LIVING TOGETHER: A BLUE STRATEGY TO PRESERVE AND PROMOTE DIVERSITY

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ABSTRACTBAND

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Plenarvorträge

Keynote Session: *Global change and biodiveristy*

Freshwater biodiveristy in mediterranean climate regions: current status and future trends

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Freshwater ecosystems account for 0.3% of the planet's freshwater but they are the habitat for 9% of all described species and 35% of vertebrate species. The levels of freshwater biodiversity loss are alarming, doubling those found in terrestrial or marine ecosystems. Mediterranean climate regions are considered global hotspots of biodiversity, also for freshwater organisms. Rivers in these regions (med-rivers) are unique ecosystems because of their predictable winter flooding and summer drought regimes. They support many species adapted to both floods and droughts, and their high levels of freshwater biodiversity are explained by past historical events and current environmental heterogeneity. At the same time, Med-rivers have been affected for centuries, in some cases millennia, by multiple human activities that increasingly threaten their biodiversity. These threats include changes in land use, nutrient loads, heavy metal concentrations, salinity, water withdrawals, invasive species and, more recently, xenobiotics or emerging organic pollutants. In addition, future climate change scenarios predict increases in drought conditions and in the occurrence of extreme events, such as floods, heat waves, and wildfires. The diversity of aquatic organisms is declining more rapidly in med-rivers than in rivers anywhere else in the world and, for some taxonomic groups, Mediterranean regions have more introduced than native species. Freshwater biodiversity conservation in med-rivers requires innovative approaches to account for both natural and human disturbances. Current protection figures, including the Natura2000 network, do not appear to be very efficient in protecting freshwater biodiversity in med-rivers, so it is necessary to establish conservation criteria adapted to the characteristics of these ecosystems.

Global change and biodiversity – a megafauna perspective

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Freshwater megafauna species, i.e. freshwater animals that can reach a body mass of 30 kg or more, are vulnerable to anthropogenic impacts. There are intense and growing threats such as overexploitation, dam construction, habitat degradation, pollution, and biological invasions on freshwater megafauna, resulting in e.g. half of all assessed species being considered as threatened on the IUCN Red List. I will provide an overview on trends such as global population declines, range distribution changes, or impacts by invasive species. Furthermore, I will discuss their potential to function as flagship and umbrella species but maybe more importantly their potential to reconnect people with nature through their cultural values.

Sustainable water management under Global Change: What can be learned from monitoring data?

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Under the conditions of Global Change, land and water uses need to be adapted. Main challenges include: To increase infiltration, to reduce surface runoff, to reduce water temperatures and to mitigate other stressors that are multiplied by Climate Change. The required adaptations therefore address the stream, the riparian zone and the catchment.

Actions require a profound understanding on general stressor effects and on how stressors, including those initialised by Climate Change, interact. A Europe-wide analysis revealed that river ecological status is affected by a mixture of hydromorphological degradation (responsible for 40% of the variation in status classes), nutrients (35%) and toxic substances (25%). Based on > 180 datasets on two stressors and one biological response we can show that nutrients are still the overarching stressors in lakes (often enhanced by higher temperatures), while multiple stressors in rivers are more case-specific and require more bespoke management decisions.

The riparian zone is a key scale to mitigate the effects of Climate Change on streams, e.g. by shading of woody riparian vegetation; a shaded stretch of about 400 metres is required to initialise a new thermal equilibrium of water temperatures, which are about 2°C lower. In lowland streams, increasing the coverage of woody riparian vegetation from 0 to 100% can enhance ecological status by two classes.

Most of these findings are based on monitoring data that are collected by public authorities. Making these data easily accessible is key to cooperation between water management and scientists. At the same time, scientists need to communicate intensively with water managers to understand their needs.

Herausforderungen, Maßnahmen und Erfolge der Wasserwirtschaft im Gewässerschutz, bei der Förderung der Biodiversität und der Anpassung an den Klimawandel

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Seit den 1970-er Jahren hat der Kläranlagenausbau zu einer erheblichen Verbesserung der Qua-lität der Oberflächengewässer geführt. Die Programme zur Gewässer- und Auenrenaturierung seit den frühen 1990-er Jahren führten vielerorts zu ökologisch verbesserten Gewässern und teils zur Reaktivierung von Auen. Langzeitdaten aus den letzten 50 Jahren zeigen in der Folge eine erhebliche Erholung im biozönotischen Bereich.

Spätestens seit 2000 – mit der Implementierung der EG-Wasserrahmenrichtlinie (WRRL) – stel-len Gewässertypisierung und Leitbildentwicklung weitergehende Anforderungen an die hydro-morphologische und biozönotische Entwicklung aller Oberflächengewässer. Die Ziele der WRRL scheinen jedoch bis heute nahezu unerreichbar – nicht einmal 10 Prozent der deutschen Ober-flächengewässer erfüllen die Bewirtschaftungsziele. Aktuelle Herausforderungen im Gewässer-schutz sind die Reduzierung der sogenannten Spurenstoffe im Abwasser und den Gewässern und die durch den Klimawandel hervorgerufenen Wasser-Extrema.

Auch wenn noch nicht alle Wirkzusammenhänge erfasst und beschrieben worden sind, besteht Handlungsbedarf. Neben größeren wasserwirtschaftlichen Maßnahmen ist es sinnvoll, sogenann-te No regret-Maßnahmen anzugehen, die idealerweise gleich mehreren Funktionen dienen. Die Entwicklung blaugrüner Infrastruktur im Siedlungsraum gehört ebenso dazu wie der Bau von Rückhalteräumen, die dem Hochwasserschutz, der Auenentwicklung und der Biodiversitätsför-derung nutzen, wie eigene Untersuchungen zeigen. Beim Thema Monitoring und Ursachenanaly-se besteht seitens der Wasserwirtschaft Bedarf an Unterstützung durch Forschung und technolo-gische Entwicklung um von der Gewässerbeobachtung über die Ursachenanalyse zu den Maß-nahmen schneller zu werden. Auch braucht es neue, ergänzende Verfahren, um den Erfolg von Maßnahmen zu bewerten. Das Prinzip der Ökosystemleistungen kann hierbei eine wesentliche Rolle spielen, wie an Beispielen gezeigt wird.

Keynote Session: *Invasive Species*

Freshwater biodiveristy in mediterranean climate regions: current status and future trends

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Freshwater crayfish are ecosystem engineers and have as such a high impact on freshwater biodiversity. Moreover, they are of high economic value as luxury food product. Unfortunately, population trends of native crayfish all across Europe are in severe decline, predominantly due to the increasing populations of invasive North American crayfish entering Europe mainly via the pet trade. These invasive crayfish are vectors of the crayfish plague pathogen Aphanomyces astaci, an oomycete listed amongst the 100 worst invasive species worldwide, leading to elimination of entire crayfish populations across Europe. To replace the diminishing native crayfish populations, repeated introductions of its North American crayfish species have been conducted throughout Europe, an example of a man-made ecological disaster, stemming from the naive belief that the manipulation of an ecosystem would be straightforward. The alien crayfish species, which were supposed to replace the eradicated native stocks, not only transferred the deadly disease but also outcompeted their native crayfish counterparts, because they are not subject to the same biotic factors within the existing community that control population size. North American crayfish species are usually resistant towards the crayfish plague disease. For European crayfish on the other hand, A. astaci is a highly infectious pathogen, leading to crayfish mortality usually within a few days to weeks, depending on pathogen strain virulence and environmental conditions. However, recent reports from studies conducted both in the laboratory and in the wild indicate that A. astaci-exposed noble crayfish can, in some cases, resist an acute crayfish plague infection. In my research we are using this host-pathogen-model to investigate the immune response in native and invasive freshwater crayfish towards an A. astaci infection with a multi-omic approach. We investigate the genomic basis of host resistance and pathogen virulence, which will be used to create genomic biomonitoring tools for identifying resistant crayfish populations and enable the A. astaci strain determination via eDNA samples, paving the way for an advanced management strategy to conserve freshwater crayfish. Apart from basic and applied research on management and biocontrol of invasive crayfish and the crayfish plague disease agent, as well as strict and enforced European pet trade regulations, awareness raising of the common public regarding the general threat of alien species introductions is essential for an effective long- term change of the common anthropocentric mindset. Education of the laypersons, including school children, retailers, fishermen and pet owners, reduces the probability of alien crayfish species release into the inland waters. Once informed and more aware of the negative impacts of alien crayfish species, general public engagement can significantly contribute to nature conservation. For this goal, we have created an educational animation for past, present and future children and youngsters and all those interested in the fascinating and complicated history of freshwater crayfish in Europe. The Crayfish Tale (see YouTube link below) introduces freshwater crayfish and their fundamental role as keystone species, tells about the mistreatment of native crayfish, and advices how we humans must behave in order not to finally lose these essential species and the wellbeing of our freshwater ecosystem. The fundamental lesson of the crayfish tale is that we all should carefully think before acting, while afterwards is usually too late. If we start to look after our crayfish and waters, then the future will look after us.
https://www.youtube.com/channel/UCTITjaUzHwkTbNXqk1HOK4g/videos

Applied research of invasive species – Crucial for understanding their impact and providing practical solutions

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Applied research, based on a foundation of sound fundamental research, is crucial for the successful and timely implementation of knowledge transfer from scientists to operatives: with effective management strategies being the desired outcome. This is ever more relevant and urgent in the face of the world's biodiversity crisis. In this regard the negative impacts of neobiota form a major component, especially in the freshwater domain.

This talk will highlight three cases which demonstrate inasive species' negative impacts, the challenges of managing without harming other biota and the difficulties of translating knowledge into legislation:

1) Invasive sticklebacks of Lake Constance with their impact on the pelagic keystone species whitefish and the selective removal problem

2) Invasive Ponto-Caspian gobies with their impact on river fish fauna assemblages, plus the need and challenge to implement them in the 'Ecological Assessment' of the Water Framework Directive (WFD)

3) Invasive crayfish with their displacement action of native crayfish, prevention as the only remaining possibility and the resulting direct conflicts with similarly important conservation measures

Finally, the presentation will discuss, from an applied point of view, major concerns and requirements on fundamental research which works on topics on the intersection between both disciplines. E.g. setting realistic limits, making allowances for data boundaries and questioning model outcomes. The necessity of effective dissemination will also be briefly touched upon.

Freshwater biodiveristy in mediterranean climate regions: current status and future trends

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Invasive alien species (IAS) continue to be a threat to biodiversity and ecosystems, calling for a continued effort to prevent or, if inevitable, minimize their impact. The implementation of suitable management measures related to IAS depends, to a great extent, on insights from both basic and applied scientific research. Species specific knowledge and data must be translated into useful information to detect a potential invasion, identify the appropriate management measures and anticipate possible impacts on other species and the environment. The Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN) commissions research projects that bundle current and relevant information for various authorities in charge of implementing policies and regulations, as well as for the general public. Outcomes include publications on risk assessments for invasive species, information around the implementation of the EU-regulation on IAS (EU Nr. 1143/2014) including but not limited to the EU List of Invasive Alien Species and the notification of IAS found in the federal states (Bundesländer). While efforts to properly manage IAS have to be sustained and prioritized in space and time, there must be a clear emphasis on prevention, as it minimizes the extent and intensity of the impact, as well as the efforts and costs required. Serving as a link between science and management in the context of legislation at the national and European levels, is both challenging and rewarding.

Invasive Quagga mussels potential change ecosystem functions in Lake Constance

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Lake Constance, one of the largest Alpine lakes on the border between Germany, Austria and Switzerland, has undergone extensive changes in the past century. In the 1950-1980s, Lake Constance experienced a phase of severe eutrophication caused by untreated sewage and intensive agriculture, resulting in significantly increased nutrient-levels. Although the natural trophic state of the lake has been almost completely restored, there have been irreversible changes to the communities of aquatic organisms.

In addition to eutrophication, climate change and especially the invasion of non-native plant and animal species are endangering natural biodiversity. This leads to changes in the food webs and affect ecosystem functioning in Lake Constance. Today, there are more than 37 non-native species in Lake Constance, including e.g. three-spined stickleback (Gasterosteus aculeatus), Zebra mussel (Dreissena polymorpha) and Quagga mussel (Dreissena rostriformis bugensis).

Especially the three-spined stickleback and Quagga mussel populations have exploded in the last years, with sticklebacks becoming the most abundant pelagic fish species of the lake. Compared to the Zebra mussel, the Quagga mussel is able to settle in greater water-depth, which causes problems with water intake pipes and other structures; it also reproduces the whole year round. Our recent research shows that the Quagga mussel is present everywhere in the lake, even in the deepest parts. Comparisons with the great lakes in North America, where the Quagga mussels invaded 10-15 years earlier show that more affects of this invasive mussel in Lake Constance can be expected.

Vorträge der DGL-Nachwuchs-preisträger

Not just temperature – How global warming affects drinking water reservoirs

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Lakes and reservoirs show clear and fast response to global warming. Around the globe a rise in surface water temperature, loss of ice cover and change in mixing dynamics can be observed. The general patterns are similar, but the specific response of a reservoir depends on its individual characteristics like morphology, mixing regime, and catchment. In Germany we observe a prolongation of summer stratification and a regime shift from dimictic to monomictic. Especially in drinking water reservoirs, stratification and temperature are important factors as they influence bio-geo-chemical processes and ecosystem dynamics and thus affect water quality. So, to safeguard drinking water production under a warming climate, mitigation strategies are needed. To develop and evaluate such strategies in advance, dynamic simulation models are applied. Models help to produce probabilistic predictions of future conditions and allow to compare different management strategies. We used a combination of data analysis and dynamic modeling to explore the impact of global warming on three drinking water reservoirs in Germany and to compare mitigation strategies that focus on selective withdrawal.

Many drinking water reservoirs have outlet structures that allow to withdraw water from different depths and at variable rates. These structures were mainly build to withdraw raw water of optimum quality for drinking water production, but can also be used to discharge water to the downstream river from different depths. This can then be used to e.g. flush turbid layers, but it can also impact the thermal structure. Discharging water from the epilimnion to the downstream river can preserve hypolimnetic water, but as a side effect prolongs summer stratification. To better understand the impact of different withdrawal strategies, we employed hydrodynamic lake models and simulated the effects of the withdrawal strategy on temperature and stratification. In particular, we assessed the potential of depth and time-variable withdrawal to mitigate the impacts of global warming. The modeling study shows that deep water temperatures (25 m below surface) and the end of summer stratification are strongly controlled by the withdrawal regime. Compared to the observed impact of global warming, the simulated impact of the withdrawal strategy was of the same order of magnitude. Adapting the withdrawal strategy can thus be one component of safeguarding water resources from reservoirs.

The long-term effect of iron amendments on phosphorus retention in lake sediments

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The effectiveness of iron as a precipitant for in-lake phosphorus retention is considered limited by low redox conditions. This field study aimed to guide the planning of these eutrophication management measures by investigating the long-term fate of iron added to two urban lakes (Plötzensee and Groß Glienicker See) in Berlin, Germany. The internal phosphorus precipitation by iron was applied as part of a set of management measures in the year 1992 in Groß Glienicker See and in 2000 in Plötzensee. Consequently, the eutrophic status of the two lakes improved.

In both lakes, the added iron was preserved in the sediments. In Groß Glienicker See, phosphorus retention increased following the addition of iron. The transformation of initially redox-sensitive iron(oxi)hydroxide-bound phosphorus to the redox-stable ferrous iron phosphate vivianite enabled long-term phosphorus retention in the anoxic sediment. On the contrary, sulphur was retained by the excess iron in Plötzensee due to the formation of iron sulphides. The iron-rich layer did not contain a higher phosphorus content in comparison to reference layers and no increase of iron-bound phosphorus was identified. This contrasting effect is attributed to significantly different sulphate reduction rates in the two lakes. According to one-box modelling of the sulphur fluxes in both lakes, sulphate reduction explained both decreasing sulphate concentrations after the iron applications as well as increasing sulphur deposition in the sediments.

Table: Microbial reduction of iron and sulphate affect long-term phosphorus retention in sediments after iron dosing.

	Low microbial iron reduction	**High microbial iron reduction**
Low sulphate reduction	Fe(oxi)hydroxides bind phosphorus in the long term.	Vivianite binds phosphorus in the long term.
High sulphate reduction	Sulphide dissolves iron(oxi)hydroxides and prevents long-term phosphorus retention.	Sulphide dissolves vivianite and prevents long-term phosphorus retention.

