zoogeographical region. The new species was found associated with aquatic macrophytes, and in the benthos of both lentic and lotic environments. In *Pseudocypretta* n. sp., the carapace is characterized by a rounded shape in dorsal and ventral view, and by a somewhat elongated shape in lateral view. The left valve is larger than the right valve, overlapping it along all margins. The sideways directed bristles on the Maxillula are absent. On the second thoracopod, seta d1 is absent, and seta d2 present, while the fourth segment on this limb is undivided. The third thoracopod lacks the distal pincer structure so that the fourth segment is isolated. The caudal ramus is fully absent. In the overall carapace shape and structure, this species shares many similarities with some *Cypretta* species. However, the morphology of the appendages shows remarkable differences, especially in the second and third thoracopod.

Keyword: Taxonomy, morphology, Cyprettinae

## Bovine faecal contamination of surface waters in a dairy-dominated catchment in Ireland.

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The source and fate of faecal microorganisms of bovine origin in surface waters in Ireland is poorly understood or monitored, despite their potential harm to animals and humans. The widespread contamination of running waters by agriculturally-derived organic matter, however, indicates that faecal microbial contamination follows a similar pattern. However, as for nutrients and organic matter, the source of bacterial contamination may originate from diffuse (from overland runoff) or from point sources (including direct cattle access to streams or from farmyard drainage). Knowing where such contamination arises, and why, is the vital first step in managing it effectively. This study reports an investigation into the sources of faecal indicator organisms (FIOs) in a dairy-dominated catchment in SW Ireland. The objectives were (1) to quantify the attenuation, if any, of FIOs within small drainage channels receiving direct farmyard effluent and (2) to determine the distributions, and hence origins, of FIOs within the wider catchment. We showed that FIOs were abundant along the entire length of farmyard drainage channels, despite the reported low survival and persistence of thermotolerant organisms outside of the enteric environment. Results from the catchment-wide study revealed widespread faecal contamination of surface waters from persistent farmyard drainage sources, as well as from intermittent direct deposition by cattle accessing streams.

## Litter decomposition in created wetlands: a nature-based solution for nitrate mitigation

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Litter decomposition is strongly linked to wetland functions in different ways. Decomposition rate directly influences organic matter accumulation and nutrient cycling and also affects the physical and chemical properties of wetland soils. That is especially relevant in those wetlands where plant litter is not removed from the system. This material represents a source of labile carbon pivotal for nitrate elimination through denitrification, especially in created wetlands treating agricultural drainage waters, with low DOC concentration. We studied decomposition of *Phragmites australis* leaves litter in a pilot plant of constructed wetlands with different types of substrate: gravel, gravel + soil (30%) and gravel + biochar (10%). Specifically, we compared i) nutrient content and chemical composition of litter, ii) decomposition rates, iii) microbial activity through the FDA hydrolysis and iv) glucosidase and phenol-oxidase activities between the three substrate types and over a period of six months. Plants growing in gravel+soil wetlands showed the highest C, N and P content in tissues. Gravel and gravel+soil substrates showed the highest organic matter loss and microbial activity. Gravel+soil and gravel+biochar wetlands showed similar values of enzyme activities while in gravel substrate phenol oxidase activity was the lowest and glucosidase activity was the highest. Our results suggest a greater carbon mobilization from plants in gravel and gravel+soil substrates and highlight the importance of substrate type in created wetlands influencing leaf litter quality, decomposition rates and microbial activity.



## Applicability of DNA metabarcoding methods for benthic diatom biomonitoring in Mediterranean rivers

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The use of benthic diatoms as indicator of ecological status in aquatic ecosystems is a standard that has been used for river biomonitoring during the last decades. This approach is based on traditional morpho-taxonomy methods using species abundance metrics (IPS index for Mediterranean rivers). Recently, the use of molecular techniques based on high throughput sequencing (HTS) and DNA metabarcoding, were proposed as a complementary tool for diatom biomonitoring with the objective of reducing processing time and requirement of expert taxonomist. In the present study, we have used this new approach, in parallel with traditional methods, for the ecological status assessment in different sampling stations along Ebro river in Spain. In general, our results show that the calculated ecological status using metabarcoding methods is highly similar to that calculated by morpho-taxonomy. However, in some of the sampling points, the calculated IPS values using the molecular approach were lower than those obtained by morpho-taxonomy. This could be related to the lack of some relevant Mediterranean diatom species in the diatom barcode database (diat.barcode v9.2) that are not being identified using molecular methods. Although the results are promising, for some sampling points, the ecological status changed from excellent to good or even from good to moderate. These changes in the ecological status could imply relevant consequences in the management of these ecosystems if they receive a bad classification, so an improvement in the diatom barcode database for Iberian species should be addressed to improve the correlation between both biomonitoring methods.

## The chironomids larvae assemblages of small water bodies in agricultural areas

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Chironomidae (Diptera) is one of the groups of aquatic organisms considered to be the most species-diverse group of animals. They reach their maximum numbers in eutrophic water reservoirs, and especially in small water bodies. The study aimed to find out about the assemblages of chironomids larvae inhabiting small water reservoirs located in agricultural areas and try to determine whether the management method influences the changes in the composition of this group of insects. The material was collected in 3 seasons (spring, summer, autumn) from 4 mid-field small reservoirs (10-20 ares), located in agricultural areas with varying agricultural intensification levels, i.e. 1 - organic; 2, 3, 4 - integrated with different level of using pesticides and artificial fertilizers, 2- small farm (20 ha) with moderate chemization, 3- medium farm (90 ha) with intensive chemization, 4- big intensive farm (2000 ha) with elements of precision agriculture. As a result of the study, 411 Chironomidae larvae representing 12 types were collected. The analysis of the fauna similarity (based on the Bray-Curtis index) showed the most similar assemblages occur in reservoirs 2 and 3. The most numerous were 3 genera: Glyptotendipes, Polypedilum, and Chironomus, characteristic for eutrophic water reservoirs with strongly developed aquatic vegetation. The assemblages occurring in water reservoirs in an organic farm (1) and integrated farm with elements of precision agriculture (4), differed significantly, which can be associated with the method of use within their catchment area, affecting the trophic level of the reservoirs.