The table summarizes that anoxic conditions and microbial iron reduction do not impede the long-term effect of iron amendments on phosphorus retention (Groß Glienicker See). However, sulphide provided by sulphate reduction competes with the binding of phosphorus to iron (Groß Glienicker See) and a high sulphate reduction rate can prevent the continuous effect of an iron amendment on phosphorus retention (Plötzensee). Thus, iron amendments to enhance long-term phosphorus retention must consider the competing process of iron sulphide formation during the entire management plan period. To account for this effect additional iron may need to be applied. Further research on direct and indirect biogeochemical interactions between iron dosing and the sulphate reduction rate is required to allow improved planning and management of iron amendments.

Warum fehlen Edelgase im Tiefenwasser des Kivu-Sees? Eine quantitative Analyse von Temperatureffekten gegen Ausgasung

Cornelis Schwenk

Gewässer enthalten durch Austausch mit der Erdatmosphäre Edelgase in berechenbaren Konzentrationen, die durch Umweltbedingungen wie Temperatur und Gasblaseneinschluss oder Ausgasung bestimmt sind. Für die Edelgase Neon, Argon, Krypton und eigentlich auch Xenon (nicht so für Helium und Radon) kann man zumindest für bestimmte Isotope Quellen in hydrologischen Zeitskalen ausschließen. Edelgase sind chemisch und biologisch inert und speichern damit Bedingungen bei der Bildung von Grundwasser und geben Aufschluss über physikalische Einwirkungen danach.

Der Kivu-See in Zentralafrika ist ein meromiktischer See (es kommt nie zu einer vollständigen Mischung der Wasserschichten) dessen Tiefenwasser große Mengen an gelöstem Kohlendioxid und Methan enthält (Boehrer et al. 2019). Diese erzeugen einen enormen Gasdruck der möglicherweise das Potential hat, eine limnische Eruption auszulösen. Solche Eruptionen können tödlich sein; wie 1986 als in Kamerun 1746 Menschen in der entstehenden Gasblase aus dem Nyos See erstickten. Im Falle des Kivu-Sees wären ca. 2 Millionen Menschen bedroht. Die jüngsten Ausbrüche des Nyiragongo-Vulkans im Januar 2002 und im Mai 2021 haben die Welt an die prekäre Situation erinnert: Magma, das mit dem tiefen Wasser des Kivu-Sees in Kontakt tritt, könnte zu einer lokalen Erwärmung und zur Bildung von Blasen führen, die im schlimmsten Fall einen großen Anteil der gelösten Gase freisetzt. Darüber hinaus wurden starke Erdbeben und große Erdrutsche als externe Faktoren genannt, die zu einer limnischen Eruption des Kivu-Sees führen könnten, da sich der See im Boden eines jungen seismisch aktiven Grabens befindet. Sollte ein großer Anteil der gelösten Gase aus dem Tiefenwasser entwichen sein, kann man das an Hand von fehlenden Edelgasen detektieren. In der Tat ergaben Messungen (Bärenbold et al. 2020) dass Edelgase fehlen.

Niedrige Edelgaskonzentrationen sind also zunächst ein Hinweis auf stake Ausgasungsvorgänge, es könnte aber auch ein Temperatureffekt verantwortlich sein. Durch die Messung mehrerer Edelgase kann man die Effekte quantitativ separieren. Wir haben daher durch Messungen Löslichkeiten von Edelgasen bei höheren Temperaturen bestimmt und neue Löslichkeitsfunktionen generiert, die auch für Temperaturen über 35°C gültig sind (Schwenk et al. 2022a). Wir haben diese verwendet um Edelgasthermometrie (Siehe Aeschbach-Hertig and Solomon 2013) an den Messungen im Kivu-See durchzuführen. Temperaturen lassen sich dann über (1) Sättigung, (2) Konzentrationsverhältnisse und (3) Kleinste-Quadrat-Approximation bestimmen. Letztere erlaubt Gaseinschluss und liefert damit einen quantitativen Hinweis auf Ausgasung. Übereinstimmend liefern die einzelnen Ansätze (Schwenk et al 2022b), dass sich das Tiefenwasser bei ca. 65°C mit der Atmosphäre äquilibriert hat. Das bestätigt die Vorstellung, dass das Tiefenwasser des Kivusees durch Grundwasser, das sich unterhalb der Nyiragongo-Vulkans gebildet hat, gespeist wird. Dadurch werden die unterschiedlichen Anteile der fehlenden Edelgase quantitativ erklärt. Ein Hinweis auf eine großskalige Ausgasung ergibt sich aus den fehlenden Edelgasen danach nicht.

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Vorträge

S03: Responses of aquatic ecosystems to anthropogenic stressors

Sensitivity of Invasive round goby and native European perch to anthropogenic stressors

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Salinity and temperature are influential abiotic environmental factors in aquatic species. In freshwater, salinization is one major cause of ecosystem degradation and temperature is changing globally. Both of these factors can be affected by anthropogenic activities, and this is also occurring in the River Rhine with for instance mine water emission. Salinity and temperature also have impacts on both behaviour and physiology, and thus could affect freshwater fishes. Therefore, we investigated how salinity and/or temperature affected ecological relevant behaviour, oxygen consumption, and stress physiology in European perch and round goby. Our results are confirming that the behavioural effects of salinity and/or temperature can be species-specific, and that to some extent the species have diametrically different responses. Further, the sensitivity for salinity and/or temperature differs between European perch and round goby.

A6: Nebiota und invasive Arten

Quagga mussel invasion in Lake Constance: implications for the fish community

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Since its first appearance in Lake Constance in 2016 the invasive quagga mussel *Dreissena rostriformis bugensis* has come to dominate the mussel community and now occurs in hyperabundant densities over the whole lake bottom. A lake-wide field study was conducted between 2019 and 2020 to obtain a systematic insight into the importance of this novel source of potential prey for the native fish community. In total 664 fish of 20 different species were caught and their digestive tracts were analysed. Furthermore, to evaluate the actual impact of quaggas on the local food web of Lake Constance, the stable isotope compositions of pelagic whitefish and different benthic fish species from before and after the quagga invasion were compared.

The results show that nearly all benthivorous fish are able to forage efficiently on quaggas, especially roach (*Rutilus rutilus*) and tench (*Tinca tinca*) show high levels of quagga consumption. In the case of one keystone species with very high commercial interest, the benthic whitefish *Coregonus spp.*, quagga consumption is more limited as only individuals larger than 35 cm consumed quaggas in relevant amounts. Pelagic whitefish (*Coregonus wartmanni*) still feed exclusively on pelagic zooplankton, however, a significant increase in d13C was detected in pelagic whitefish one year after the establishment of the quagga mussel in the lake. Therefore, this change was most likely the consequence of an increase in benthic-derived nearshore primary production and a shift towards more littoral feeding, than a change in dietary composition. Furthermore, differences in d15N from periods before and after the quagga invasion were found in other fish species. The results suggest that energy sources and pathways have changed considerably for both pelagic and benthic dwelling fish species in Lake Constance following the establishment of quaggas.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Exposure to environmental stressors decreases the resilience of river microbial communities towards invasion by alien resistant bacteria

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When wastewater treatment plant effluents are released into rivers, the river microbiome gets exposed to high loads of antibiotic resistant bacteria (ARB) along with complex mixtures of abiotic pollutants acting as stressors.

To understand the proliferation of antimicrobial resistance (AMR) it is crucial to determine the factors that govern invasion of ARB into the river microbiome. Consequently, we here aim at elucidating how the resilience of the resident microbial communities against invasion by foreign ARB is affected by co-released stressors.

To achieve this, natural river biofilms were grown on glass slides in two pristine German rivers for 1 month. Biofilms were then transferred to laboratory recirculation systems filled with sterile river water and exposed them to a single pulse of the fecal model strain *E. coli* hosting a conjugative AMR plasmid for 14 days. Experiments were carried out in the presence or absence of Cu^{2+} at environmentally relevant concentrations to determine how stress exposure affects the community resilience against invasion by ARB.

There was clear evidence of initial invasion of E. coli into the biofilms with no significant differences in invasion success between the stress and the control treatment. After the initial invasion, the relative, as well as the absolute, abundance of *E. coli* in the biofilm steeply decreased with time in the control. However, in presence of Cu^{2+} *E. coli* not only established itself long-term but even increased in abundance over time. This was directly correlated with a significant decrease in the diversity of the biofilm community when exposed to Cu^{2+}. The observed dynamics were consistent across the two tested rivers.

In conclusion, we demonstrate that the intrinsic resilience of the river microbiome towards invasion by ARB is strongly linked with maintaining diversity and that co-exposure to stressors that disrupt community diversity and structure increases long-term invasion success.

S08: Plankton ecology

Oligotrophication and fish invasion effects on Bosmina trait dynamics

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Bosmina is a classic example of cyclomorphosis caused by, for instance, seasonal changes in traits such as antennulae and mucro lengths. While these changes have been examined in many different lakes in individual study years, there are hardly any studies which examine interannual variability in trait dynamics and their response to environmental changes. Here, we study changes in population and trait dynamics of Bosmina species during three decades of oligotrophication and a recent invasion of sticklebacks in peri-alpine Lake Constance. Bosmina was highly resilient to environmental changes, the genus declined hardly with oligotrophication, and increased with the stickleback invasion. We show that Bosmina species have large trait changes partially during oligotrophication and rapidly with stickleback invasion. With the invasion of the sticklebacks, residual mucro size of Bosmina had rapidly decreased. In addition, the responses of Bosmina species with the invasion in terms of residual antennule size and residual antennule curvature were highly variable and different – while residual antennule size decreased, the residual antennule curvature increased and then started to decrease again. Similarly, a large change shift on the size at maturity of bosminids after the invasion was observed. There also seems to be a rapid species turnover within Bosmina species with invasion and this shift between different Bosmina species results to changes in traits. However, it is still unclear to which extent these trait changes result from, Bosmina species change or selection on traits.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Auswirkung reduzierter Talsperrenabgaben auf die Gewässergüte im Ruhr-Einzugsgebiet

Karin Banhold; Daniel Teschlade

Ruhrverband Essen

Das 4.500 km² große Einzugsgebiet der Ruhr mit fünf Stauseen und acht Talsperren versorgt 4,6 Millionen Menschen sowie Gewerbe- und Industriebetriebe mit Trink- und Brauchwasser. Der Ruhrverband ist gesetzlich verpflichtet, aus den Talsperren Wasser abzugeben, sodass vorgeschriebene Mindestabflüsse nicht unterschritten werden, um genannte Versorgung sicherstellen zu können. In Dürrezeiten sieht das Gesetz die Möglichkeit vor, auf Antrag diese Mindestabflüsse zu reduzieren. Hiervon hat der Ruhrverband in den letzten Jahren mehrfach Gebrauch gemacht. Auf diese Weise konnten die Wasservorräte in den Talsperren geschont und krisenhaften Entwicklungen entgegengewirkt werden.

Doch wie wirkt sich die Reduzierung der Mindestabflüsse auf die chemisch-physikalischen Parameter aus? Sind Flora und Fauna durch deren Veränderung gefährdet? Diese und weite-re Fragen wurden im Rahmen des Projekts „EKlima“ (Erhöhung der Klimaresilienz des Ruhr-verband-Talsperrensystems durch Anpassung des Ruhrverbandsgesetzes) mit Hilfe des Ge-wässergütemodells QSim beantwortet.

Die Größe des Betrachtungsgebietes gibt hier eine Dreiteilung des Modells vor: (1) Das Modell der oberen Ruhr mit knapp 100 km Fließweg, (2) das Modell der unteren Ruhr mit knappen 90 km Fließlänge und (3) das Modell des Nebenflusses Lenne mit rund 70 km Gewässerlän-ge. Untersucht wurden drei Kalenderjahre (2018 bis 2020), die durch eine besondere Tro-ckenheit gekennzeichnet waren. Als Eingangsdaten stehen real gemessene Werte zur Verfü-gung, welche die Topografie der Gewässer, die Hydraulik, die Wetterlage und die Gewässer-güte abdecken. Um den Einfluss reduzierter Mindestabflüsse zu untersuchen, wurde dieser Zeitraum abermals modelliert, allerdings mit verringerten Abgaben aus den Talsperren. Diese wurden so verändert, dass an den vorgenannten Pegeln ein um 3 m³/s verringerter Min-destabfluss erreicht wird. Die Unterschiede dieser beiden Modellierungen wurden verglichen und der Einfluss auf die Gewässergüte ermittelt. Die Ergebnisse wurden aufbereitet und zur nachfolgenden Interpretation auf unterschiedlichste Weise grafisch dargestellt. Die Ergebnisse und deren Darstellungsformen werden vorgestellt und diskutiert.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Herleitung des Maßnahmenbedarfs zur Schaffung funktionsfähiger Lebensräume für die Fischfauna in den Fließgewässern Baden-Württembergs

Andreas Becker

Andreas Becker - HYDRA Wiesloch

Um in unseren Gewässern den guten Zustand nach der EG-Wasserrahmenrichtlinie zu erreichen, ist insbesondere die Verbesserung der Gewässerstruktur zur Wiederherstellung der Lebensraumfunktion ein wesentlicher Baustein. In Baden-Würt¬tem¬berg wurde im Rahmen der sog. Landesstudie Gewässerökologie unter Federführung der Geschäftsstelle Gewässerökologie** ein landeseinheitliches Vorgehen erarbeitet, um den Bedarf an Strukturmaßnahmen unter Berücksichtigung des Strahlwirkungs- und Trittsteinkonzepts zu quantifizieren, zu lokalisieren und zu priorisieren.

Insbesondere in restriktionsgeprägten Gewässerabschnitten, in denen durch anthropogene Nutzung und Veränderung eine naturnahe und eigendynamische Gewässerentwicklung nicht oder nur sehr eingeschränkt möglich ist, wird ein alternativer Planungsansatz verfolgt, in welchem fischökologische Ansprüche im Zentrum stehen. In einer landesweiten Arbeitsgruppe aus Vertretern aller Regierungspräsidien, der Fischerei¬forschungsstelle und externer Experten wurde eine Methode entwickelt, um Defizite an fisch¬ökologisch funktionsfähigen Strukturen zu ermitteln und daraus Konzeptionen für Strukturmaßnahmen abzuleiten. Ziel dieser Herangehensweise ist die gezielte Schaffung funktionsfähiger Fischökotope, um die Lebensraumfunktion und damit das Erreichen des guten ökologischen Zustands der biologischen Qualitätskomponente Fische auf Wasserkörperebene zu ermöglichen. Die Methode beruht auf zwei fachlichen Annahmen:

1) Die hydro¬morpho¬logischen Ansprüche der meisten Arten jeder Referenzfischzönose lassen sich durch die Berücksichtigung einzelner - dies¬bezüglich besonders anspruchsvoller - Arten subsummieren. Hierfür wurden acht Fokusarten ausgewählt: Äsche, Barbe, Nase, Lachs, Bachforelle, Bodensee-Seeforelle, Bachneunauge und Groppe.

2) Die Ansprüche an Teilhabitate in den einzelnen Lebensstadien im Lebenszyklus insbesondere rheophiler Fischarten lassen sich durch die Erfassung von acht funktionalen Strukturen darstellen: „überströmte Kiesflächen“, „flache, strömungsarme Bereiche“, „flach abfallende, angeströmte Bereiche“, „Fließrinnen“, „Rauschen“, „Deckungsstrukturen“, „Feinsedimentbänke“ und „Kolke“. Diese sind dann in ihrem räumlich zusammenhängenden Bezug sowie der jeweils art¬spezi¬fischen Anforderungen an die Aus¬prägung dieser Strukturen zu bewerten. Nur in wenigen Sonderfällen müssen weitere Aspekte berücksichtigt werden.

Diese Methode wird in Baden-Württemberg seit dem Jahr 2019 über die Landesstudie Gewässerökologie an Gewässern I. Ordnung angewendet und mit Praxiserfahrungen sukzessive weiterentwickelt.