## Elodea nuttallii in polish waters: effect on aquatic biota and ecological status

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The Nuttall's waterweed (*Elodea nuttallii*) was identified in Poland for the first time in 1990. Since then it rapidly spreads along large rivers. Until recently, the species has been reported from six lakes monitored and assessed for ecological status under the WFD. We investigated one of these lakes to explore the rate of invasion, potential threat to the native aquatic flora and the impact on the lake ecological status of this new alien hydrophyte in Poland. In the years 2019 and 2020, the inventory of phytolittoral for macrophytes was performed. The lake was surveyed also for phytoplankton, macrozoobenthos and water chemistry in sites dominated by *E. nuttallii* and in sites where *E. nuttallii* was absent or unabundant. Results were compared with those derived from the state monitoring in 2011 and 2017. Since 2011, a rapid increase of *E. nuttallii* abundance from 0 to 60% of the phytolittoral area was observed. The macrophytic Ecological Quality Ratio decreased from 0.639 in 2011 to 0.509 in 2020 reflecting the loss in phytocenotic diversity. However, the ecological status class reminded good. In the phytoplankton community, the dominance of the Cyanobacteria *Lyngbya hieronymusii*, species exotic to Poland, was observed. The phytoplankton index value fluctuated between good and poor status with no directional change. In zoobenthos community, the slight deterioration from good to moderate status was observed. Despite the observed deterioration in biological assemblages' composition and abundance, biomonitoring methods appeared almost insensitive to invasion of alien macrophyte species indicating the need for modification.

## Impact of meteorological forcing on seasonal phytoplankton succession in a peri-urban lake.

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Located in the Great Paris peri-urban area (France), Lake Champs-sur-Marne is a former shallow sandpit whose water source is primarily groundwater and now, a eutrophic recreational water body. The water quality must comply with European Union bathing water directive. The monitoring of water quality has been set up since the late 2000's with the deployment of autonomous submersible sondes recording for physics, biology and chemistry parameters whereas phytoplankton identification and enumeration have been implemented since April 2019. Unlike phosphorus, nitrogen was found to be the limiting nutrient for substantial algal growth. During the summer 2019, a massive bloom of nitrogen-fixing cyanobacteria *Aphanizomenon flos-aquae* was observed in parallel with nitrogen depletion in water. Although the same pattern of nitrogen was observed in 2020, no cyanobacteria bloomed. Despite similar average air temperatures between summers 2019 and 2020, the lack of a strong thermal stratification was observed throughout the summer 2020. This phenomenon led to a dominance of chlorophyceae and later cryptophyceae species with total algal biovolumes much lower than those developed by cyanobacteria the previous year. As commonly assumed, global warming will increase water temperatures, strengthen water column thermal stratifications and subsequently lead to more frequent and more severe cyanobacterial blooms. However, complex interplays between meteorological conditions and phytoplankton traits may result in different species assemblages, potentially outcompeting cyanobacteria.

## Thermal and salinity tolerance of a Mediterranean killifish and the alien mosquitofish

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The populations of the Mediterranean killifishes *Valencia robertae* and *Valencia letourneuxi* are in sharp decline, due to anthropogenic habitat degradation and competition with the alien Eastern mosquitofish *Gambusia holbrooki*. In this study, we conducted first a thermal tolerance experiment, using male and female *V. robertae* (total n = 32) and *G. holbrooki* (total n = 32). After a 20-min acclimation period (initial temperature 20°C) in a 12-L experimental tank, temperature was raised at a constant rate (1°C/5min). When fish showed loss of equilibrium, they were removed and temperature (Tmax) was recorded. In a similar experimental setup, we measured then the salinity tolerance of *V. robertae* (n = 11 males) in comparison to *G. holbrooki* (n = 12 males). Subjects were placed in pairs in an identical tank, and water salinity increased at a steady rate of 10‰/h. When fish showed loss of swimming capacity, they were removed and salinity (Smax) was recorded. In the thermal experiment, male mosquitofish showed significantly lower average Tmax (35.44°C) compared to male (36.35°C) and female killifish (36.11°C), as well as to female mosquitofish (36.26°C). Similarly, average Smax for the killifish (42.64‰) differed significantly from the average Smax for the mosquitofish (40.25‰). Our results suggest that the Mediterranean killifish can withstand higher maximum values of temperature and salinity in comparison to the Eastern mosquitofish, when tested in a short-term constant-ramping regime. The ecological implications of our findings within the frame of current climate change scenarii are discussed.

## The importance of driftwood for aquatic invertebrates in urban streams

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This study was focused on the importance of wood accumulations as a habitat for benthic invertebrates in restored urban streams. In these streams, wood is still considered inappropriate, despite the fact that wood is an important component of natural streams. Samples of benthic macroinvertebrates were taken at four localities on small watercourses (3-4 Strahler order) in the municipality of Prague. At each locality, riffle, glide and wood habitats were sampled by Surber sampler. Stream channels of all localities were restored 2-4 years before the sampling into a semi-natural pattern respecting local conditions. Wood accumulations mostly consisted of small branches and twigs of driftwood, which accounted for less than 1% of the stream cover. Significantly higher abundance of stream invertebrates was found in wood samples than in other habitats. Within localities, the average abundance of invertebrates in wood samples exceeded the abundance of invertebrates from riffle and glide 2-5 times. There was no significant difference in abundance of invertebrates between riffle and glide habitats. Concerning species richness, there was no significant difference between habitats within a locality. Invertebrate assemblage from wood was dominated by common gatherers and grazers. Xylophagous species were quite rare. However, wood habitat contributed on average 16 % of species which did not occur in other habitats within given locality. The results indicate the importance of driftwood as a complex habitat of aquatic invertebrates in restored urban streams. They also provide an argument for using wood in stream restoration and a challenge for management of urban streams.

## Tracking historical human impacts on remote islands using sedimentary charcoal analysis

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The discovery and colonization of remote oceanic islands drastically modified their ecosystems, and the Azores archipelago settlement was no exception. One of the first impacts of human arrival is the change in vegetation due to land clearance practices (e.g. slash and burn), often associated with the increase of macroscopic charcoal particles on lake sediments. Here, we provide the first macro charcoal analysis from Terceira island (Azores archipelago). The macro charcoal record obtained from Lake Ginjal (380m a.s.l.) spans the last 650 years (c. 1420–2018 cal. yr AD). We identified five prominent fire activity zones during: ca 1420-1450, 1520-1580, 1680-1720, 1750-1820, 1980-modern. High fire frequency coincided with periods of high human farming activities evidenced by the historical record and is linked to the main historical economic cycles. Fire frequency sharply increased after the official colonization of the Azores around 1450AD. The second fire zone (1520-1580AD) begins during the expansion of cereal and dyer's woad agriculture. During Spanish governance, fire occurrence remained low (1580-1640). With the Portuguese governance return, a new peak of fires was observed (1680-1720AD) associated with the destruction of forest remnants and diversification of the economy. The fourth fire zone (1750-1820AD) was related to the period of production and export of oranges that has profoundly transformed the Azores' landscape. The last fire recorded zone (1980-modern) is coincident with increases in livestock production, which led to new productive pasture ecosystems. This research is funded by FCT (DISCOVERAZORES Project PTDC/CTA-AMB/28511/2017; DL57/2016/ ICETA/EEC2018/25)

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## Next generation Mediterranean freshwater bioassessment – first eDNA metabarcoding study from Sicily

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The Mediterranean region is among top biodiversity hotspots housing numerous, often endemic freshwater taxa. It is also one of the most threatened regions worldwide, with freshwater biodiversity particularly endangered. Given the scarcity of knowledge about insular freshwater ecosystems, the current situation calls for novel ways for studying regional freshwater biodiversity. DNA-based methods, in particular environmental DNA (eDNA) metabarcoding, provide an opportunity for rapid, straightforward bioassessment of aquatic ecosystems. However, given the incompleteness of genetic reference databases for insular freshwater taxa, the species' assignment can be troublesome. Here, we present results of the first eDNA metabarcoding study from Sicily, aiming to i) investigate the general diversity patterns, ii) assess seasonal changes in community composition, and iii) identify potential dispersal barriers. Additionally, we compared our species-based to an exact-sequence variant (ESV) based approach, by comparing three subsets: one including freshwater macroinvertebrates assigned to species level, another with all freshwater macroinvertebrate ESVs and finally, an entire dataset with ESVs spanning across the tree of life. We observed that diversity was generally higher in autumn compared to winter. We could also detect a dispersal barrier, which had a stronger effect in autumn. Interestingly, our results show similar patterns, regardless of the approach. Our findings indicate that eDNA metabarcoding provides data that can facilitate the understanding of freshwater ecosystem functioning. Integrating biological information across the tree of life using eDNA could provide a promising solution for studying remote and understudied regions, where much of the observed molecular diversity cannot be yet assigned to species level.



## Implications of fine sediment clogging for macroinvertebrates in lowland and alpine rivers

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Fine sediment (particles < 2mm) deposition in riverine ecosystems represents a critical human induced threat to global freshwater diversity. To date, much of the published research has focussed on fine sediment deposition and the subsequent ecological effects at spatial scales specific to the study location with little consideration of the context-specific implications for biota or the transferability of results between studies. To investigate the importance of environmental context in controlling fine sediment effects, we examined the response of benthic macroinvertebrate communities to experimental manipulation of fine sediment clogging in a lowland river (UK) and an Alpine river (Italy). This was achieved via colonisation devices installed in the riverbed over three different durations. Fine sediment was found to result in discrete macroinvertebrate communities in both locations, with the effects of clogging becoming stronger over time for Alpine communities. In marked contrast the effects within lowland rivers became less evident over time. Our results indicate that environmental context is vital to be able to disentangle the potential implications of fine sediment for instream ecology.

## Distributions of antibiotics in wastewater treatment systems and effects on microbial activity

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The antibiotic use for human and livestock treatment is extensive and continuously increasing. Although water contaminated with antibiotics from hospitals or the community is processed in sewage treatment plants, the extent to which antibiotics are degraded or enter the environment is not well defined. The effects of antibiotic discharge into connected water bodies on microbial activity, as well as environmental and seasonal influences, may contribute to changes in functional processes and present a pressing gap in our knowledge. In the ANTIREs project we aim to understand the nature, extent and degradation of antibiotics before, during and after wastewater treatment, and their impact on the microbial aquatic communities and their metabolism in connecting waters, especially the carbon turn-over and greenhouse gas production, in relation to seasonal changes. Over 2 years, samples from all stations of 2 wastewater treatment plants (Göttingen, Greifswald), and connected surface waters were collected quarterly and subjected to biogeochemical and greenhouse gas analyses (e.g. N, P, C, metals, O<sub>2</sub>, CO<sub>2</sub>, CH<sub>4</sub>). Concentrations of 13 antibiotics were determined by HPLC-MS/MS. First results indicate interesting differences in bacterial metabolism in the different treatment plant stages and connected surface waters, as well as seasonal influences. Microbial community activity changes were related to changes in microbial community compositions, and antibiotic presence and concentrations were reduced but not eliminated during wastewater treatment. This project will gather highly valuable knowledge on how antibiotics affect seasonal dynamics of microbial activity and greenhouse gas emissions, and potential preventative measures against antibiotic release into the environment.

## Paleoenvironmental interpretation in the testate amoebae assemblages in a sedimentary record Azores.

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Testate amoebae respond dynamically to environmental variation and reveal well-defined ecological preferences. Here we present preliminary results of a multiproxy study on a peatland core (4.5 m) from Lagoa da Prata (São Miguel, Azores). The geochemical data show a drastic change at 2 m when the lake collapsed and transformed into a Sphagnum peatland. The basal part of the core contains three tephra layers, the upper one identified as the P17 eruption from Sete Cidades ( $500 \pm 100$  14C years BP), the middle one corresponds to Pico do Carvão cone eruption ( $1280 \pm 150$  14C years BP) and the lower one probably corresponds to P15 eruption also from Sete Cidades volcano. The top first meter of the record corresponds to a peatland system characterized by the dominance of *Euglypha strigosa*, *Assulina muscorum* and *Diffflugia cf. pulex*. The second meter is remarkable for the abundance of *Diffflugia bacillifera* and *Diffflugia rubescens*, taxa characteristic of Sphagnum peatlands. In the lower unit, below 2 m of Sphagnum-dominated peat, the assemblages of testate amoebae change significantly, being mainly dominated by *Euglypha rotunda*, *Diffflugia cf. lithophila*, *Centropyxis* spp, *Trinema* spp and *Arcella* spp. This study will enable to understand the changes over time in the lake-peatland system and compare these with models of environmental change at local and regional scales. The historical data of the Lagoa da Prata will allow us to understand better the speed of these changes and the resilience of this ecosystem to natural (volcanism) and anthropogenic (deforestation, water extraction and grazing) changes.

## Linking Flow Disturbance and Phytobenthos Communities Dynamics in Alpine Streams

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Rivers are characterized by a strong dynamic due to the continuous running water. Riverine biotic communities had to cope with this permanent instability that becomes even greater when high-flow events cause noticeable bedload transport. Primary producers in streams live attached to the substrate and present a colonization pattern strongly related to the hydrologic dynamics and the riverbed morphological features. Understand how the phytobenthos community responds to high-flow events can shed light on the ecological implications for higher trophic levels. The aim of this work was to characterize and compare the phytobenthos communities in different alpine streams highlighting the role of the flow regulation due to hydropower reservoirs accounting for the influence of the lithology and the seasonality. The presented data derive from a one-year sampling campaign in four alpine streams representative of different flow conditions (natural vs regulated flow discharge) and lithology (silicate vs carbonate). During the survey, the composition and the structure of the phytobenthos community have been characterized by investigating all the main taxonomic groups and, alongside, the magnitude and the frequency of flow disturbance to riverbed have been monitored. The results indicate that regulated streams seem characterized by a greater algae biomass possibly due to a more stable environment. Moreover, winter promotes phytobenthos colonisation especially for the low frequency of relevant high-flow but also for the absence of the shading due to the tree canopy.