Weitere Informationen:

**Geschäftsstelle Gewässerökologie:

https://rp.baden-wuerttemberg.de/themen/wasserboden/landesstudie-gewaesser/

E-Mail: GS.Gewaesseroekologie@rpt.bwl.de

Download: Fischökologisch funktionsfähige Strukturen in Fließgewässern

A3: Grundwasser und Quellen

Spring biodiversity monitoring in protected areas: Molecular tools as a non-invasive supplement to traditional approaches

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Springs are considered highly diverse freshwater ecosystems inhabited by characteristic species assemblages. Due to their insular appearance and specialised species with often limited dispersal abilities, especially alpine springs, are isolated habitats with relatively low genetic interconnection. Therefore, national and local monitoring campaigns exist to assess spring ecosystem integrity over time. Spring assessment methodologies are based on the collection of physicochemical data coupled with faunistic investigations, which, compared to a reference state, provide an overall picture of the ecological status quo of a spring. However, traditional approaches are often based on direct sampling and morphological identification of entire species communities, which can be considered invasive and putatively impact otherwise near-natural habitats. To circumvent these drawbacks, we aimed at developing a non-invasive, additional set of methods, including targeted indicator species detection and metabarcoding of eDNA filtered water samples. Results show relatively good congruence of the newly developed molecular methods with the traditional procedures. They have proven to serve as cost and time efficient complementary approaches circumventing the risk of impacting vulnerable spring habitats. The newly developed techniques are particularly applicable in protected areas with a strong nature conservation focus that regularly implement spring monitoring campaigns.

A2: Seen und Feuchtgebiete

Extreme gas pressures in lakes: the "killer" Lake Nyos (Cameroon) and Guadiana Pit Lake (Spain)

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Several lakes show extreme loads of gases in their deep water. In most cases, volcanic sources are responsible for the high gas charge but also geochemical processes and decomposition of organic material have created gas loads of concern. We report, how reliable measurements of extreme gas loads could be accomplished [1]. In the case of Lake Kivu 40 billion m³ of exploitable methane could be substantiated, while in Guadiana Pit Lake carbon dioxide loads of nearly 3 liters of gas per liter of lake water were detected [2]. We report about possibilities to confirm high gas loads by direct measurements of gas pressure or sound speed [3]. In the case of Guadiana Pit Lake, authorities followed the recommendation to remove the gas load artificially to avert the danger of a limnic eruption [4], while in the case of Lake Kivu prescriptions for the survey of the lake have been issued by an international expert team for the period of methane exploitation.

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S07: DNA-basierte Erfassung von biologischen Qualitätskomponenten für Wasserwirtschaft und Naturschutz

Assessing eDNA sampling for macroinvertebrates on species to index level

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Aquatic ecosystems are subjected to anthropogenic pressures that cause unprecedented loss in habitats and associated communities. In river systems, macroinvertebrate communities have served as indicators for assessing anthropogenic pressures. To understand changes in these bioindicator groups, a standardized way to assess long-term trends across large scales is fundamental in order to disentangle drivers and effects of change. Here, we used environmental DNA sampling to assess macroinvertebrates across more than 90 river sites in diverse biogeographic regions and compared this approach with pairwise sampled kick-net data. Local diversity patterns were not congruent across the taxonomically broad group, but the eDNA based community composition still successfully predicted a biotic index for water quality monitoring for the majority of the river sites (~72 %) . Furthermore, we show that a refinement of the degenerate metabarcoding approach with a primer pair targeting a narrower group of organisms improves not just the taxonomic assignment of said groups, but further increases the comparability with the routine kick-net monitoring. Especially the comparison on a species level for the highly indicative insect orders of Ephemeroptera, Trichoptera and Plecoptera indicated that each approach detects a distinct set of species. Thus, the combination of molecular and traditional approaches gives a complementary, and more comprehensive, perspective on aquatic communities. We conclude that methodological refinements in the eDNA metabarcoding approach can improve the assessment of macroinvertebrate patterns depending on the indicator group of interest, which is useful for their implementation in biotic indices.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Multiple stressor effects of deposited fine sediment, increased salinity and reduced flow velocity on the transcriptomic landscape of *G. fossarum*

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Freshwaters are exposed to multiple agricultural stressors, leading to habitat degradation and declining biodiversity. Agricultural stressor effects are difficult to predict as they can yield complex interaction patterns, which are mediated through food web interactions. Stressor exposures can result in decreased species densities and community shifts towards more tolerant taxa, but changes in abundances may require time. In contrast, changes in gene expression constitute an immediate physiological response of an organism to its environment. In the presented study, transcriptome-wide sequencing data was used to quantify single and combined effects of fine sediment deposition, increased salinity, and reduced flow velocity on the transcriptional activity of the amphipod *Gammarus fossarum* in a mesocosm field experiment with a 2x2x2 factorial design. Across all treatment combinations, 4,048 genes were differentially expressed. Stressor exposure resulted in a strong transcriptional suppression of genes involved in metabolic and energy consuming cellular processes, indicating that *G. fossarum* reacts with energy allocation to vitally essential processes. Considering single stressor effects, fine sediment deposition induced the strongest transcriptional response, followed by increased salinity, and reduced flow velocity. However, the sediment induced expression profile was less pronounced when other stressors coincided. These compensatory patterns are consistent with abundance data of gammarids, which preferred experimental mesocosms with elevated sediment loads under reduced flow. Further, no evidence for salinity effects were found based on abundance data, contrasting the gene regulatory response patterns: in fact, the strongest differential expression was detected when salinity was increased and flow velocity reduced. Salinity treatments affected the expression of ion transporter genes which control the membrane permeability of sodium, potassium or chloride and maintain ionic hemolymph composition. Our findings imply that transcriptomic data can be used to detect stressor effects that similarly propagated to higher ecological levels, but additionally uncover effects which are not reflected in abundance data.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Long-term monitoring of a heterogeneous karstic stream: Effects of hydrological changes through time on benthic diatom communities

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Non-perennial rivers and streams are widely spread. Through the effect of increasing frequency and severity of droughts, more rivers and streams might be affected, even in temperate climates. Many studies have addressed the effect of drying on higher trophic levels, but the understanding on the effects of drought on primary producers has been underrepresented. In this study, we aimed to identify changes of benthic diatom biodiversity and community composition, as well as the photosynthetic activity of the biofilm in a drying and connectivity gradient. Two samples per year have been taken since 2020 at the karstic, naturally non-perennial Menne stream, to appraise the diatom community using digital microscopy (see presentation Michael Kloster). A total of six sites was sampled in a drying gradient and divided into one of three categories: pools, dry and flowing sites. The diatoms were processed and identified in triplicates. Results show that through the loss of connectivity and the creation of new ecological niches the local (α-) diversity increased in the pool sites and decreased at dry location. Diatom communities had a longitudinal gradient in species composition. Biomass as measured by photosynthetic activity was highest in pools of the spring in comparison to autumn samplings. This increase in biomass correlated with increased proportions of cyanobacteria. This study shows that drying reduces benthic diatom biodiversity and homogenizes the diatom community. The time series is the baseline for a current investigation of the benthic community of several natural non-perennial karstic streams.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Trait and compositional succession in natural phytoplankton communities

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The PEG (Plankton Ecology Group) model describes the seasonal succession of phytoplankton in a typical temperate lake. The model predicts the influence of abiotic (environmental changes) and biotic (e.g., grazers) factors on abundances and species composition over a season. The model uses taxonomy to describe the phytoplankton dynamics, but misses information on the ecological functions and properties of the community. Here we present our study aiming to integrate changes in the community function due to the compositional succession into the PEG model by exploring the relationship between traits and composition. For this, we chose different temperate lakes and combined analyses of data on phytoplankton functional traits and their distribution with diversity analyses. Specifically, we used eco-physiological traits to explore the community functional properties and decomposed beta diversity into turnover (species replacement) and nestedness (species gain/loss) to comprehend better community diversity and the processes behind the observed patterns. Coupling the two approaches, we could identify the relationship between the assemblage heterogeneity and the functional heterogeneity in a community and found that compositional changes not always translate to functional changes at the community level. The analysis showed that traits and their distribution can explain community dynamics in response to environmental and temporal gradients. Finally, our approach allowed us to reveal deviations from the predicted dynamics of the PEG model for some lakes.

A6: Nebiota und invasive Arten

Massnahmen gegen die Einschleppung von Neobiota am Hallwilersee: Reinigungs- und Kontrollpflicht für Boote

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Invasive Neobiota werden oft unbemerkt mit Booten, Wassersport- oder Fischereimaterial von einem Fluss oder See zum nächsten verschleppt. Wenn eine invasive Art in einem Gewässer einmal eine stabile Population etabliert hat, ist sie meistens nicht mehr einzudämmen und es können grosse Schäden an Ökosystem und Infrastrukturanlagen entstehen. Die zurzeit problematischste Art, deren Einschleppung in den Hallwilersee befürchtet wird, ist die Quaggamuschel (*Dreissena bugensis*). Die Süsswassermuschel hat im Bodensee, in einigen Westschweizer Seen, im Rhein und in der Aare bereits dichte Bestände gebildet.

Der Kanton Aargau hat basierend auf der schweizerischen Freisetzungsverordnung (FrSV, Art. 52) und dem Gewässerschutzgesetz (GSchG, Art. 3) ein gesamtheitliches Massnahmenkonzept gegen die Einschleppung der Quaggamuschel und anderer Neobiota in den Hallwilersee ausgearbeitet und setzt dieses nun um. Für das Konzept wurde eine Beobachtungsliste mit 20 Arten erstellt und mögliche Einschleppungspfade analysiert. Das grösste Risiko für eine Einschleppung von invasiven Arten sind Schiffe, die längere Zeit im Wasser liegen. Zum ersten Mal in der Schweiz wurde 2021 eine Reinigungs- sowie Kontrollpflicht für Boote eingeführt. Halterinnen und Halter müssen ihr Boot nach dem Aufenthalt auf einem anderen Gewässer sachgemäss reinigen. Diejenigen mit einem Wasserliegeplatz müssen es vor dem Einwassern zusätzlich kontrollieren lassen. Die Betreibenden der Einwasserungsstellen wurden durch den Kanton per Verfügung verpflichtet, diese Gruppe von Booten zu kontrollieren. Sie dürfen nur Boote einwassern lassen, die frei von Neobiota sind. Die Betreibenden von kommerziellen oder gemeinschaftlichen Bootsstegen wurden zudem verpflichtet, die Reinigungs- und Kontrollpflicht in ihrem Stegreglement zu verankern.

Eine Informationskampagne, welche vorwiegend auf Bootsbesitzer aber auch auf Taucherinnen, Angler, und Wassersporttreibende ausgerichtet ist, macht auf wichtige aquatische invasive Arten aufmerksam und zeigt Handlungsempfehlungen auf.

Das Massnahmenpaket wurde in enger Zusammenarbeit mit den lokalen Gemeinden, Werften und Vereinen ausgearbeitet und stösst auf breite Akzeptanz. Mittels eDNA-Untersuchungen wird regelmässig überprüft, ob neue Neobiota im Hallwilersee zu finden sind.

S01: Aquatic viruses

Off-target effects in the ecology and evolution of aquatic viruses

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Viruses are one of the most abundant biotic agents in water bodies and are important drivers of community dynamics, affecting host mortality, metabolism, horizontal gene transfer, and nutrient cycling. Like many other members of the microbial community, viruses are not currently considered in ecological risk assessments of chemicals entering water bodies. However, it is likely that the ecological and evolutionary dynamics of viruses are influenced by chemical exposure, for example, by altering infection dynamics and species coexistence of microbial communities. Here, we use a microbial community consisting of a heterotrophic flagellate, a giant virus and a virophage to test if and how Predicted No Effect Concentrations (PNEC) of antiviral exposures impact the microbial community at both ecological and evolutionary levels. Communities were established in chemostats for 50 days (~200 host generations) under three antiviral treatments: control, no exposure; pulse, a single pulse of 0.1 mg/L; and, disturbed, one pulse of 0.1 mg/L every day. We monitored population dynamics and assessed host and virus trait changes. Host, virus and virophage population dynamics and ratios changed depending on antiviral exposure. Host population traits diversified from ancestor populations used to start the experiments, suggesting that they evolved during the experiment. Specifically, clonal populations of the host isolated from the end of the experiment survived virus infections. This was most pronounced for those isolated from the disturbed treatments where virus pressure was expected to be lower due to antiviral exposure despite of the virus selection pressure being similar as in the pulse treatment based on virus densities from both communities. Virus and virophage trait changes are still under study.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Auswirkungen eines Extrem-Hochwassers im Juli 2021 in Hagen (Westfalen) auf die Hydromorphologie und -biologie

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Am 14./15. Juli 2021 kam es zu einem Extrem-Hochwasser an der Volme und ihren Nebengewässern sowie zwei Nebengewässern der Lenne im Stadtgebiet Hagen. Vorausgegangen waren anhaltende Starkregen mit lokal bis zu 250-285 mm Niederschlag in 21 h. Es kam zu katastrophalen Schäden und Zerstörungen an Ufermauern, Brücken, Straßen, Eisenbahnlinien, Versorgungsleitungen und -einrichtungen, Gewerbe- und Industriehallen sowie an Wohngebäuden. Daneben wurden durch das Extrem-Hochwasser neue Strukturelemente in und an Fließgewässern geschaffen. Da im Volme- und Lenne-Einzugsgebiet die Gewässer-Typen 5 und 9.1, „Grobmaterialreiche, silikatische Mittelgebirgsbäche“ bzw. „Silikatische, fein- bis grobmaterialreiche Mittelgebirgsflüsse“ vorherrschen, kam es hier zu umfangreichen, kilometerweiten Sedimentverlagerungen der vorherrschenden Kornfraktionen Kies, Schotter und Steine. Durchlässe und Brückenbauwerke wurden daher teilweise komplett mit Sohlsubstrat und Treibgut verklaust oder sogar zerstört. Es kam in gefällereichen Gewässerabschnitten zu massiver Sohlerosion bis auf das Grundgebirge. Es stellten sich vor allem an Nebengewässern nahezu Gebirgsbach ähnliche Initialzustände ein, mit von jedem Aufwuchs befreiten Substraten. Es wurden umfangreiche Tiefrinnen (> 1 m), Auskolkungen, Ufer- und Inselbänke, Schnellen und Rauschen, Steilufer, Sturzbäume, Umlaufbäume, Totholzansammlungen etc. geschaffen. Es kam zu Gewässeraufweitungen und Laufverlagerungen bzw. -verzweigungen sowie zu umfangreichen Aufschotterungen.

Die neu geschaffenen Gewässerstrukturen haben für eine (temporäre) ökologische Aufwertung der vormals oft stark veränderten Gewässer gesorgt, die teilweise im Zuge der Hochwasserfolgenbeseitigung leider wieder entfernt wurden.

Zur Einschätzung des Einflusses des Hochwassers auf die Gewässergüte wurden chemische und biologische Untersuchungen durch das LANUV NRW durchgeführt. Beim Makrozoobenthos ist kein Totalausfall der Lebensgemeinschaft zu verzeichnen, auch wenn die Individuendichte einiger Taxa geringer als üblich erscheint.

Nach bisheriger Einschätzung hat das Hochwasserereignis in der aquatischen Umwelt der betroffenen Region keinen dauerhaften Schaden hinterlassen. Eine befürchtete Ölpest blieb aus. Ebenso konnten erhebliche und akut gefährliche Schadstoffeinträge und -freisetzungen nicht festgestellt werden.

S11: Blue Nature-based solutions: co-benefits for nature and people

Mindscapes and Landscapes: Africa's New Urban Building Culture in A Changing Climate

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In urban Africa, new homes protected or decorated with high built fence walls are in vogue and are the dominant architectural preference in residential areas. The ground in the compound of these walled homes is also mostly sealed with concrete or tiled in ways that alter the surface characteristic and functions in conduction runoff and energy fluxes. This has the tendency to transform the integrity of the natural environmental conditions to perform its natural dynamic functions. This contrasts with the recent past where homeowners used hedges and other nature-based enclosures as well as lawns in their compounds to conduct runoff and to enhance infiltration and percolation of water into sub-surface and groundwater aquifer systems. The transition from the latter to the former, presents opportunities to interrogate the changing mindsets relative to the changing natural land cover attributes, in the dynamic socio-environmental landscapes. From a survey of residents and interview of stakeholders, it becomes bare that this disconnection between society and nature is driven largely by insecurity, privacy concerns, search for modernity and easiness in terms of low cost for management. The practice deviates from a climate-resilient urban developme

S03: Responses of aquatic ecosystems to anthropogenic stressors

Historical environmental DNA to track the establishment and effect of neozoa

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The establishment and effects of neozoa are among the anthropogenic stressors that aquatic systems have been subject to increasingly in the past decades. While especially invasive alien species (IAS) cause considerable upheaval in the structure of biological communities, date on the tempo and mode of their establishment is only available for well monitored systems - and even there will usually be incomplete. Historical sources of DNA, such as lake sediment cores and ethanol-preverved samples, can potentially provide alternative sources of information, but are not used for this to date. Lake Constance is a very well studied system that is routinely monitored, and establishment dates for recent neozoen arrivals are quite well known, making . it an ideal system to evaluate the sensitivity and fidelity of sedimentary DNA to track their establishment.

Using a combination of species-specific reactions and DNA metabarcoding, we investigate the reliability of sedimentary DNA to track the presence of different neozoa in the lake and evaluate these records to investigate their effects on biotic communities. Both surface sediments collected across the lake, as well as sediment core DNA recorded the presence of different neozoa, but with varying sensitivity. For the invasive mussels, *Dreissena polymorpha* and *Dreissena bugensis*, DNA could be recorded in the core, and the records are in good accordance with previously supposed time spans of arrival. Their first occurrences seem to predate the first records by some years, which we are attempting to corroborate using further historical sources of DNA. The effect of the establishment of the invasive mussels on planktonic communities is not unambiguously recorded in the sediment cores, as the time periods coincide with changes in trophic state and temperature. Sediment core DNA can provide a valuable source of information on the tempo and mode of establishment of invasive species in freshwater systems.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Diagnose und Management multipler Belastungen von Fließgewässern mit Bayesischen Modellen

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Die Fließgewässerbewertung ist integrativ, d. h. sie integriert die Wirkungen multipler Belastungen auf die Gewässerbiologie in wenige „Core"-Metrics und final in einen Wert, der den ökologischen Zustand bzw. das ökologische Potenzial beschreibt. Ein Nachteil dieser Integration besteht im Informationsverlust, der es praktisch unmöglich macht, ausgehend von der Bewertung Rückschlüsse auf einzelne, ursächliche Belastungen zu schließen. Diese Lücke kann durch Diagnosewerkzeuge geschlossen werden, die – ähnlich der klinischen Diagnose – zahlreiche Ursachen (Belastungen) mit ihren Wirkungen (biologische Metrics) verknüpfen. In ähnlicher Weise können Ursache-Wirkungsbeziehungen aber auch genutzt werden, um die biologischen Wirkungen von Änderungen der Belastungssituation abzuschätzen.

Bayesische Netzwerke bieten eine Möglichkeit, solche Ursache-Wirkungsbeziehungen zu strukturieren und zu quantifizieren. Sie bilden den Rahmen für probabilistische Modelle, mit denen Wahrscheinlichkeiten von Wirkungen in Abhängigkeit einer oder mehrerer Ursachen berechnet werden können. Die Modellierung kann dabei sowohl von den Belastungen ausgehend in Richtung der Wirkungen (prognostisch) als auch von den Wirkungen ausgehend in Richtung der Belastungen (diagnostisch) erfolgen. Ein wesentlicher Vorteil des probabilistischen Modellansatzes ist es, bei der Modellentwicklung sowohl empirische Daten als auch literaturbasiertes Wissen und/oder Einschätzungen von Expert:innen einbinden zu können. Selbst die Modellentwicklung ausschließlich auf Basis von Expert:innenwissen ist möglich.

Im Vortrag werden Beispiele für diagnostische und prognostische Modellansätze präsentiert sowie deren Anwendungsmöglichkeiten erläutert. Bei den Diagnosemodellen stehen die Identifikation ursächlicher Belastungen sowie ihre hierarchische Einordnung im Fokus. Sie unterstützen damit die Identifikation von Maßnahmen zur ökologischen Verbesserung von Fließgewässern. Die Abschätzung von Maßnahmeneffekten kann dann durch Prognosemodelle unterstützt werden. Mit beiden Modellansätzen können Maßnahmenprogramme stärker auf die individuelle Belastungssituation einzelner Gewässerabschnitte bzw. Wasserkörper abgestimmt werden.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Warm or anoxic? Managing climate effects on drinking water reservoirs

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Global warming is increasing water temperature and lengthening the duration of summer stratification in lakes and reservoirs. Water temperature and stratification are important factors for drinking water production as they influence biogeochemical reactions and thus water quality. Increased hypolimnetic water temperature and longer summer stratification duration can lead low oxygen levels or even anoxic conditions at the end of summer and in consequence sediment release of manganese, iron and phosphorus.

Most drinking water reservoirs have withdrawal structures that allow for an adaptive selection of withdrawal depth that can be used to mitigate -- to some extend -- the impact of global warming. In previous hydrophysical simulation studies it was possible to quantify the impact of selective withdrawal on water temperature and stratification duration, but only few studies analyzed the impact on hypolimnetic oxygen and phytoplankton development directly. Using a custom biogeo-chemical model coupled to the hydrophysical lake model GOTM we compared the impact of four different selective withdrawal strategies onto oxygen concentration and phytoplankton dynamics of the German drinking water reservoir Eibenstock.

The coupled model was able to reproduce water temperature and stratification patters and after calibration also water quality variables. To take the uncertainty of the model parameters into account we used an ensemble of 10 different parametrizations to simulate the withdrawal strategies. The impact of the withdrawal strategies on physical structure is in line with previous studies. For the water quality variables we see a distinct effect of the withdrawal strategy on simulated oxygen concentrations and a weaker effect on phytoplankton biovolume. Our results confirm previous studies that showed a management trade off between saving cold hypolimnic water for drinking water production and preventing low oxygen concentration.

S09: Auen

Ongoing gene flow in riparian plant metapopulation at the catchment scale

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River alterations for natural hazard mitigation, gravel excavation and hydropower resulted in habitat fragmentation for riparian plant species. Connectivity between populations along rivers helps to counteract species loss, and genetic analyses reveal if metapopulation networks are still functionally connected. In this study, we analyzed the metapopulation structure of the endangered riparian shrub species *Myricaria germanica* along the river Isel, which is part of the Natura 2000 network, and its tributaries. The use of 22 microsatellite markers allows to assess the role of tributaries and single populations as well as gene flow up- and downstream.

The analysis of 1307 individuals from 45 sites shows the influence of tributaries to the genetic diversity at Isel, with ongoing bi-directional gene flow and no overall isolation by distance. The genetic pattern at the mouth of river Schwarzach into Isel and shortly thereafter river Kalserbach indicate that geographically close populations remain connected. The tributaries can form important refugia for M. germanica in the dynamic riverine network, e.g. during extreme flood events at Isel. Still, genetic diversity in some populations show signals of population declines and high inbreeding. Conservation measures should focus on sufficient habitat along tributaries of various size allowing the pioneer plants to find refuge during extreme events in the main channel, especially as floods are expected to be more frequent under changing climate.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Food quality impacts on life history traits of a freshwater calanoid copepod

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The nutritional quality of phytoplankton is essential for the fitness of herbivorous zooplankton and for efficient carbon fluxes in pelagic ecosystems. In freshwater lakes, cladocerans and calanoid copepods are the main pelagic herbivores in terms of both numbers and grazing impact. However, most studies focused on the easily cultivable cladocerans, while only few studies addressed the impact of the diet on freshwater calanoid copepods due to their more complex life cycle. We here supplied five different phytoplankton diets to the freshwater calanoid copepod Eudiaptomus sp. to investigate their dietary quality for the copepods' fitness traits over the copepod's entire life cycle. While all tested diets supported comparable reproductive success in adults, egg production, hatching success and survival rate differed markedly between diets. In the offspring generation, diet affected developmental and reproductive periods, size at first reproduction and clutch size. Eudiaptomus body fatty acid composition only partially reflected their diet, indicating that the copepods are able to selectively accumulate and interconvert certain essential fatty acids. This capability may allow them to cope with nutritional deficiencies and may thus be interpreted as an ecological adaptation strategy to the fluctuating environmental conditions and resource availabilities in freshwater plankton.

A1: Aquatic Ecotoxicology

Microphytobenthos in small agricultural streams: Community structure and Pollution induced community tolerance

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Microphytobenthos is used as a biological quality element and indicator in the EU Water Framework Directive. Microalgae, growing in biofilms are ubiquitously present in water bodies and contribute significantly to aquatic ecosystem functions and services. Pollution may affect river systems as microphytobenthos may be affected by toxic pollution. The goal of this study was to investigate pollution-induced community tolerance (PICT) and changes in community structure in microphytobenthic communities induced by chemical mixtures characteristic for agricultural landscapes.

The study used biofilms grown in situ for 4 weeks on artificial substrate at 10 streams in agricultural areas. They were subsequently used for short-term exposure laboratory experiments to determine community tolerance. The diatom community on artificial and natural substrate was assessed by metabarcoding, where the sequencing data was further processed using the DADA2 pipeline. The chemical exposure within the stream water and the biofilm was measured using LC-HRMS, where extraction was performed using i.a. the QuEChERS method.

Biofilm communities from agricultural streams were found to be up to 20 times more tolerant to pesticides than those from reference streams in 9 out of 10 agricultural sites. The differences in diatom community structure were investigated regarding the different pollution loads within the biofilms. Further, a methodological comparison of diatom community structure on artificial vs. natural substrate was performed.

These results illustrate that microphytobenthos as an essential component of the EU Water Framework Directive allows the parallel detection of chemical exposure and its biological effects on community structure by metabarcoding and tolerance acquisition.

S06: Coupling biofilm biodiversity and biogeochemistry with habitat heterogeneity across spatio-temporal scales

The microbial community composition of corrosive biofilms in German waterways

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Biofilms on hydraulic structures can cause serious corrosion processes, whereby corrosion is often severely accelerated by the microbial activity (microbially influenced corrosion, MIC). Within the project “RimiK” (risk factors and indicators of microbially induced corrosion), we characterized rust biofilms occurring on steel structures like bollards, lock gates and sheet pile walls in German waterways using biogeochemical and microbiological analysis. We sampled rust tubercles from different water lock sites for DNA extraction and 16S-Amplicon-Sequencing to characterize and compare the microbial community between and within sites. Additionally, we characterized the rust tubercles themselves for their carbon and sulfur contents and the surrounding water chemistry at each site.

The tubercles are characterized by strong geochemical gradients in pH, redox potential and O_2, strongly differing from the surrounding environment. The geochemical gradients within tubercles are reflected in their microbial community composition. With this new dataset covering ~10 sites in Germany, we compare the microbial community composition between and within sites to investigate whether there is a common core microbial community and to identify microbial key players within the tubercles. Furthermore, we correlate the water chemistry such as nutrient concentration, pH and conductivity to investigate what drives the pattern in the microbial community composition. The overall objective is to identify risk factors for MIC in order to use this knowledge to make the maintenance of hydraulic steel structures on German waterways more efficient in the future.

S02: Aquatic Symbioses – different forms of interactions, context-dependence and consequences for population and community dynamics

About the symbiotic nature of *Paramecium bursaria* and Choricystis – the role of the symbiont

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Behavior, frequency, and distribution of ciliates are often influenced by their interactions with e. g. prokaryotic or eukaryotic symbionts. Even though the symbiont's role and contributions are important factors influencing the realized ecological niche of such associations, they are still inadequately understood. Paramecium and its diverse symbionts are a suitable model system to address eco-evolutionary consequences and questions regarding the nature of symbiotic associations. Analysing *P. bursaria's* algal symbiont diversity, an additional alga was observed co-occurring with the microalgal photobionts *Micractinium conductrix* respectively *Chlorella variabilis*. Previously shown, this additional alga, namely *Choricystis parasitica*, possesses the ability to form an intimate long-term relationship as intracellular symbiont to P. bursaria. Nevertheless, knowledge about the nature of this association is still sparse. By combining molecular analysis with quantative photoaccumulation experiments, comparative growth assays, and differently designed infection experiments, we aim for insights regarding the character of this symbiosis and to determine its place within the mutualism-parasitism continuum. It also provides the opportunity for an additional perspective to the observed occurrences of such associations in the environment. After elimination of the original photobiont and subsequent infection with Choricystis, the newly symbiotic paramecia show an increased fitness compared to their aposymbiotic counterparts. Cell density levels as high as for the original symbiotic cells were not observed. A similar pattern occurs with the photoaccumulation assays. Even though statistically significant more Choricystis-infected than aposymbiotic cells accumulated in illuminated areas, the number of light attracted newly infected cells was significantly lower than for the original symbiotic *P. bursaria*. Thus, our data allow us to characterize this symbiotic association between P. bursaria and Choricystis as at least commensalistic. Furthermore, our findings support previous work on photoaccumulation in P. bursaria, showing this trait as an adaptive strategy to maximize benefits gained from living in symbiotic association with green algae.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Phenotypic Plasticity and Community Functions

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Environmental changes caused e.g. by the anthropogenically driven climate change, land use alterations, pollution or invasions of alien species have major implications for local communities. Changes in species abundance, population distribution and species loss have been observed, all of which affecting composition and functions of communities, with possible consequences for the entire ecosystem. To survive, organisms have to be able to maintain their individual fitness by adjusting their functional traits; those characteristics of organisms that have a strong impact on their fitness (growth, reproduction, survival). One fundamental mechanism to adjust functional traits is phenotypic plasticity, which is defined as one genotype or individual expressing different phenotypes in response to environmental differences. Phenotypes may be expressed across generations or as morphological shifts during the lifetime of an individual. Phenotypic plasticity is a well-known phenomenon. Other than trait diversity exhibited from interspecific and intergenotypic differences, however, trait diversity arising from phenotypic plasticity and its potential importance for community properties and ecosystem functioning and resilience is currently understudied. To fill this gap, we investigate the diversity of phenotypic plasticity on the basis of plankton communities. We compare the extent of trait variability due to plasticity to that from variability among species and clones, and discuss the relevance of phenotypic plasticity for the functioning of aquatic ecosystems.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Spatial heterogeneity in Lake Constance: Changing in underwater lakescape shaped by submerged macrophyte composition in the last decades

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The littoral vegetation of Lake Constance was subject to severe changes in recent decades as a result of trophic fluctuations. Their importance for creating diverse spatial habitat structures and linking different ecological functions like fish and invertebrate shelter, but also for nutrient sink and bank protection is already known.

Areal macrophyte polygon data of 1967, 1978 and 1993 in parts of Upper and Lower Lake Constance was analysed and compared with recent data. For the analysis of spatial heterogeneity, selected landscape metrics (edge, shape, area) were calculated with GIS based on a classification by plant growth form and height as well as leaf shape.

Charophyte structure classes are increasing both in area and in total edges, especially since 1993 in both parts of the lake. A more differentiated picture emerges for the structural classes broad-leaved and narrow-leaved elodeids: In terms of surface area, the former have in the Lower Lake (98% compared to 1993), whereas in the Upper Lake they have risen to the level of 1967. The latter show a

decrease of 59.8% in the Lower Lake and 8.6% in the Upper Lake compared to 1993. Analyses on shape and edge metrics indicate that tall vertical macrophyte structures are more fragmented compared to 1967 and 1978.

This shows that the heterogeneity of the lakescape provided by macrophytes increased with the re-oligotrophication and demonstrates the usefulness oflandscape metrics for monitoring of aquatic ecosystems.

S08: Plankton ecology

Depth preferences of european catfish (*Silurus glanis L.*) in a deep pre-alpine lake.

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Climate change is suspected to have an important influence on non-native species dynamics. Increasing temperatures, changed precipitation, and altered runoff can facilitate their spread and establishment: creating new opportunities for them to become invasive. In several european countries such as Spain, Italy and France the wels is considered invasive. The wels catfish is a species that generally benefits from climate change because it´s reproduction and feeding behaviour are positively temperature dependent. In recent years there has been a sharp population increase and spread of the european catfish in German waterbodies as well. The impact of this trend on the native fish community, however is still unknown. Their seasonal behaviour for example has hardly been researched at all. In summer many prey fish species migrate to deeper water layers. Whether the catfish follow those movements or if they overwinter there during colder months when they are inactive is still unknown. Therfore the project investigates which depths the catfish prefer during the course of the year in Lake Constance using depth-loggers. These record the ambient water pressure and temperature. Temperature and depth records, combined with stomach content analysis, will then be used to assess the risk of certain pelagic species, such as whitefish (*Coregonus wartmanni*) and arctic char (*Salvelinus alpinus*) to predation by catfish. In addition, adaptation to new habitats will be studied. Furthermore to better understand the role of introductions, tagged catfish from tributaries of Lake Constance will be translocated in to the lake and vice versa, to investigate catfish depth preference in new habitats.