## LivingRiver - Caring and protecting streams life and culture

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“LivingRiver - Caring and protecting the life and culture around rivers and streams” is a European Project that includes Universities and NGO’s of Portugal, Romania, Spain and Turkey. The project aims to provide advanced training as well as pedagogical and scientific tools to be used by schools, and by the general community, to a better understanding of streams, their ecology, history and cultural legacy. In this project, participants from different countries are invited to make and immerse mesh bags filled with alder leaves in selected forested stream reaches. Along with a physico-chemical characterization of the study sites, the participants “follow” the leaves’ decomposition – a key stream ecosystem process - gaining insights on streams’ ecology and functional integrity. In parallel, they collect and analyze sources of tangible and intangible heritage using provided scientific validated protocols, which contribute to the knowledge of the history and valorization of cultural legacy of watercourses in close relation with the communities who live in their margins. Proposed activities stimulate, in a concerted way, informed practices of citizenship towards the protection and sustainable use of these life-supporting systems. Data resultant from this crossed ecological-social approach are discussed and registered online contributing to an international database. All activities of the LivingRiver project are disseminated to the general public in a multimedia and citizen science-based platform (<http://www.livingriver.eu/>).

## Classification of riparian delivery points for improved specification of mitigation measures

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Sources and pathways by which macronutrients (nitrogen and phosphorus) and sediment enter watercourses have traditionally been classified as being either point or diffuse, with agricultural sources typically classed as the latter. Increasingly, however, the idea of diffuse pollution is being replaced with the idea of multiple point sources. Whilst previous work has sought to identify the locations of these multiple point sources (to support greater targeting of mitigation measures), little research exists describing or classifying the variety of delivery points. An element of the Smarter BufferZ project (Irish EPA-funded) aims to classify different morphologies of the delivery pathways by which water crosses from edge of field to stream to create a typology of delivery points. This applied research presents proposed supplementary DEM-based decision-support tools with examples to describe different scenarios and to demonstrate some considerations that aid in site selection and assessments of potential interventions.

## Deriving DOC concentrations in Petit-Saut reservoir (French Guiana) from remote sensing data.

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Freshwaters play a significant role in the global carbon cycle by degassing carbon fluxes. It is established that most of this carbon emitted to the atmosphere comes from organic matters – transported by and stored in rivers and lakes – that is progressively degraded. This is particularly true for freshwaters in tropical context such as Petit-Saut reservoir in French Guiana (365 km<sup>2</sup>). Knowledge of the temporal and spatial dynamics of Dissolved Organic Carbon (DOC) in this reservoir and its tributaries is fundamental for understanding degassing mechanisms and better predicting their evolution. Hence, we tested the potentialities of satellite imagery to estimate the absorption from Coloured Dissolved Organic Matter (CDOM) – as a proxy for DOC. Optical properties (CDOM absorption and water reflectance) as well as water quality measurements were carried out at 25 stations evenly distributed over the lake. CDOM absorption was stronger and stronger as we got closer to the main tributary (Sinnamary river). A linear relationship between CDOM and DOC has been defined, suggesting that CDOM can be used as an efficient tracer to estimate DOC in Petit-Saut waters. In situ and satellite reflectance spectra were compared. Strong adjacency effects (due to the surrounding rainforest) were observed on satellite signals, making atmospheric and sunglint correction difficult. Nevertheless, an empirical algorithm using Sentinel-2 B3 to B5 bands has been designed. New measurement campaigns will be conducted but these preliminary outcomes on lake in tropical context stress on the need of algorithm dedicated to correct adjacency effects on satellite images.

## Short-term thermal acclimation modulates predator functional response

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Phenotypic plastic responses to temperature can modulate the kinetic effects of temperature on biological rates and traits and thus play an important role for species adaptation to climate change. However, we have very little information on how these plastic responses to temperature can influence trophic interactions. Here, we conducted an experiment using marbled crayfish and their water louse prey to investigate how short-term thermal acclimation modulates the predator functional response. As reported in previous studies we found that the predator search rate increases with temperature, reaches a maximum and then decreases at higher temperature whereas handling time tended to decrease with warming. However, this general pattern was highly sensitive to thermal acclimation. We found that acclimation to cool temperatures decrease maximum predation rate whereas acclimation to warmer temperature tend to increase maximum predation rate relative to non-acclimated predators. Moreover, we showed that the magnitude of the acclimation effects can be as strong as the direct kinetic effects of temperature. Our study highlights the importance of taking into account thermal plasticity to improve our understanding of the potential consequences of global warming on species interactions.



## Biologic effects of the heavy metal Cadmium and microplastics on Asian clam

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One of the most widespread aquatic organisms in the rivers and estuarine ecosystems, in the world, is Asian clam *Corbicula fluminea*. This clam, that can adapt to environmental changes, is an invasive species in several areas and it was adopted as a model for toxicity tests. This study evaluated the effects of the exposure to cadmium (Cd), to microplastics (MPs) and their mixtures on *C. fluminea*. The oxidative stress responses, lipid peroxidation (LPO), changes in the activity of energy-related enzymes and neurotoxicity were assessed on the gill, digestive gland and gonad. The results show that Cd, MPs and their mixtures cause oxidative stress, damage and neurotoxicity. The enzymes superoxide dismutase (SOD), glutathione S-transferase (GST), acetylcholinesterase (AChE) and the LPO levels could be chosen as biomarkers of Cd pollution. Exposure to MPs induced an increase in reduced/oxidized glutathione (GSH/GSSG) ratio and increased AChE activity. The combined exposure to Cd and MPs caused a synergetic effect in gill and gonad, while an antagonism response was recorded in the digestive gland. The results provide new insights for unveiling the biologic effects of heavy metal, microplastics and their mixtures on *C. fluminea*. Besides, we demonstrated that the Asian clam is a good bioindicator of microplastic pollution that can occur in aquatic environments.