S08: Plankton ecology

Mysterious ciliates: seasonally recurrent and yet hard to predict

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Ciliates consume approximately 50% of the primary production and thus represent a crucial link between phytoplankton and bacteria and mesozooplankton in pelagic food webs, but little is known about the processes influencing the dynamics of individual species. Using 12 years of long-term, high frequency observations, we compared the diversity and temporal variability in biomass and species composition of the ciliate community in large, deep, mesotrophic Lake Constance to that of the phytoplankton and rotifer communities in the same lake. Furthermore, we used boosted regression trees to evaluate possible environmental predictors (temperature, bacteria and different algal prey groups, and daphnids, calanoid and cyclopoid copepods as predators or competitors) influencing ciliate net growth. The biomass of all ciliate species showed a common, recurrent seasonal pattern, often with peaks in spring and summer. The ciliate community was more diverse than the rotifer community, most species exhibited highly synchronous dynamics and numerous species were regularly encountered during the season. The top-down control by copepods likely contributed to the ciliates' synchronized decline prior to the clear water phase when food concentration was still high. The high temporal autocorrelation of the ciliate biomasses together with the inter-annual recurrent seasonal patterns and the low explanatory power of the environmental predictors suggest that the dynamics of individual ciliate species are strictly controlled, yet it remains difficult to determine the responsible factors. This raises the question whether a niche based perspective or one based on neutral theory is more appropriate to understand ciliate community composition and species and community dynamics.

A6: Nebiota und invasive Arten

Verbreitung von Neozoen am Niederrhein – Globale Veränderungen, Klimawandel und Wasserqualität im Spiegel regionaler Datenreihen

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Globale, regionale und lokale Veränderungen der Umwelt haben Auswirkungen auf den Zustand von Gewässern. Veränderungen lassen sich gerade dann gut belegen, wenn langfristige Datenreihen ausgewertet werden können. Das Zentrallabor der LINEG in Moers (NRW) führt seit 1960 Gewässeruntersuchungen im 624 km^2 großen Verbandsgebiet am Niederrhein durch. Seit 1987 werden die Daten systematisch in einer Datenbank erfasst. Dies ermöglicht Veränderungen über einen Zeitraum von mehreren Dekaden auszuwerten.

Gerade der Niederrhein hat im Vergleich zum langjährigen Mittel seit Jahren deutliche Niederschlagsdefizite zu verzeichnen, die sich in den Gewässern mit niedrigen Wasserständen und häufigerem Trockenfallen bemerkbar machen. Die letzten Dürrejahre trafen die Gewässer besonders hart. Bäche und Kuhlen waren über viele Monate ohne Wasser oder hatten mit den hohen Temperaturen und niedrigen Sauerstoffgehalten zu kämpfen.

Auswirkungen auf die Lebensgemeinschaft aus heimischen Arten und Neozoen durch den Klimawandel und veränderte chemische Belastungen der Gewässer werden anhand von Beispielgewässern aus dem Tiefland aufgezeigt. Mit der Schließung der Bergwerke ist die Hebung und Ableitung von salzbelasteten Grubenwässern über oberirdische Gewässer seit 2013 nicht mehr erforderlich. Hieraus resultierende drastische Reduktion von Salzbelastungen und klimabedingtes Austrocknen von Gewässern triggern die Invasion von neozoischen Amphipoden. Eutrophierung, Sauerstoffmangel und Temperaturerhöhung vermindern die Biodiversität heimischer Unioniden zugunsten von *Corbicula fluminea*.

Die Folgen des Klimawandels können zu erheblichen ökologischen Defiziten und Einwanderung von Neobiota der ohnehin gestressten Gewässer führen. Fließgewässer mit einem hohen Grad an Resilienz sind deutlich weniger anfällig gegenüber Veränderungen der Umwelt. Retentionsräume in der Gewässerlandschaft, Renaturierungen und weitere Maßnahmen im Kontext der EUWRRL können die Biodiversität fördern und Gewässer resilienter gegenüber den Auswirkungen des Klimawandels machen.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Seasonality of parasitic and saprotrophic zoosporic fungi: linking sequence data to ecological traits

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Zoosporic fungi of the phylum Chytridiomycota (chytrids) regularly dominate pelagic fungal communities in freshwater and marine environments. Their lifestyles range from obligate parasites to saprophytes. Yet, linking the scarce available sequence data to specific ecological traits or their host ranges constitutes currently a major challenge. We combined 28S rRNA amplicon sequencing with targeted isolation and sequencing approaches, along with cross-infection assays and analysis of chytrid infection prevalence to obtain new insights into chytrid diversity, ecology, and seasonal dynamics in a temperate lake. Parasitic phytoplankton-chytrid and saprotrophic pollen-chytrid interactions made up the majority of zoosporic fungal reads. We explicitly demonstrate the recurrent dominance of parasitic chytrids during frequent diatom blooms and saprotrophic chytrids during pollen rains. Distinct temporal dynamics of diatom-specific parasitic clades suggest mechanisms of coexistence based on niche differentiation and competitive strategies. The molecular and ecological information on chytrids generated in this study will aid further exploration of their spatial and temporal distribution patterns worldwide. To fully exploit the power of environmental sequencing for studies on chytrid ecology and evolution, we emphasize the need to intensify current isolation efforts of chytrids and integrate taxonomic and autecological data into long-term studies and experiments.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Wie langwirkend ist die hohe Phosphorretention von Tagebauseen?

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Die meisten neutralen Tagebauseen (TBS) haben aufgrund bergbaulich bedingter Einträge von Eisen und Aluminium ein hohes Phosphor-Retentionsvermögen. Im Rahmen eines durch die Deutsche Bundesstiftung Umwelt geförderten Projekts wurden empirische Modellansätze entwickelt, die der höheren tolerierbaren P-Belastung besser entsprechen als die herkömmlichen Trophiemodelle natürlicher Seen (z.B. (Vollenweider). Vor dem Hintergrund der Alterung und Reifung der Tagebauseen muss klar definiert werden, unter welchen Bedingungen diese speziellen Modelle gelten, und welche Indizien ein Nachlassen der hohen P-Retention anzeigen, so dass die für natürliche Seen bekannten Modelle für Prognosen der seeinternen P-Konzentration dann auch für TBS entsprechend ihres Reifestadiums genutzt werden sollten.

Anhand der Daten von ca. 30 neutralen Tagebauseen verschiedenen Alters und Daten natürlicher Seen mit unterschiedlichen Fe-Gehalten im Sediment konnte gezeigt werden, dass der bergbaulich bedingte Fe-Eintrag auch längerfristig eine positive Wirkung auf den P-Haushalt der Seen haben wird. In der nachbergbaulichen Phase hat zusätzlicher Fe-Eintrag großen Einfluss auf die P-Retention, auch wenn dieser gering ist im Vergleich zur bergbaulichen Phase. Auch bzw. gerade unter anoxischen Bedingungen werden die Fe-reichen Sedimente ein ideales Milieu für die dauerhafte Festlegung von P in Form von Vivianit bilden. Zudem wird durch reduktive Auflösung von $Fe(OH)_3$ und Re-Oxidation die P-Sorptionskapazität an der Sedimentoberfläche ständig erneuert. Erst wenn der Fe- und P-Kreislauf entkoppelt sind, erkennbar z. B. an Phosphatkonzentrationen etwa > 0,01 mg/l im Porenwasser der obersten Sedimentschichten und entsprechender P-Freisetzung aus dem Sediment sowie intensiver Sulfatreduktion mit Sulfidbildung, ist mit sinkender P-Retention zu rechnen. Dies wurde bisher jedoch bei keinem TBS beobachtet. Für TBS mit langer Wasserverweilzeit und entsprechend hoher Relevanz seeinterner Prozesse mit effektiver P-Sorption im Sediment ist eine Eutrophierungsgefährdung aus externen und internen Quellen daher unwahrscheinlich.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Nachweis natürlicher Reproduktion der stark gefährdeten Flussperlmuschel im sächsischen Vogtland – Erfolg von 20 Jahren Nachzuchtprogramm

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Die Flussperlmuschel (FPM, *Margaritifera margaritifera*) ist eine Schlüssel- und Flaggschiffart und eine der am stärksten gefährdeten Arten Europas. Bis ins 18. Jahrhundert war die FPM im sächsischen Vogtland weit verbreitet und besiedelte 13 verschiedene Bäche mit einer Gesamtlänge von ca. 125 km. Im Verlauf des 19. und 20. Jahrhunderts brachen diese Populationen stark ein, sodass zur Jahrtausendwende nur noch wenige stark überalterte Reliktvorkommen vorhanden waren. Im Rahmen des 1999 gestarteten Artenschutzprogramms wurde schließlich eine Nachzucht der sächsischen FPM-Bestände etabliert.

Nur aufgrund dieses Nachzuchtprogramms konnte die genetische Linie „Weiße Elster“ gesichert und vor dem Aussterben bewahrt werden. Ca. 10 Jahre nach Beginn der Nachzucht, waren keine trächtigen Altmuscheln dieser genetischen Linie mehr im Freiland zu finden und die Nachzucht wurde mit der genetischen Linie „Saale“ aus dem benachbarten Populationsverbund weitergeführt.

In den Jahren 2005 – 2020 konnten ca. 5000 nachgezüchtete FPM beider genetischen Linien im sächsischen Vogtland ausgewildert werden. Die ältesten ausgewilderten Tiere haben nun ein Alter von 15-20 Jahren erreicht und sind damit potenziell reproduktionsfähig.

Mittels Elektrobefischung wurden im Mai 2022 alle Auswilderungsstrecken hinsichtlich des Fischbestandes untersucht. Die gefangenen Bachforellen wurden dabei auf eine Infektion mit Flussperlmuschelglochidien analysiert. In allen Abschnitten konnten infizierte Forellen nachgewiesen werden.

Der Bachforellenbestand variierte zwischen den verschiedenen Auswilderungsgewässern stark, lag aber in allen Gewässern oberhalb des Grenzwertes von 10 Individuen pro 100 m2, der für eine erfolgreiche Reproduktion der FPM als notwendig angesehen wird.

Die Ergebnisse dokumentieren den Erfolg des sächsischen Nachzuchtprogramms und im besonderen Maße die Rettung der genetischen Linie „weiße Elster“, welche ohne die Nachzucht nun vollständig ausgestorben wäre.

S09: Auen

Influence of lateral connectivity on floodplain vegetation along the Elbe river

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Anthropogenic river bed incision disturbs the natural river-floodplain connectivity, which leads to a reduction of natural floodplain areas and thus to a loss of typical floodplain vegetation. However, exactly how differential connectivity affects plant communities and phytodiversity is still poorly understood. Therefore, the influence of connectivity on plant communities is investigated in four areas along the river Elbe determining which abiotic parameter have the highest explanatory share in the differentiation of the plant communities within the ElBiota-project. Two of the areas (Elsnig and Bösewig) are largely disconnected from the Elbe (with strong river bed incision). Two other areas (Schönberg Deich and Jasebeck) in the area of the lower middle Elbe still show relatively good connectivity of floodplain and river (without river bed incision).

Multivariate statistics were used to determine the relation between abiotic variables and vegetation data. The hydrological parameters (e.g. flooding duration, elevation above mean water level), grain size and soil nutrients contributed most to the differentiation of the vegetation data, which is reflected for instance in the vegetation types, the biological-ecological traits as well as the indicator species. Plant composition differed between the areas with low and high erosion and in an ordination it was ordered along the hydrological gradient. In total 239 species were detected that were predominantly in open landscape, with lower total species counts for the erosion areas (183) than for the areas without erosion (198). The erosion areas were also characterized by significantly lower species counts per plot and diversity parameter values than the areas without river bed incision. In trait analysis water level fluctuation indicator species, therophytes, R-strategists, CR-strategists as well as the floodplain section type specific species were less frequent in the plots of areas with river bed incision. This study indicates that disturbed connectivity can affect typical floodplain vegetation

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

A monitoring strategy for the development of gravel pit lakes - adaptations of zooplankton to the occurrence of fish

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In the approval procedure for excavations of gravel, both the future use of the resulting lakes and the detailed recultivation measures have to be specified and are consequently fixed at the very start of the procedure. The ecological development of such newly created water bodies over the decades of excavation is, however, hardly predictable. Thus, considerable discrepancies are likely to develop between the fixed measures and utilisation plans and the real status of the water body regarding nature conservation (e.g., the appearance of endangered species). The present project targets at investigating and analysing this conflict of objectives and finding solutions for its avoidance. One aim is to establish a simple and cost-effective monitoring method to provide continuous data input into a forecast of the future development of such water bodies. Thereby we focus on zooplankton as the central group in bottom-up and top-down processes within lake ecosystems, using the ZooScan, a digital zooplankton image-analyser. We study two gravel pit lakes that were free of fish for about 10 years. In both lakes an ecosystem had established that is mainly characterised by a dense macrophyte vegetation, a zooplankton community with particularly large Daphnia and populations of the protected great crested newt (*Triturus cristatus*). In 2019, fish (*Leucaspius delineatus*) were documented for the first time in one of the lakes. Besides giving details on the project design, first results on possible adaptations of the zooplankton community after the appearance of fish compared to the still fish-free lake are presented.

S08: Plankton ecology

Temperature and species competition drive co-limitation of light and nutrients in phytoplankton

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For phytoplankton, nutrients and light are major resources controlling phytoplankton community structure, biomass and growth. Besides the basic conceptual understanding of resource limitation deriving from Liebig's law of the minimum, multiple resources can interactively affect the response of phytoplankton leading to co-limitation. Temperature is among the strongest drivers affecting phytoplankton metabolism and can therefore influence its resource requirements. In this study, we investigated how light and nutrients interactively influence phytoplankton growth and how temperature impacts this co-limitation. We conducted a gradient experiment with 5 levels of temperatures, light intensities and nutrients each using 3 isolated freshwater phytoplankton species in monoculture. To test whether interspecific competition alters the effects of temperature on co-limitation, we compared single species responses with those from a mixture of all species. All species were co-limited by light and nutrients and showed species-specific shifts between sub-additive and super-additive responses in growth with temperature. This temperature driven co-limitation effect differed between species growing in monoculture to those growing in mixture due to species competition. Our results highlight the importance of temperature in mediating interactions between multiple environmental factors and help to understand how temperature influences the resource requirements in isolated species and the ability to compete for limiting resources within species communities.

S13: Imaging Plankton

The use of machine learning in the classification of algal phenotypes in mixed populations

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Microbes are often used in eco-evolutionary studies, for example to study evolutionary rescue or eco-evolutionary feedback dynamics in predator-prey systems. Tracking the evolutionary changes in such studies still poses the major challenge and hampers advances in the field of eco-evolutionary dynamics. Evolutionary changes are commonly followed by tracking frequency changes of heritable phenotypes within population in response to environmental changes and/or the interaction with other species. The currently available methods for tracking phenotype frequencies are often labour intensive, expensive and/or not available for the study organisms. As most phenotypes can be identified by morphological differences, a combination of imaging and machine learning could provide an alternative. Machine learning has had a resurgence in recent years due to its improved accuracy in object recognition with breakthroughs in neural networks such as deep learning. Ecologist already use machine learning for the classification of phytoplankton species. Here we present extension of this approach for the classification and tracking of phenotypes over time. We used six different isolates of the green algae Chlamydomonas reinhardtii that differ in their morphology and where the traits were heritable. Using image flow cytometry, we collected twenty thousand images per isolate and extracted 192 features values from each image. The features were then used to train neural network models. We compared the accuracy classifying pairs of isolates when training with only those two isolates to a model trained with all six isolates and classifying all six isolates with the model trained with all six isolates. Accuracy was high for all analyses, but decreased from 97% for the paired models, to 91% for the six clone model classifying pairs and 82% classifying all six isolates. Overall, our method is efficient and reliable and can be used also for other phytoplankton species and microbes.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

DECIDE - Entwicklung und Evaluierung eines ökotoxikologischen, wasserrahmenrichtlinienkonformen Bewertungssystems für Fließgewässer

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Weniger als 10% der deutschen Oberflächengewässer erfüllen derzeit den nach europäischer Wasserrahmenrichtlinie geforderten guten ökologischen Zustand. Maßnahmen zur Verbesserung defizitärer Gewässerzustände wie Renaturierungsmaßnahmen oder die Reduktion stofflicher Einträge sind jedoch mit einem hohen Kosten- und Planungsaufwand verbunden und zeigten oftmals nur vergleichsweise geringe Erfolge. Ursächlich dafür ist unter anderem eine mangelnde Gesamtsicht aller Faktoren und das Fehlen einer eindeutigen Entscheidungsgrundlage für die zielgerichtete Auswahl der geeignetsten Maßnahmen am Gewässer.