## Antimicrobial susceptibility profiles of multidrug-resistant aeromonads isolated from Northern Portugal freshwater ecosystem

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The inappropriate use of antibiotics, one of the causes of the high incidence of antimicrobial-resistant bacteria isolated from aquatic ecosystems, represents a risk for aquatic organisms and the welfare of humans. This study aimed to determine the antimicrobial resistance rates among riverine *Aeromonas*, taken as representative of autochthonous microbiota, to evaluate the level of antibacterial resistance in the Tua River (Douro basin). The prevalence and degree of antibiotic resistance were examined using motile aeromonads as a potential indicator of antimicrobial susceptibility for the aquatic environment. Water samples were collected from the middle sector of the river, which is impacted by several anthropogenic pressures. Water samples were plated on an *Aeromonas*-selective agar, with and without antibiotics. The activity of 19 antibiotics was studied against 30 isolates of *Aeromonas* spp. using the standard agar dilution susceptibility test. Antibiotic resistance rates were fosfomicin (FOS) 83.33%, nalidixic acid (NA) 60%, cefotaxime (CTX) 40%, gentamicin (CN) 26.67%, tobramycin (TOB) 26.67%, cotrimoxazole (SXT) 26.67%, chloramphenicol (C) 16.67%, and tetracycline (TE) 13.33%. Some of the nalidixic acid-resistant strains were susceptible to fluoroquinolones. Multiple resistance was also observed (83.33%). The environmental ubiquity, the natural susceptibility to antimicrobials and the zoonotic potential of *Aeromonas* spp. make them optimal candidates for studying antimicrobial resistance in aquatic ecosystems. Aquatic environments may provide an ideal setting for the acquisition and dissemination of antibiotic resistance because anthropogenic activities frequently impact them. The potential risk of multi- and pan-resistant bacteria transmission between animals and humans should be considered in a “One Health-One World” concept.

## Endangered mussels as antimicrobial-resistant *E. coli* and other species (Enterobacteriaceae family) reservoirs

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Freshwater unionoids are one of the most threatened animal groups worldwide, suffering dramatic regressions globally. The freshwater pearl mussel *Margaritifera margaritifera*, currently listed as critically endangered in Europe, and *Potomida littoralis*, listed as endangered, are both present in the River Tua basin (Portugal). The inappropriate use of antibiotics has led to the emergence and spread of resistant bacteria, recognized today as a serious public health problem. Based in the concept of “One health”, the objective of this study was to examine the antibacterial resistance rates in *Escherichia coli* and other Enterobacteriaceae isolates obtained from both bivalves collected in the River Tua Basin during the summer of 2018. Activity of 22 antibiotics was studied using disc diffusion (Kirby–Bauer) method. Multidrug resistant in *E. coli* and Enterobacteriaceae isolates was observed only from *P. littoralis*. Overall, results show that *M. margaritifera* inhabits more pristine sectors of river not subject to the development of multidrug resistance, unlike *P. littoralis* which, although does not tolerate high levels of contamination, is naturally found in lower stretches is subject to greater pressure and, as such, a greater probability of the appearance of multi-resistant organisms. The presence of *E. coli* in freshwater bivalves can represent serious public health problems once bacteria are one of the most important biological contaminants in foodborne diseases. Given the conservation status of both studied species their protection against this silent/invisible enemy should be a priority, although work done with Unionid Mussels from Northern Portugal showed that they had a great antimicrobial and antibiofilm activity.

## Just add water: exploring our relationship with temporary rivers through headwater restoration

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Chalk streams represent some of the most beautiful and rarest freshwater habitat on earth. The headwaters of these streams naturally range in time and space between flowing, ponded and dry phases in response to seasonal fluctuations in groundwater levels, giving rise to their name – winterbournes. Winterbournes are etched into cultural heritage in place names such as Otterbourne, Lambourn and Winterbourne Abbas which dot the rolling chalk landscape of south England. What are the perceived cultural ecosystem services and disservices from chalk stream winterbournes? Ongoing research with local people suggests that they are accustomed to the natural rhythm in dryness, but still perceive a subjective restorative effect on their mental wellbeing from flows returning to their local winterbourne. These positive relational values are associated with cultural ecosystem services such as aesthetic beauty, recreation and place identity. However, the prevalence of such perceptions and the extent of other perceptions, such as ambivalence, remain undocumented. Plans to restore a 200 m reach of the Candover Brook winterbourne, which was historically destroyed by ploughing, offer opportunities to investigate responses in cultural ecosystem services provision and human well-being. This research will characterise perceptions and values of, and cultural ecosystem services and disservices from the damaged reach of a winterbourne, before (the damaged state) and after restoration of form and function. Understanding how people value temporary streams which they perceive to be in a poor and then restored condition, will inform future headwater restoration schemes, including naturally temporary streams.

## A new experimental device for measuring uprooting force of aquatic plants

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Aquatic plants are frequently exposed to water movement that can lead to mechanical failure as shoot breakage or plant uprooting. In lotic habitats, plants permanently encounter hydrodynamic forces induced by flow, whereas, in lentic habitats, they can be exposed episodically to high levels of hydrodynamic forces induced by floods or waves generated by wind or boats. The impacts of water movements on plants depend on the magnitude of the forces acting upon them and on their mechanical resistance to breakage or uprooting. The processes leading to the uprooting of aquatic plants have been poorly investigated due to limited experimental tools and methods available. Here, we present a new experimental device and a standardized procedure designed to study in situ the uprooting of aquatic plants through tensile tests. The principle of the device is to apply a continuous tension on isolated plants or patches under standardized conditions (speed, angle...) until plant uprooting. The force exerted on vegetation is recorded at high frequency throughout the test and the uprooting force is determined as the maximal force the plant can encounter before uprooting. The first measurements have been carried out on a diversity of plant species and growth forms (hydrophytes vs. helophytes, isolated plants vs. patches) and have demonstrated a very large range of uprooting forces among species, plant organization and environmental conditions. This device offers new opportunities to investigate plant mechanical resistance to uprooting in the field, which is a key process of the responses of communities to flow.

## Two-dimensional numerical modeling of the uprooting of macrophytes on the Rhône River

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In recent years, the development of certain species of macrophytes (i.e., aquatic plants large enough to see with the naked eye) in French streams and rivers has led to recurring problems for users and managers of aquatic environments (fishing, navigation, water pumping, etc.). A major issue is that if these plants are transported by rivers (for example, in the event of high flow), they can induce the clogging of the water intakes of hydroelectric structures. A research program between EDF and U CNRS 5023 is currently underway to better understand the drifting mechanisms (uprooting conditions and force) of macrophytes in fluvial environments. The objective of this numerical study is to determine the flow conditions leading to the uprooting of macrophyte meadows (i.e., when the drag force of the plants becomes greater than the uprooting force) and to study their transport within a reach of the Rhône River. This work is based on the use of the two-dimensional Telemac-2D hydrodynamic code (developed within the open-source Telemac-Mascaret system) coupled with a module simulating the uprooting of macrophytes.

## Integrative taxonomy of the Triops present in Valencian temporary ponds

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Mediterranean temporary ponds contain a rich biodiversity, but they are in decline due to degradation, drought, agriculture and changes in land use. In collaboration with the regional Environmental Agency, we have developed an analysis of the populations of Triops present in the Valencian territory. Thus, we have characterized the morphological differences (through drawings and photographs) and the genetic variation of populations sampled in 12 localities of Castellón and Valencia. We found that there are 3 main groups of haplotypes, corresponding to 2 species (one of them undescribed), and that these can be distinguished by a detailed study of their morphology. In addition, we have been able to detect the co-occurrence of two genetic variants of the new species in several localities. The genetic variation of the new species, with a wider distribution within the Valencian community, could correspond to ancient lineages and/or be related to different adaptations to the natural environment. The results of our work highlight the importance of complementing morphological studies with molecular data to develop an appropriate management and protection plan of Triops spp.

## Aquatic alien species affect the macroinvertebrate diversity of the Doñana pond network.

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Freshwater ecosystems are one of the most invaded ecosystems across the world, whereas the characteristics behind the invasion success still remain quite understandable. The pond network in the Doñana National Park (SW Spain) includes more than 3000 temporary ponds, most of them classified as EU priority habitats (code 3170 of the Habitat Directive: Mediterranean temporary ponds), 2-3 natural permanent ponds, and approximately 200 artificially deepened small water bodies with a permanent water regime. We used data on macroinvertebrates abundance and the physic and chemical characteristics of 88 ponds sampled between March and June 2007 to construct a database including the functional traits of these species. Our goal was to evaluate the effects of the aquatic alien species (*Trichochorixa verticalis*, *Stenopelmus rufinasus*, *Physa acuta*, *Procambarus clarkii* and *Gambusia holbrooki*) on the macroinvertebrate assemblages. We found a significant variation in the taxonomical composition of the macroinvertebrate species in the ponds that harboured *G. holbrooki*. The presence of *P. clarkii* only was significant in temporary ponds, but not in permanent ones. Also, the presence of *S. rufinasus* had a significant effect on the macroinvertebrates in temporary ponds, whereas *T. verticalis* had a marginally non-significant effect. Some alien species, such as *S. rufinosus* and *T. verticalis*, were not apparently resident, but probably used the ponds as "stepping stones" for dispersal. In contrast, we suggest that even sporadic occurrences of the red swamp crayfish, introduced in this pond network in 1983, can severely modify the macroinvertebrate assemblages in our study temporary ponds.



## Remediation of phosphate levels in a semi-suburban catchment feeding a protected estuary.

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Phosphate levels in a complex small catchment in north county Dublin impinged by suburban and urban sites on the north of Rogerstown Estuary were found in excess of statutory limits over a 3 year period. Samples of water collected from the catchment were percolated through steel fragments in nets and cages to model water flow in the real environment. A modest reduction in total phosphate levels was found when contaminated water was percolated through columns packed with scrap steel fragments. This paper presents the results of (A) the initial findings in the field, and (B) the findings of reduction due to percolation through steel fragment columns. It is expected that field-testing of cages packed with steel fragments forming riffles in streams will provide some remediation to dissolved phosphate contamination, and a model of the projected dimensions of the riffle beds required to handle phosphate loads from domestic outflows and agricultural runoff is presented. It is anticipated that whereas such a system might remediate ongoing chronic pollution, acute polluting events may not be offset.

## Organic-matter decomposition as a bioassessment tool of stream functioning

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Organic-matter decomposition has long been proposed as a tool to assess stream functional integrity, but this indicator largely depends on organic-matter selection, which may vary depending on the environmental change being considered. We assessed eight decomposition-based indicators along two well-known environmental gradients, a nutrient-enrichment gradient (0.2–1.4 mg DIN/L) in central Portugal and an acidification gradient (pH: 4.69–7.33) in north-eastern France to identify the best organic-matter indicator of stream functional integrity. Functional indicators included natural leaf litter (alder and oak) enclosed in coarse and fine mesh bags, commercial tea (green and rooibos teas), wood sticks, and cotton strips. The effectiveness of organic-matter decomposition rates as a functional indicator depended on the stressor considered and the substrate used. Decomposition rates responded more to acidification than to the nutrient-enrichment gradient. Decomposition rates of alder and oak leaves in coarse mesh bags, green and rooibos teas, and wood sticks were positively related to pH. Decomposition rates of rooibos tea and wood sticks were related to DIN concentration; decomposition rates along the nutrient-enrichment gradient were confounded by differences in shredder abundance and temperature among streams. Our results suggest that commercial substrates may be a good alternative to leaf litter to assess stream functional integrity, especially in the case of nutrient enrichment.

## Eutrophic lowland lake ecological quality assessment using structural and functional indicators

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Lake Saukas is a shallow lowland lake in Latvia. Its surface area is 718.2 ha and its mean depth is 5.1 m. The ecological quality of the lake has deteriorated due to agricultural practices and the discharge of insufficiently treated wastewater. Although anthropogenic pressures have now decreased in the catchment area, the lake still suffers from frequent algal blooms. In order to elaborate scientifically sound management measures for remediating the lake ecosystem and improving its ecological status, complex limnological surveys were conducted in 2020. Seasonal analyses of phytoplankton, zooplankton, benthic invertebrates, and aquatic chemistry were done. Macrophyte surveys were carried out in July. Indices characterizing community structure, functional groups, and interactions between them were analysed. The community structure, density and biomass of organisms in the lake shows spatial and temporal heterogeneity. The phytoplankton is characterised by high species diversity, with Chlorophyta and Cyanobacteria dominating in summer. 50 taxa of zooplankton were recorded, with tolerant planktonic taxa dominating. 37 macrophyte species were recorded. The richest communities of benthic invertebrates were found on sandy substrate in littoral zones, with *Dreissena polymorpha* biomass dominating in some locations. The results indicate that the lake can be characterised as eutrophic according to species composition and biomasses. This study was supported by the integrated project “Implementation of River Basin Management Plans of Latvia towards good surface water status” (LIFE GOODWATER IP, LIFE18IPE/LV/000014), funded by the LIFE Programme of the EU and the Administration of the Latvian Environmental Protection Fund.