Einen Lösungsbeitrag hierfür soll das dreijährige Projekt DECIDE liefern, indem ein ökotoxikologisches Bewertungssystem für Fließgewässer entwickelt wird, das letztlich als Entscheidungshilfesystem in der wasserwirtschaftlichen Praxis eingesetzt werden soll. Konkret wird ein umfassendes Spektrum an aktiven und passiven Effektmonitoring-Verfahren auf ihre Aussagekraft und Praxistauglichkeit hin überprüft. Gemeinsam mit einer Bewertung des Makrozoobenthos und unterstützender hydromorphologischer und physikalisch-chemischer Qualitätskomponenten sollen so entweder stoffliche Ursachen oder strukturelle Defizite als Haupttreiber für den unzureichenden Gewässerzustand identifiziert werden. Als Modellregion dient das Hessische Ried, das eine wichtige Bedeutung für die Trinkwassergewinnung für die Metropolregion Rhein-Main hat. Neben einer strukturellen Veränderung sind die Fließgewässer vielfach auch stofflich durch diffuse Einträge und eine Reihe von Kläranlagenabläufen erheblich belastet.

Im Beitrag werden das Projekt und erste Ergebnisse aus dem Einzugsgebiet der Gersprenz vorgestellt und kritisch vor dem Hintergrund des zu entwickelnden Entscheidungshilfesystem für die wasserwirtschaftliche Praxis diskutiert.

Danksagung: Das Projekt DECIDE wird von der Deutschen Bundesstiftung Umwelt (DBU) gefördert (Förderkennzeichen AZ 35663/01).

S08: Plankton ecology

Blick in die Zukunft (BLIZ): Einfluss von Temperaturerhöhung und Trübung auf die Makrophytenentwicklung

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Als Teil des Forschungsverbundes werden an der Limnologischen Station Iffeldorf (LSI) die Folgen des Klima- und Landnutzungswandels auf Kipppunkte in limnischen Systemen untersucht. Der Schwerpunkt der Forschung liegt hierbei auf den Auswirkungen steigender Trübungen und erhöhter Wassertemperaturen auf ausgewählte submerse Makrophyten bzw. auf Makrophytenbestände. Zudem sollen in Zusammenarbeit mit Modellierern der Julius-Maximilians-Universität Würzburg (JMU) Kipppunkte ermittelt werden, ab denen sich die zukünftigen Klima- und Landnutzungsszenarien auf die Unterwasservegetation in Seen auswirken werden.

Aus diesem Grund wurden in Mesokosmen- und Klimakammerversuchen verschiedene Stoffeinträge und Temperaturbedingungen simuliert und deren Folgen auf die morphologische und physiologische Entwicklung verschiedener Makrophytenarten untersucht. Neben den Effekten von Trübungsintensitäten und -dauer wurde auch der Einfluss von spezifischen Trübungsarten (Schwebstoff-, Gelbstoff- oder Algentrübung) bestimmt. Anhand der gewonnenen Daten konnten für verschiedene Klimawandelszenarien mögliche „Winner“ und „Loser“-Arten identifiziert werden.

Außerdem wurden die Wachstumsdaten der Makrophyten von Wissenschaftlern des Center for Computational and Theoretical Biology (JMU) genutzt, um Projektionen bezüglich der zukünftigen Biodiversität in bayerischen Seen zu erstellen. Modellierer der JMU formulierten auf Grundalge der Mesokosmen- und Klimakammerversuche Parameterranges für verschiedene Makrophytengruppen und simulierten deren Entwicklung in einem Macrophyte Growth Model. Durch eine Analyse der vorhergesagten Biodiversitätsveränderungen konnten zusätzlich „Winner“ und „Loser“-Traits der Makropyhten bestimmt werden.

BLIZ ist Teil des Bayerischen Netzwerks für Klimaforschung (bayklif) und wird durch das Bayerische Staatsministerium für Wissenschaft und Kunst (StMWK) gefördert.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Temporal changes in the roles of species sorting and diversification determine community dynamics

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Competition and predation are two major processes structuring natural communities through species sorting (ecology) and their role as major drivers of diversification (evolution). The contribution of ecology and evolution to shaping communities needs further elucidation as the relative importance of competition and predation can change along environmental gradients, and selection by competition and predation often favours different traits. Furthermore, the interactions between species sorting and diversification are largely unknown. Predation has, for example, been found to increase the rate of molecular evolution, and bacterial populations are known to rapidly evolve anti-predator defences during co-evolution with (protist) predators. Whether predation in complex bacterial communities selects for defence or competitive and/or cooperative types is unknown. To estimate the contributions of species sorting and diversification during predation on bacterial communities, we co-evolved twelve rich bacterial communities (24 species) for 60 days with their protist predator Tetrahymena thermophila. We found that species sorting and prey adaption shaped the community composition. While community dynamics were initially explained by species sorting, changes in defence and competitive ability (growth rate) contributed to the community dynamics later in the experiment. In contrast to observations from single bacterial populations, bacterial anti-predator defences declined rapidly, whereas higher levels of competitive ability were measured, suggesting competition as the main driver of selection . Overall, we show that temporal changes in species sorting and evolution determine the dynamics within the bacterial prey communities resulting in selection for prey traits that are qualitatively different from those that emerge under simple pairwise predator-prey coevolution.

A1: Aquatic Ecotoxicology

Immissionsorientierte Feinsedimentuntersuchungen in den Lachsgewässern von NRW

Sven Holl; Frederike Kroll; Thomas Zumbroich

Planungsbüro Zumbroich sowie Universität Bonn

Trotz langjähriger Wiederansiedlungsprogramme ist eine selbst reproduzierende Population des atlantischen Lachses (Salmo salar) im Rheinsystem weiterhin nicht gesichert. Zu den vielfältigen Gründen hierfür zählen mangelnde ökologische Durchgängigkeit, Fressfeinde sowie eine unzureichende Güte der Laich- und Jungfischhabitate. Als Interstitiallaicher ist der Lachs zur Fortpflanzung auf gute Wasserqualität und eine durchströmte, grobmaterialreiche Sohle angewiesen. Aus angrenzenden Flächennutzungen eingetragene Feinsedimente können die Sauerstoffdiffusion im Kieslückensystem einschränken und zu einer Anlagerung von ökotoxikologisch relevanter Schadstoffe führen.

Das Forschungsprojekt (Projektträger: DBU; AZ: 37595-01) widmet sich der Habitatqualität von Lachslaichgewässern des Wanderfischprogramms NRW im Einzugsgebiet von Sieg, Wupper und Rur. Es wird durch das Planungsbüro Zumbroich in Kooperation mit dem Geographischen Institut der Universität Bonn, unter Beteiligung des LANUV NRW mit der Landesfischereianstalt in Kirchhundem-Albaum sowie den zuständigen Wasserverbänden als assoziierte Partner durchgeführt. Das aktuelle Projekt führt Untersuchungen (DBU; AZ: 53211-01) der Jahre 2019 bis 2021 fort und erweitert diese um den Aspekt der stofflichen Belastungen. Anhand von in-situ Versuchen wird der Einfluss von Feinsediment- und Schadstoffbelastungen im Interstitial auf die Entwicklung der Lachsbrut untersucht. Die eingesetzten innovativen Feldmethoden, kombiniert mit chemischer Laboranalytik, versprechen neue Erkenntnisse für die strukturelle und ökotoxikologische Beurteilung der Gewässer als Lebensraum für rheophile Fischarten.

Der Vortrag fasst die Ergebnisse des Vorläuferprojektes kurz zusammen und stellt darauf aufbauend die nunmehr anvisierten, erweiterten Projektziele von "IMI Lachs" vor. Zudem können erste Geländearbeiten und -methoden der vergangenen Brutsaison präsentiert und zur Diskussion gestellt werden. Es ist zu erwarten, dass die Arbeiten neue Erfahrungen zum Monitoring der „Qualitätskomponente Fisch“ im Zusammenhang mit Feinsedimentbelastungen der Gewässersohle bieten. Mit dem Projekt können letztendlich Möglichkeiten zur nachhaltigen Förderung der biologischen Vielfalt von Fließgewässern aufgezeigt werden.

S13: Imaging Plankton

Automated microscopy and AI-based image analysis of algae and phytoplankton using Molecular Devices high content solutions

Christian Holz, Sr. Application Scientist

Molecular Devices

Molecular Devices high content imagers and analysis software are commonly used by pharma for screening of fluorescence-labelled mammalian cell cultures and 3D organoids in research fields such as oncology, virology, toxicology, and neuronal diseases. With intelligent and flexible acquisition routines and machine-learning algorithms, the use can be extended to microscopic organisms with more complex morphology. The Limnological Institute of the University of Konstanz is using the ImageXpress Micro for high throughput acquisition of green algae. Feasibility studies with the INCarta software show robust segmentation and classification of these small aquatic organisms using deep-learning and unsupervised-clustering methods.

S02: Aquatic Symbioses – different forms of interactions, context-dependence and consequences for population and community dynamics

Context dependency in a ciliate-algae endosymbiotic interaction

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University of Konstanz

Endosymbiosis has evolved multiple times independently across the tree of life but the factors driving it remain largely unexplored. Evolutionary theory states that for any endosymbiotic interaction to evolve and remain stable over time, fitness of both partners needs to be higher in symbiosis than when living freely. Here, using a freshwater ciliate-algae system (Paramecium bursaria and Chlorella algae), we studied under which conditions these two separate species could have evolve to live as one single entity. Specifically, we did so by measuring the fitness of each of the partners in symbiosis versus free-living across varying biotic environments. We found that both the ciliate hosts and the algae endosymbionts always acquired positive fitness net effects by forming endosymbiosis. Specifically, the host benefitted in areas of low-quality food and the endosymbionts in areas with predators, which included the ciliates themselves. We also experimentally manipulated the endosymbiotic algal species harbored by the hosts and found variations in the total algal net effects, indicating the importance of their coevolutionary history with the hosts. Overall, this study provides evidence that being endosymbiotic was beneficial for both species under certain conditions.

S03: Responses of aquatic ecosystems to anthropogenic stressors

ADAPT - Towards understanding the role of evolutionary adaptation in multiple stress responses of keystone aquatic taxa

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Rapid climate change and severe anthropogenic impact result in a multitude of environmental stressors that have profound consequences on global freshwater biodiversity. The resulting stressors often interact, sometimes in unexpected ways, making it very difficult to accurately predict biodiversity responses. The net response to multiple stressors is determined by organismal tolerances to the individual stressors. In this context, eco-evolutionary mechanisms like performance trade-offs where organisms cannot optimally mitigate for multiple stressors at once can alter the responses to stressor exposure. This makes generalisation of stressor effects on species difficult and poses an emerging research field. Our aim was to evaluate the role of eco-evolutionary adaptation on multiple stress responses of freshwater amphipods, keystone aquatic species. We specifically investigated the stress response to a sudden heatwave and increase as well as decrease of salinity in two populations of Gammarus roeselii. One of those populations served as a proxy for rapid evolutionary adaptation as it was sampled from an anthropogenically impacted stream with elevated water temperature and high salinity, while the second population occurred in ambient water conditions, which served as a control population. We performed indoor mesocosm experiments using a full factorial design. The first results obtained from mortality levels show a clear impact of the increased temperature in both populations. However, the sublethal responses on a behavioural level (leaf consumption rate) show that even though individuals from the adapted population cope well with heatwave conditions, they are more sensitive to environmental change, indicating that evolutionary adaptation alters the organismal stress response. The findings will be combined with molecular data (RNA:DNA ratio, HSP70 expression). The results of this study provide a foundation for a subsequent project where the effect of rapid as well as long-term thermal evolutionary adaptation on the multiple stressors response related to heatwaves and droughts will be investigated.

A2: Seen und Feuchtgebiete

Spontane Eutrophierung des Stechlinsees: Welche internen Mechanismen steuern die hohe saisonale Phosphordynamik im Wasserkörper?

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Es häufen sich Beispiele, dass auch Seen in relativ gering belasteten Gebieten einer Eutrophierung unterliegen. Im Stechlinsee, dessen Einzugsgebiet zu 80% bewaldet ist, ist die Phosphor (P)-Konzentration innerhalb von 10 Jahren von etwa 15 auf 60 µgP L-1 angestiegen. Auch im Jahresgang zeigt der gesamte P- Inhalt im See eine zunehmende saisonale Dynamik, welche nur durch den Wechsel von Festlegungs- und Freisetzungsprozessen am Sediment erklärt werden kann. Massebilanzen in verschiedenen Schichten des Hypolimnion zeigen, dass die P-Akkumulationsraten bezogen auf die Sedimentfläche im tiefen, anoxischen Bereich geringer sind als in besser mit Sauerstoff versorgten Zonen oberhalb von 55 m Wassertiefe. Im tiefsten Bereich des Sees kommt es trotz anoxischer Verhältnisse paradoxerweise sogar zur Anreicherung von Eisen (Fe) und/oder Mangan (Mn) gebundenen P an der Sedimentoberfläche. Ursache dafür sind redoxgesteuerte Rückfällungsprozesse im Bereich der Oxykline, die sich durch Sedimentationsmessungen von Fe, Mn und P sowie die Analyse von P-Bindungsformen in 20 und 60 m belegen lassen. Mit Hilfe von Laborexperimenten an ungestörten Sedimentkernen konnte demonstriert werden, dass das geochemische Fokussing von Fe und Mn kleinräumig zu großen Unterschieden im P-Freisetzungsverhalten der Sedimente führt und dass übliche Erklärungsversuche mit „Sauerstoff verhindert die P-Freisetzung“ nicht anwendbar sind. Laborversuche mit unterschiedlichen Zugabemengen von Fe-P Präzipitaten auf die Sedimentoberfläche des Stechlinsees zeigten zudem, dass es unter anoxischen Bedingungen zur Bildung des zweiwertigen Fe-P Minerals Vivianit kommen kann. Die Verfügbarkeit des Eisens spielt daher auch mit Blick auf mögliche interne Restaurierungsmaßnahmen eine zentrale Rolle für die Steuerung der dauerhaften P-Festlegung im Sediment.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Management of small lotic waterbodies and its consequences for the ecological value: a survey referring to German authorities

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Water management includes practices at small lotic waterbodies to maintain mostly the duly runoff. However, the reconciliation of both, water management and nature conservation interests, is crucial to reach a good ecological potential for heavily modified waterbodies and a good ecological status for natural waterbodies according to the European Water Framework Directive (WFD). Small lotic waterbodies provide microhabitats for a variety of species, contributing to the WFD and nature conservation when they are well managed in an ecological way.

The present research identifies responsible authorities within the distribution of a threatened and protected under the Habitats Directive species, Coenagrion mercuriale (Odonata), which is highly dependent on water management actions. A sent questionnaire aimed to reveal the current status of water management concerning small lotic waterbodies, regarding different topics as reasons, seasonality, frequency, deposition of accruing material, equipment and social demographics.

It is demonstrated that current water management practices of small lotic waterbodies implement scientific nature conservation research to a certain extent, especially in the context of frequency and seasonality. However, there are improvements to make regarding equipment and accruing material, which is frequently disposed without further utilization or even left at site. To reconcile nature conservation and water management interests, it is essential to communicate and to exchange knowledge. Challenges of both interests have to be addressed in cooperation to meet the goals of the Water Framework Directive.