## Ecological assessment of a renaturalised pond in the quarries of Alpedrete (Spain).

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Invertebrates have recently been recognised under a global decline, a situation that seems to be accentuated in continental waterbodies. In the EUROPONDS project we deepened in the contribution of aquatic invertebrates to terrestrial ecosystems, representing countries all over Europe. Our study was encompassed in a restored quarry in Alpedrete, Madrid, Spain, a landscape destined for livestock activities. We evaluated the invertebrate assemblages of a small permanent pond after restoration (physicochemical variables, macroinvertebrates assemblages and macrophytes species) and its contribution to the landscape by the

emerging insects. To do that, we have carried out seasonal samplings starting in autumn 2020 and finishing by summer 2021. We detected a highly aquatic biodiversity in our study pond, showing oversaturation of dissolved oxygen concentration and a rich and dense cover of macrophytes. A diverse assemblage of aquatic macroinvertebrates included odonates, heteropterans, coleopterans, culicids, chironomids and ephemeropterans. We located two traps for emergent insects during one week each season, and we captured flying and adult individuals of some of these macroinvertebrates (even 60 chironomids in winter), revealing the importance of this pond for the adjacent landscape. We concluded that our shallow permanent pond shows a high degree of naturalisation due to the huge diversity of fauna and flora recorded. We consider of concern that the cattle's faeces in the surroundings of the pond could reduce the water quality as detected an increase in nitrate concentration (0,16 mg/L in winter). Therefore, we encourage regional authorities to include this pond in the regional program for wetland conservation.

## Experimental floods shape temporal genetic diversity patterns of an amphipod population

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Dams can affect rivers in many ways. By acting as physical barriers, they disrupt flow and sediment regimes, dramatically changing the downstream physical habitat template. At the same time, dams cause longitudinal fragmentation of the fluvial network, isolating local populations. Flow regulation allows colonization of stream ecosystems by non-native species, favoured by stable conditions. On the River Spöl, dams built in the 70s caused a dramatic change in flow-dependent downstream environmental conditions. The amphipod *Gammarus fossarum* colonized the system and became dominant in benthic assemblages (~90%). Between 2000 and 2016, experimental floods were conducted twice per year to mitigate the adverse flow effects of the dam, and to reintroduce disturbance in the system. Experimental floods reduced *G. fossarum* densities due to environmental changes as well as increased mortality. Experimental floods, acting as repeated bottleneck events, can cause a reduction in genetic diversity in populations of this fully aquatic species, for which dispersal – and gene flow – mostly follows flow direction. In the long term, the influence of these physical controls on gene flow were quantified by assessing changes in allele frequencies in polymorphic neutral genetic markers (microsatellites). In this study, we reconstructed the effects of habitat fragmentation and experimental floods on *G. fossarum* populations over the last 20 years. We applied automated genotyping of microsatellites and a mitochondrial marker on archived specimens to track “in real time” changes in genetic diversity at different evolutionary timescales, to investigate population-level processes regulating the persistence of this species under new flow-disturbance conditions.

## Cyanobacteria bloom in a multiple-uses reservoir and its impact on the irrigation-network

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Harmful cyanobacteria blooms (CyanoHABs) are one of the main water quality threats affecting reservoirs. Guidelines suggest the integration of laboratory, real-time in-situ, and remote sensing data to improve the monitoring of CyanoHABs. This integration, however, is still little adopted in monitoring programs. The present study demonstrates the importance of this integration to improve both frequency and spatial resolution of the acquired data. Field data were from a CyanoHAB (*P. rubescens*), occurred in a south Italy multiple-uses reservoir (Lake Occhito) in winter 2008-2009 and regarded both lake and irrigation network. In the lake, laboratory, and in-situ fluorometric data were related to satellite imagery (from MODIS and MERIS satellite) using simple linear regressions, to produce surface lake wide maps (300m resolution) reporting the distribution of both *P. rubescens* and microcystins concentrations, in a range of interest for the management of both drinking supply (1 µg L<sup>-1</sup>) and bathing (25 µg L<sup>-1</sup>). For irrigation, no thresholds are currently available in official guidelines. Yet, at the first node of the distribution network total microcystin concentrations reached values (4-10 µg L<sup>-1</sup>) potentially able to determine damages to the culture. Our results, however, show a decrease of the microcystin concentrations with the distance from the lake, which allowed to mitigate the impact of the bloom on the irrigation water. We finally underline that the recently acquired improvement in the satellite imagery resolution to tens of meters would allow to monitor the spread of CyanoHAB in the main tanks of the irrigation network.

## Trophic ecology of exotic fish in “Tancat de la Pipa” wetland (Valencia-Spain).

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In the last centuries, many fish species have been introduced into the Iberian Peninsula with different purposes, such as biological control of water borne diseases (e.g. *Gambusia* spp.) or for fishing and other recreational activities. These introductions have had detrimental effects for native species, in some cases caused by the overlapping of trophic niches and the competition between introduced and native species, even producing the displacement of some autochthonous species. Therefore, the knowledge of the trophic ecology and preferences of non-native species is relevant to study the competition for resources with the native ones, and investigate the possible effects on native populations. Our study was developed in three canals located in a Mediterranean wetland (Tancat de la Pipa) during a year. Fish were caught using fyke nets left during 24 hours, and were preserved in ethanol. The most frequent exotic fish species found were *Lepomis gibbosus*, *Gambusia holbrooki*, *Cyprinus carpio* and *Carassius auratus*. After weighting and measuring each individual, gastrointestinal tracts were extracted and cleansed with NaCl 0.9 %. The contents were observed in the microscope to analyze the main ingested items. Crustaceans, aquatic and terrestrial insects, vegetal remains or seeds, and even some microplastic fibers, were commonly found, with notorious differences among species.



## Population structure and composition of non-native fish species during a year Valencia

**CLAUDIA MILENA RODRIGUEZ- SIERRA<sup>1</sup>**, Barbara Alvarado Arranz<sup>1</sup>, Francisco Villa-Navarro<sup>1</sup>, Anna Valentín<sup>1</sup>, María Antón-Pardo<sup>1</sup>, Xavier Armengol Díaz<sup>1</sup>, Diana Ferris<sup>1</sup>

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Non-native fish are dominant in many aquatic ecosystems of the Iberian Peninsula, and they have been considered as the main cause of several environmental problems, such as the detrimental effects on populations of vulnerable native species. Some of these non-native species have been considered invasive, because they can develop their populations in places far from its original distribution displacing or negatively affecting the autochthonous inhabitants. Throughout competition or predation or as vectors of pathogens, these invasive species can alter the structure and composition of native communities. “Tancat de la Pipa” is an area in the surroundings of “Albufera de Valencia” lake, a hypereutrophic shallow coastal lake in eastern Spain. In this area, a system of green filters has been implemented, in order to reduce the organic and nutrient inputs to the lake. Using six fyke nets distributed in three water canals, fish have been monthly caught during a year. The nets were left in the canals during 24 hours once a month. Non-native species were much more abundant in density and biomass than native ones. The most abundant species and their size (total length  $\pm$  sd) were: *Gambusia holbrooki* ( $3.5 \pm 0.8$  cm), *Lepomis gibbosus* ( $6.8 \pm 2.8$  cm), *Cyprinus carpio* ( $18.8 \pm 5.1$  cm) and *Carassius auratus* ( $17.2 \pm 3.7$  cm). The only native species caught was *Anguilla anguilla*.

## Winter biological processes in northern lakes under the influence of climate variability

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Winter in temperate and arctic regions is the most critical period for many natural processes. This season accounts for most of the inter-annual changes in air temperature, these fluctuations, more than in summer, directly affect the survival of many species. Although the importance of winter processes has been recognized by now, there is very little information about polar lakes covered with ice in winter. Detailed studies of biological processes were conducted in the winter 2019-2021 on two small (<1 km<sup>2</sup>) lakes located in North Karelia (Russia) near the Arctic Circle. Sampling was carried out before the freezing of lakes in October-November, after the ice cover formation (December), in the middle (February), end of the ice period (April), after the opening of the lakes in May and during summer. The water temperature, illumination and dissolved oxygen were constantly recorded using autonomous recorders (loggers). Obtained results have shown a very high level of quantitative development of biological communities in the under-ice period. For example, the chlorophyll concentrations under the ice in April reached 2–3 µg/L, which exceeds all the maximum values, observed during the warm season. Analysis of long-term data showed that indices of phytoplankton (chlorophyll concentration, biomass) positively correlated with air temperature in winter with a lag-period of two years, and weather peculiarities of wintertime significantly affect the state of lake communities during the warm season. Changes in primary production, apparently, were one of the main factors determining the development of plankton and benthic animals, especially in the coastal zone.

## Unclogging EU rivers: prioritisation of barrier removal in stream networks

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Barriers associated to human infrastructure are a widespread impact in freshwater ecosystems worldwide, disrupting connectivity along river networks and key processes. Restoration of connectivity has risen in the last decade, with thousands of dams, weirs and culverts removed, and will be supported by the EU Biodiversity Strategy, that aims to reconnect 25,000 km of rivers by 2030. Spatial optimisation methods can help inform decision on what barriers to remove to maximise gain in connectivity under limited budgets. We demonstrate how to prioritise the allocation of barrier removal projects. For this, we mapped the distribution of >900 barriers in the Tagus River (Iberian Peninsula) and 29 freshwater fish species with different movement abilities and needs. We assessed the passability of each barrier by all species and relative removal cost. We then identified priority barriers for removal to increase connectivity of populations of all species simultaneously. We found that connectivity recovery targets could be achieved by removing a small proportion of barriers, and avoiding large infrastructure, with a high opportunity cost. However, for some species, large recovery targets could only be achieved by removing some of these large infrastructures at high increases in cost. Our approach demonstrates how to use a robust optimisation approach to address the complexity of prioritisation exercises commonly faced by stakeholders when deciding where to invest in barrier removal projects. This will improve decision-making for river connectivity restoration through a transparent, reproducible, and better-informed approach than traditional opportunistic or ranking-based approaches.

## The transfer and effects of xenobiotic pollutants in freshwater ecosystems

Fred Windsor

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The diversity of synthetic, xenobiotic chemicals reaching the wider environment has increased rapidly over the past century. The nature and severity of their ecological effects in freshwater systems, however, remains poorly understood, even for the so-called 'legacy' pollutants. These persistent, bioaccumulative and toxic compounds still risk having negative effects at all levels of biological organisation long after their initial release into the environment. The ability to determine the ecological risks posed by persistent pollutants remains restricted due to: (1) reliance on standardised toxicology testing on individuals; (2) limited understanding of how natural variation alters potential ecological effects at population, community and food web levels; and (3) poor knowledge of how pollutant bioaccumulation and biomagnification translate to effects. Through global, catchment and reach-scale empirical assessments, this thesis investigated spatial and biological variation, trophic transfers and ecological risk in freshwater ecosystems associated with persistent xenobiotic pollutants (polychlorinated biphenyls [PCBs], polybrominated diphenyl ethers [PBDEs] and organochlorines [OCs]). The transfer, accumulation and magnification of persistent pollutants were related to environmental conditions, biological traits, food web structure, and chemical characteristics, and were sufficient for widespread, hazardous levels of contamination. Across river systems, pollutant body burdens were linked to putative structural and functional effects conveyed through food webs. Overall, these data indicate the importance of natural processes in influencing the effects of persistent pollutants in freshwater ecosystems. Risk assessments that incorporate the variation present in natural systems are required to improve understanding of the role of xenobiotic pollutants in global environmental change across freshwater ecosystems.

## Exploring the diversity of snow algae using polyphasic approach

Dr Lenka Procházková

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Organisms regarded as true snow algae thrive in a liquid water film between melting snow crystals, and usually do not reproduce outside of this habitat. These microalgae cause snow blooms in mountain and polar regions. In our research, we applied a polyphasic approach, i.e. studied cell morphology, ultrastructure, genetics, ecophysiology (fatty acid and pigment profiles, light requirements) of field collected cells as well as cultured material. Firstly, we focused on phylogeny, molecular diversity and geographical distribution of the main algae responsible for the red snow phenomenon (Procházková et al. 2019, FEMS). This is what people called *Chlamydomonas nivalis*. We explored field samples from the Arctic, Antarctic, North and South America and Europe. No culturable isolates of these investigated algae are available yet. We described it as *Sanguina* (Procházková et al. 2019, FEMS). Furthermore, a new species *Chloromonas hindakii* causing orange snow blooms was described (Procházková et al. 2019 Microorganisms). Multiple populations were collected over a wide altitudinal gradient, and the exploration of light preferences of field samples and a laboratory strain showed a high intraspecific ability to adapt their photosynthesis to different light conditions. Next, the application of high throughput amplicon sequencing was evaluated for the characterization of snow algal communities. An optimized workflow was proposed for such projects to assist in accurate biodiversity analyses (Lutz et al. 2019 Fottea). The poster briefly summarizes main outcomes of the work which was awarded a third prize of European Federation of Freshwater Sciences Ph.D. award 2019-2020. The thesis is available here: <https://dspace.cuni.cz/handle/20.500.11956/116591?locale-attribute=en>



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