S11: Blue Nature-based solutions: co-benefits for nature and people

Societal co-benefits of river restoration: what social media can tell us

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In the EU countries, river restoration takes place primarily under the premise of the Water-Framework Directive (WFD) with the aim to improve the conditions for (aquatic) organisms and thus the ecological status of the water bodies. However, restorations do not only serve aquatic organisms, but also human well-being. Since there are no standardized methods for the assessment of these benefits, they are less often included in the evaluation of restoration measures. To better understand the occurrence of co-benefits for aquatic organisms and for people it is central to know where these occur, and which attributes of the restoration are responsible for this co-occurrence.

We used publicly available photo posts from social networks, such as Flickr, Twitter and Instagram, to identify different human-nature interactions, serving as a proxy for benefits of restoration and therefore human well-being, along a hydromorphological gradient along the river Emscher, Germany.

We highlight which hydromorphological elements supporting the aquatic life are associated with specific human-nature interactions. With our research, we want to gain an understanding of multiple co-benefits and discuss limitation of the approach. The knowledge of the co-occurrence of benefits improves the planning of future restoration projects, which also has a positive effect on the societal acceptance of such projects.

Can DNA metabarcoding replace traditional methods for biodiversity assessment?

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The global biodiversity crisis requires the development of a new generation of reliable, high-throughput and high-resolution techniques to measure and describe state and change of biodiversity. In recent years, DNA metabarcoding has emerged as a promising solution that could meet these criteria. However, several challenges still stand in the way of widespread adoption of environmental DNA to track biodiversity, one of the most important and urgent being the validation of DNA metabarcoding as an effective and sensitive approach to detect targeted species and the comparability between the results obtained by metabarcoding and those obtained by traditional methods. Here, we present a global meta-analysis of all the available studies reporting comparisons between metabarcoding and traditional methods to assess the richness and composition of biological communities in aquatic environments. We found that metabarcoding provides richness estimates that are globally consistent to those obtained using traditional methods. Metabarcoding also generates species inventories that are highly congruent with traditional methods for fish. Contrastingly, species inventories of microorganisms and macroinvertebrates obtained by metabarcoding showed pronounced differences to traditional methods. Based on these results we will highlight how DNA metabarcoding could be integrated with traditional approaches to provide a powerful solution to monitor freshwater diversity in a changing world.

S02: Aquatic Symbioses – different forms of interactions, context-dependence and consequences for population and community dynamics

Multiple keys to one lock: the role of molecular exaptation in novel intracellular endosymbiosis

Joseph Kelly; Manuela Spagnuolo; Lutz Becks

University of Konstanz

Paramecium bursaria is well recognized for its facultative symbiosis with the algae *Chlorella variabilis*, in which bidirectional transfer of benefits occurs in an evolutionarily stable association. This system is characterized by the phenomenon that symbiosis can occur between ciliates and algae that do not share an evolutionary history, and which are therefore likely naïve to each other's biology. How these symbiotic leaps of faith occur despite the potential challenges presented to both parties remains an open question. To fill this gap in knowledge, we elucidated the molecular underpinnings of this symbiotic flexibility by coupling comparative transcriptomics with experimental cross-inoculations of *P. bursaria* with *C. variabilis*, the native symbiont of *P. bursaria*, and *Micractinium tetrahymenae*, the algal symbiont of the ciliate *Tetrahymena utriculariae*. We tested two hypotheses: 1) that similar genetic profiles are involved in endosymbiosis of *M. tetrahymenae* and *C. variabilis* with their respective native hosts and 2) that this shared suite of genes enables the infection of a novel host. We discovered that despite evolving in similar host environments, substantial non-overlap in pathways that are involved in the inhabitation of ciliates exists between the two algae. Furthermore, we found a significant number of genes that are not expressed under native symbiotic conditions in *M. tetrahymenae* but are recruited for symbiosis with the novel host *P. bursaria*. Together, these results contribute to our understanding of how new intracellular endosymbioses can spontaneously establish and are facilitated by pre-existing molecular toolkits.

S13: Imaging Plankton

Digital diatom analysis – Large scale imaging, semi-automated morphometry, manual annotation and deep learning

Michael Kloster; Andrea Burfeid Castellanos; Bánk Beszteri

Universität Duisburg-Essen

Ecological research of diatoms often involves assessing morphometric differences along environmental gradients or assessing community composition by species abundance counts based on light microscopy of silicate frustules. Such methods are broadly applied in bio-monitoring, water quality assessment and ecology / biodiversity research. However, the corresponding methods involve a lot of laborious manual work and have barely changed for more than a century.

To overcome limitations of the traditional methods, we developed a completely digital diatom analysis workflow covering the following aspects:

1) High-resolution slide scanning microscopy of large sections of diatom preparations, including focus-stacking and image stitching.
2) Morphometric characterization of diatoms from light microscopy images (taken manually or by slide scanning) by image analysis.
3) Manual identification and labelling of individual cells in gigapixel-sized “virtual slide images” using the BIIGLE 2.0 web service, for routine community composition assessment and deep learning training data collection.
4) Training deep learning models for automated segmentation and classification of diatom imagery.

A digital approach to diatom analysis opens up new opportunities for improving collaboration, quality control, taxonomic resolution, taxonomic harmonization / intercalibration, sample documentation and automation of diatom morphometric characterization and taxonomic identification. We have applied continuously evolving variants of digital workflows combining one or more above aspects to different research questions over the last years, and are continuing working on developing them into a versatile set of tools for computer-assisted diatom analyses.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Phosphorus retention in non-acidic post mining lakes: The challenge of trophic state prediction

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Post mining lakes typically exhibit oligo- to mesotrophic conditions with total phosphorus levels as low as 5-20 mg/m^3 independent of acidity. This is due to exceptionally high sedimentary stocks and/or imports of metals like iron or manganese which immobilize phosphorus via sorption and/or mineral formation. Such extraordinary sinks of phosphorus are not reflected in commonly employed semi-empirical models (e.g. Vollenweider 1976; OECD 1982) which largely attribute phosphorus retention to the settling of particulate organic matter. These models cannot be used to adequately predict the response of post mining lakes to altered boundary conditions like, e.g., increased anthropogenic phosphorus loading. Grüneberg et al., 2018, were the first to present a set of dedicated semi-empirical models accounting for increased phosphorus retention in post mining lakes. Owing to data scarcity, however, the proposed models are subject to considerable structural and parameter uncertainty and they possibly suffer from overfitting. In this contribution, we present a new set of phosphorus retention models trained on an extended set of post mining lakes (n=26). We illustrate the theoretical foundation of selected models and critically evaluate their performance with regard to the estimation of in-lake phosphorus concentrations. We thoroughly discuss the challenge of predictive uncertainty arising from inevitable structural simplifications and limited variance in observation data. We finally develop a vision for trophic state prediction models which address natural and post mining lakes in a unified framework.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

A shift from induced to evolutionary defense determines the dynamics of a microbial predator-prey system

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Predation defense is common in predator-prey interactions and it adds complexity to ecosystem dynamics. With microorganisms being used as model systems, the mechanisms of many individual defense strategies have now been deciphered. Gaps of knowledge remain, however, with regard to the evolution of defenses over longer periods of time and their impact on predator-prey dynamics. In particular, there is limited information on the appearance of multiple alternative defenses in one and the same prey, including possible successions and interactions. Moreover, replicated observations of predator-prey dynamics that include effects of both phenotypic plasticity and rapid evolution are still scarce. In this contribution, we present insights gained from the co-cultivation of *Pseudomomas putida* with a bacterivorous nanoflagellate (Poteriospumella) in semi-continuous reactors over several weeks. Surprisingly, an identical dynamics was observed in all of 16 replicates even when initial conditions varied considerably. After about two weeks, predators were always brought close to extinction as the bacteria started producing toxic metabolites. However, this very successful cooperative defense was consistently superseded by the emergence of de novo mutants among bacteria exhibiting a filamentous phenotype. By the end of the fourth week, all of the replicates had converged toward an apparent steady state with grazing resistant filaments being the predominant type of prey. Contrary to intuition, the predator-to-prey ratio remained high, indicating a sub-optimal outcome from a bacterial population's perspective. By means of dedicated experiments and process-oriented mathematical modeling, we demonstrate how the observed succession of bacterial defenses is driven by the maximization of individual rather than population benefits. We also highlight the vulnerability of cooperative defenses to rapid evolution.

A3: Grundwasser und Quellen

Approaches to evaluate spring habitats and communities for nature conservation

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Spring habitats are small and rare biotopes which highly declined in the 20th century. Especially in regions with high density of settlements and intense agricultural use, they acutally are considerably endangered. For planning in nature conservation, it is very important to evaluate the structure of springs and the communities of crenal animals and plants. In several hundred spring habitats in which macrozoobenthos was evaluated by using the existing indices the results often seemed to be implausible. In applied nature conservation it is very important to have a reliable tool to evaluate the state of habitats and communities of animals and plants in springs. For this reason, the consulting center für spring habitat of Switzerland will adapt the existing method to evaluate the fauna of springs by Fischer, which is widely used in German speaking countries of Europe. In limnocrenes, macrozoobenthos species considerably differ from those in rheocrenes or helocrenes. To be able to evaluate limnocrenes, a specific approach will be elaborated. In a first step all data of structure and fauna of spring habitats in Switzerland were analyzed for correlations between structural parameters as well as disturbances and occurring taxa of macrozoobenthos in rheocrenes and helocrenes. For limnocrenes the existing tools to evaluate ponds will be adapted to springs. The objective is to develop a plausible index to evaluate the state of spring habitats according to nature conservation. Providing evaluation tools for all types of springs will be important to prioritize measures to valorize springs which suffered human disturbances.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Individual trait and fitness variation in a phytoplankton population across eutrophic and re-oligotrophic periods

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Universität Konstanz

Aquatic ecosystems underwent major changes in the last decades. Cultural eutrophication followed by periods of attempts to revere this are probably the most significant and prominent examples. The phytoplankton species composition tends to follow these changes with losses and gains of taxa as well as changes in the dominance of species depending on the environmental conditions. However, some species persist at similar frequencies independent of the environmental conditions. We hypothesize that the persistence of some species is mediated by evolutionary adaptation to different environments. To test for this, we resurrected and isolated multiple clonal lines of *Chlamydomonas sp*. from Lake Constance sediment, associated with either eutrophic or re-oligotrophic conditions in the lake. We characterized and compared competitiveness and defense as two major trophic traits of these isolates and linked these to fitness under controlled laboratory conditions. Specifically, we followed the growth and yield of 14 isolates from each period in low and high phosphate conditions in the presence and absence of predation by *Brachionus calyciflorus*. We found significant differences in traits between isolates and that the trait ranges differed when isolates from the different time periods were compared. In addition, isolates with similar trait combinations for defense and competitiveness differed in fitness when tested in the different environments (phosphate and predator). The observation of differences in heritable trait variation and differential translation into fitness responses suggests that adaptive evolution may play a role in the resilience of *Chlamydomonas sp*. to major environmental changes.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Daphnia pulex populations: Influence of anthropogenic stressors and predation pressure on trait variation and genotypic variability

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Diversity is a major precondition for the adaptive reaction of populations to environmental change. Biodiversity at all levels (genetic, species, interactions) is crucial for ecosystem function and resilience as biodiversity provides redundancy which stabilizes ecosystems because extinct species/genotypes may be replaced. In addition, individual trait variation and/or phenotypic plasticity can stabilize population fluctuations and thereby prevent extinction, by having the opportunity of a fast adaptation to appearing stressors and changing environments. A very plastic and important genus in lake ecosystems is the micro- crustacean Daphnia. Different clones of *Daphnia pulex* express various degrees of phenotypic plastic defenses and changes in life history. Due to different sensitivity thresholds, some clones express strong reactions to even minor stress levels (elevated pCO_2/ predation pressure), while less sensitive clones show reactions only at very high stressor levels.

However, it is unknown how these stressors affect diversity within populations.

In order to understand how population compositions may change under natural and anthropogenic stress, we composed an artificial population of ten different clonal strains and monitored population responses in a mesocosm experiment.

These populations were exposed to the phantom midge larvae *Chaoborus obscuripes* as predators and an elevated pCO_2 as anthropogenic stressor. We monitored phenotypic reactions and individual trait variation. We also monitored genetic variability within artificial populations using microsatellite-markers after six weeks.

In addition, each clone was comprehensively phenotyped by measuring a set of morphological as well as life history parameters and behavioral traits in juvenile and mature Daphnia. Changing parameters were measured under predation pressure, elevated pCO_2 and control conditions.

Last we conducted predator-prey experiments to observe the survival rate of each clone.

We found that strains which show intermediate responses to predation are more likely to dominate populations in the mesocosms.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Neue Herausforderungen durch die Energiewende für den Gewässerschutz in Deutschland – Hydrothermie und schwimmende Photovoltaik

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Durch die Forcierung der Energiewende in Deutschland hin zu einer verstärkten Nutzung regenerativer Energien ist der Druck zur Einbeziehung der Potentiale, die Gewässer hierbei bieten können, sprunghaft gestiegen. Im Mittelpunkt stehen dabei die thermische Nutzung von Gewässern sowohl zur Wärmegewinnung als auch zu Kühlzwecken sowie die Nutzung von Wasserflächen zur Stromerzeugung durch den Einsatz schwimmender Solaranlagen. Eine wesentliche Voraussetzung für die Genehmigungsfähigkeit der Anlagen ist deren gewässerökologische Verträglichkeit gemäß der aktuell gültigen Rechtslage, die keine Verschlechterung des ökologischen Zustands durch die geplanten Nutzungen erlaubt.

Während in Deutschland bisher nur wenige Erfahrungen mit beiden Formen der regenerativen Energiegewinnung aus bzw. auf Gewässern vorliegen, ist die thermische Gewässernutzung in der Schweiz bereits relativ weit verbreitet. Schwimmende Solaranlagen sind neben südostasiatischen Ländern insbesondere bei unseren holländischen Nachbarn seit einigen Jahren in größerem Umfang im Einsatz. Im Vortrag sollen Erfahrungen zu den gewässerökologischen Auswirkungen vorgestellt werden, die beim Einsatz beider Technologien bisher gewonnen wurden. Darüber hinaus geben auf limnophysikalischen Modellierungen beruhende Ergebnisse aus Studien, die für Seen erstellt wurden, für die eine energetische Nutzung geplant ist, einen Einblick in die ökologische Verträglichkeit dieser neuen Arten der Gewässernutzung.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Predicting combined stress effects

Matthias Liess

UFZ - Helmholtz Centre for Environmental Research

Global change alters environmental conditions and forces an increasing number of species to face multiple environmental stressors. Stressors include climate warming, changes in hydrology and morphological structure as well as increasing loads of toxicants. According to this situation, the ability to predict the combined effects of such stressors is highly relevant. The presentation will introduce a framework to predict the response of populations to multiple stressors. Based on this framework, the effects of multiple stressors are explained and predicted in numerous studies. Combinations of natural environmental stressors, pollutants and biological stressors such as adverse interactions are considered. Furthermore, the limitations of the approach are also highlighted in order to frame its applicability.

S01: Aquatic viruses

Ecology, death (by lysis) and evolutionary history – Viral infections in phytoplankton communities and *Ostreococcus sp.* from the Western Baltic Sea

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Viruses represent an important cause for phytoplankton mortality and can thereby influence biogeochemical cycling of carbon and other nutrients. Marine phytoplankton contribute about 50% to the global production of oxygen, fuel biogeochemical cycles, and have important cascading effects on higher trophic levels in the food web. Given that viruses are highly abundant in the ocean and play an important role it is pertinent that we begin understand how viruses affect ecological and evolutionary dynamics in ecosystems. In recent years, an understanding of the potential importance of phytoplankton-targeting viruses on ecosystem dynamics has emerged, but a broadscale investigation of host-virus interactions is still missing.

Over the last years, we investigated phytoplankton communities and the picoplankton species complex of *Ostreococcus sp.* from several regions of the Western Baltic Sea that differ mainly in temperature and salinity. Here, we present two experiments investigating i) the top-down controls of viruses and zooplankton on phytoplankton communities over 7 months and ii) infection dynamics of *Ostreococcus sp*. and its viruses over more than 2 years. For the first experiment, we used modified dilution experiments and for the second experiment, we used freshly isolated strains of both Ostreococcus and its viruses. We found that top-down control on phytoplankton communities and *Ostreococcus sp.* varies strongly between seasons and less so between the different geographical regions.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Submersible Microalgae Sensor with Activity Measurement

Detlev Lohse

bbe Moldaenke GmbH

The use of fluorometry in plant and algae physiology is well established. Excitation of the photosynthetic apparatus with controlled light sources enables detailed statements about the cell conditions. For phytoplankton submersible fluorometers are available which can distinguish different algae classes and estimate the chlorophyll_a content underwater. However, the determination of phytoplankton at or near the surface becomes questionable when the photosynthetic pigments are already excited by the sunlight. Here the emitted fluorescence is no more proportional to the content of chlorophyll_a. A new approach with an internal chamber in the submersible fluorometer allows the relaxation of the excited state of the pigments before the measurement. The separation from the surrounding water body improves the determination of chlorophyl_a. With a set of Laser diodes, the fluorometer allows for the first time to measure the maximum quantum yield of the different algae classes separately in a profile. We show the first data from Lake Westensee, Schleswig-Holstein collected in May 2022. The new fluorometer will expand the knowledge of the ecological status of the phytoplankton in situ and at different depths.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

11 years of post-restoration studies: community composition changes in streams in a forested landscape

Armin Lorenz

University of Duisburg-Essen

Stream restoration is mainly conducted in rural or urban areas where the majority of stream sections are straightened and riprap or concrete is used for bank fixation. But also in forested areas streams have suffered from straightening followed by incision and disconnection from the floodplain. Nonetheless, research studies in these forested landscapes are rare. Furthermore, evaluating river restoration effects over several years is the exception rather than the rule. The benthic invertebrate fauna of three small mountain streams in the Arnsberger Wald in North Rhine-Westphalia was investigated yearly from 2010 to 2021 following remeandering measures. In former times the streams have been straightened in short sections to increase forest management and timber industry. Additionally, to the restored sections, upstream near-natural reaches were studied conducting a Before-After-Control-Impact design. Species richness and EPT richness decreased strongly immediately after restoration but had positive effect sizes in the following six years. Abundances increased in all sites after restoration. These patterns were consistent also in the upstream near-natural reaches, except for the decrease in richness in the second year, indicating that other factors beside the restoration affected the sites. A large flood event coincided with the implementation of the restoration measures depleting also the near-natural sites. Similarity between paired reaches showed a sharp decline in the first year after restoration, followed by a direct increase, which indicates fast recolonization from the upstream reaches. Community composition analysis showed a shift of all communities with the time axis, underlining a substantial effect of external factors.

Generalized linear mixed effects models exhibited that forest management in study period had significant effects on changes in richness and abundance. This talk will give insights into external and internal factors shaping benthic communities in restored streams.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Does personality have an effect on bait selectivity of Northern Pike (*Esox lucius*)?

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Predatory fish with bolder personality traits have been proposed to experience greater angling mortality resulting in lower reproductive fitness than those that have shy personality traits. This study tested the basis of this proposition by investigating how pike of different personality (bold/shy) responded to simulated angling with three common hookless fishing baits (a soft plastic natural colored lure, a soft plastic bright colored lure and natural dead bait fish) under laboratory conditions. The personality of pike (N = 42) was assessed by measuring latency to forage under stressful conditions, i.e. exposure to challenging ambient light, in three trials over a period of 15 days. Additionally, predation trials with living prey were conducted to observe the hunting behavior on an individual level. In the simulated angling trials, bold pike showed significant more predation than shy pike. This effect was independent of bait type. Handling of the bait differed during successful attacks; the natural bait was swallowed more frequently than artificial lures, which were rejected after the attack. Both personalities showed similar learning capacities by developing bait avoidance during the angling trials. Bait exposure did not affect natural pike hunting behavior on living prey. These results set the basis that pike of different personality (bold/shy) have different susceptibility to angling and increase our understanding of potential effects of fisheries-induced evolution on biodiversity and may inform future management decisions in recreational fishing to protect biodiversity of pike stocks globally.

A1: Aquatic Ecotoxicology

Artificial plastic aging as a framework for microplastics ecotoxicity evaluation

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Microplastics are widely distributed in aquatic and terrestrial environments, up to now less is known on toxicological impacts under realistic conditions. Research so far has focused mainly on the impacts on organisms by fresh plastic fragments or beats. However, plastics found in the environment are mainly a mixture of different polymers and additives and particularly are degraded during aging processes. Although especially oxidized degradation products might escape from plastic materials during aging, there is a lack of information on potentially adverse effects on aquatic biota. The latter is of particular interest as oxidized chemicals become more water soluble due to higher polarity and are more bioavailable, therefore.

The present study focused on plastic leachates of polystyrene (PS) and polylactic acid (PLA), which were derived from alternating stress by hydrolysis and UV radiation. Test specimen of PS, PLA or PS/PLA blends (each 50 %) were alternatingly maintained in water at 45 °C for five days and UV radiated at 45 °C for two days, for in total six weeks. Ecotoxicological effects of potentially generated degradation products of plastics in the storage water (natural spring water) were detected by algae growth inhibition tests with *Desmodesmus subspicatus* and photosystem II inhibition tests with Raphidocelis subcapitata.

Results clearly indicate inhibitory effects on algae growth by contaminants in the storage water of stressed plastics with increasing growth inhibition of proceeding hydrolysis and UV stress times. Here, different plastics cause variable responses of algal growth. First chemical analyses indicate dissolved monomers and their oxidation products of plastics as possible driver of detected ecotoxicological effects, since detected microplastic particles do not seem to harm algae.

The existing data highlight the relevance of plastic aging as a framework for microplastic ecotoxicity evaluation and allow a proof of concept.

A new tool in the toolbox: Evaluating the potential of DNA metabarcoding for monitoring macroinvertebrates and diatoms in regulatory context

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With the implementation of the Water Framework Directive (WFD), the European Union has set the goal to achieve good ecological status for all water bodies in Europe. To assess the biological quality, biodiversity assessments are carried out with established morphology-based identification methods. However, traditional biomonitoring remains cost- and time-consuming. In comparison, DNA metabarcoding promises to be a more time and cost-efficient method with high taxonomic resolution that has potential as new complementary tool for regulatory biomonitoring. However, while DNA-based methods have been long established in the scientific community, a large-scale method validation in the context of regulatory biomonitoring is still missing.

Therefore, the GeDNA project was initiated to bridge the gap between the scientific community and the applied sector. One main aim of the project is the validation of DNA metabarcoding as a method for assessing the ecological status of streams in comparison to traditional methods. Therefore, macroinvertebrate and diatom bulk samples were collected in two WFD sampling campaigns (2020 and 2021) across Germany. All samples were morphologically identified by taxonomic experts and subsequently processed with DNA metabarcoding.

Our results for macroinvertebrates revealed congruent species lists for 10 of 13 taxonomic groups, while systematic differences in the taxonomic richness of three groups were observed (Bivalvia, Oligochaeta and Hirudinea). However, the ecological evaluation (Perlodes module) revealed similar status classes with minor class deviations. DNA metabarcoding of diatoms resulted in species-rich taxa lists. However, at present these cannot directly be analysed for assessing an ecological status with PHYLIB as a prior taxonomy harmonization step is required.

In conclusion, our initial results demonstrate that DNA metabarcoding of macroinvertebrates and diatoms can produce comprehensive taxa lists in a time- and cost-efficient manner, but further methodological optimization and harmonization steps will be required before of DNA metabarcoding can be added to the WFD monitoring methods.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Are micropollutants dominating the macroinvertebrate response to multiple stressors? First results from two lowland catchments in North Rhine-Westphalia

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Rivers are influenced by a variety of anthropogenic stressors including eutrophication, salinization or habitat degradation. In recent years, adverse effects of micropollutants such as pesticides and pharmaceuticals have increasingly come into focus, however, to date have been less frequently considered in the joint analysis of multiple stressors. Furthermore, hydrological alteration describing the deviation of the flow regime from natural conditions often remains unaddressed by surveys of 'hydro-morphological degradation', which tend to primarily address morphological habitat characteristics. For the development of management measures to improve the ecological status of rivers, however, comparative analyses of the relevance of multiple stressors including hydrological alteration and micropollutants are needed.

We present the findings of a study that aimed at identifying and quantifying the effects of 19 stressors on 21 benthic macroinvertebrate metrics in the rivers Erft and Niers, North Rhine-Westphalia. Data on micropollutants, common physico-chemical stressors, hydrological alteration and morphological degradation were analysed using Redundancy Analyses and subsequent variance partitioning, to put the different stressor groups into a hierarchical context. We found predominant effects of common physico-chemical variables and hydrological alterations, whereas only a minor share of the biological response was attributed to the mixture toxicity of micropollutants. Our results imply a strong context-dependent stressor hierarchy for both catchments and point at the need to include hydrological alteration as an important stressor group. Current analyses of a larger dataset across Germany will further assess the hierarchy of the different stressor groups as well as differences between responses of the biological quality elements of invertebrates, diatoms and fish and we hope to present first results from the analyses at the meeting.

A6: Nebiota und invasive Arten

The East Asian bryozoan *Hislopia prolixa* in the Upper Rhine River near Karlsruhe – first records for Europe

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The bryozoan class Gymnolaemata is mostly found in the marine environment, with few representatives in European freshwaters. By collecting biological samples during the inspection of the drained Iffezheim navigation lock on 08-10-2021 we found remnants of a bryozoan we had never seen before. A targeted investigation of embankment stones downstream of the lock on 09-10-2021 on the German side and on 10-10-2021 on the French river bank provided clear evidence of living colonies. These records are the first of *Hislopia prolixa* in Europe. So far, the species is only known from East Asia. We rate the species as non-indigenous. It should already be wider distributed in European navigable waters, especially in the River Rhine.

A2: Seen und Feuchtgebiete

Methane oxidation dominates over methane production in oxic water layers of lakes

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The oversaturation of dissolved CH_4 in the oxic epilimnion (surface waters) of lakes during the stratified period represents a highly intriguing process in the CH_4 cycle. The enrichment of CH_4 in the epilimnion is commonly referred to as the "methane paradox" because it cannot be explained by vertical transport of CH_4 released from deep anoxic sediments and the lake epilimnion is typically well mixed and well oxygenated. There are two major hypotheses around this methane paradox suggesting that the main source of the enriched CH_4 in the oxic epilimnion is either (i) lateral transport of CH_4 from littoral zones or (ii) methanogenesis that occurs in the oxic water of the epilimnion. Both hypotheses are still lacking strong support by experimental evidence. We have measured net CH_4-production in oxic waters in many lakes around the globe by collecting water from oxic water layers and performing incubation experiments. These experiments provide net CH_4 -production at the sampling sites because they were conducted without adding CH_4 or oxygen to the water samples. Some of these incubations were deployed in-situ at the sampling depth ensuring the same light and temperature conditions as in the surrounding water. In all incubation experiments, CH_4 decreased over time indicating negative net CH_4-production, which implies net CH_4-oxidation. Our results therefore suggest that (i) gross CH_4-production in oxic surface layers is typically much lower than CH_4-oxidation, (ii) oxic methanogenesis is typically not the source of the enriched CH_4 in the epilimnion, and (iii) the transport of CH_4 from littoral zones can only explain the CH_4 enrichment in the oxic epilimnion if it is substantially larger than previously thought. Clearly, the methane paradox is still far from being resolved and a quantification of the processes potentially causing the CH_4 enrichment in oxic surface waters are urgently required.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Predation of cormorants (*Phalacocorax carbo sinensis*) on wintering fish in River Nister

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Since the first sighting of 118 cormorants in winter 1998/99, the River Nister is used as foraging habitat mainly during winter. Recently, between 2000 and 3000 cormorants were observed during the winter months each year (January – March + October - December, 2015-2021). Therefore, a high predation pressure of cormorants with negative effects on the fish populations of River Nister was assumed. To quantify the predation pressure of cormorants on wintering fish, we installed seven camera traps around an oxbow, a known wintering ground of fish (mainly nase (*Chondrostoma nasus*) and chub (*Squalinus cephalus*)). In addition, a surveillance camera was installed facing the mouth of the oxbow to document cormorants that usually fly in on the main channel and then swim or dive into the oxbow. At the surveyed oxbow, cormorants are lethally deterred (permission granted by the Struktur- und Genehmigungsdirektion Nord). Therefore, the observed predation occurred despite lethal deterrence of cormorants.

Our data showed, that the oxbow was used as feeding ground on a regular basis by four piscivorous bird species: cormorant (*Phalacocorax carbo sinensis*), grey heron (*Ardea cinerea*), great egret (*Ardea alba*) and goosander (*Mergus merganser*). A preliminary comparison of video footage and photos showed that the camera traps were able to document only 25% of the cormorants entering and hunting in the oxbow. During the first month (November, 5th – December, 5th) cormorants were distinctly documented by the camera traps on nine days while the video footage showed cormorants in the oxbow on 28 of the 31 days. During this first month we observed a total of 85 cormorants in the oxbow. Assuming that all of them satisfied their mean daily food demand of 500 g within the oxbow, this sums up to 42,5 kg fish consumed by cormorants alone within only the first month.

Etablierung von eDNA-Metabarcoding-Ansätzen zur Erfassung der Biodiversität des Phytoplanktons und des Phytobenthos zur ökologischen Bewertung an Bundeswasserstraßen

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Phytoplankton und Phytobenthos sind biologische Qualitätskomponenten zur Bewertung des ökologischen Zustands von Fließgewässern gemäß EU-Wasserrahmenrichtlinie. Traditionell erfolgt die taxonomische Bestimmung idealerweise bis auf Artebene mittels morphologischer Analysen mit Hilfe der Lichtmikroskopie. Allerdings haben in den letzten Jahren molekularbiologische Verfahren, z. B. eDNA-Metabarcoding, als alternative Bestimmungsmethode rapide zugenommen. Trotz der gestiegenen Bedeutung dieser Methode für Biodiversitätserhebungen und deren Anwendung zur ökologischen Bewertung in einigen Europäischen Ländern gibt es bislang in den Bundeswasserstraßen Deutschlands noch keine eDNA-Metabarcoding-Studien mit Fokus auf Phytoplankton und nur zwei mit Fokus auf Phytobenthos. Vor diesem Hintergrund zielt dieses Projekt darauf ab, eDNA-Metabarcoding-Ansätze zur Erfassung der Biodiversität des Phytoplanktons und Phytobenthos zu entwickeln und zu etablieren, mit der klassischen Taxonomie zu vergleichen und deren Anwendbarkeit für die ökologische Bewertung von Bundeswasserstraßen zu testen. Ziel ist es auch, praktische Empfehlungen für die Probenahme und die genetische Charakterisierung zu formulieren. Im August/September 2021 wurden Phytoplankton und Phytobenthosproben entlang von Längsprofilen der Mosel (23 Messstellen über 240 Fließkilometer) und der Lahn (18 Messstellen über 215 Fließkilometer) entnommen. Für das Phytoplankton wurde u.a. ein standardisiertes Probenahmeprotokoll entwickelt und für das Phytobenthos verschiedene Konservierungsmethoden getestet. Zur molekularbiologischen Charakterisierung der diversen Lebensgemeinschaften wurden drei Markergene zur Abbildung unterschiedlicher Organismengruppen verwendet (16S V3-V4 für Cyanobakterien, 18S V4 für alle eukaryotische Algengruppen und rbcL spezifisch für Diatomeen). Um die ökologische Bewertung mittels genetischer und morphologischer Methoden vergleichen zu können, wurden die Organismen parallel anhand ihrer Morphologie bestimmt (Phytobenthos nur Diatomeen). Unsere Ergebnisse liefern zum einen Grundlagen für die standardisierte Probenahme an Bundeswasserstraßen, zur Konservierung von Proben und für ein geeignetes DNA-Extraktions- und Prozessierungsprotokoll. Zum anderen bestätigen sie die Eignung des eDNA-Metabarcodings für die Bestimmung von Phytoplankton und Phytobenthos an Bundeswasserstraßen und deren Potenzial, die morphologische Analyse zu ergänzen und in Teilbereichen zukünftig zu ersetzen.

S03: Responses of aquatic ecosystems to anthropogenic stressors

EffektMon: Evaluating the effects of pollutants on water ecology with effect-based monitoring methods

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One of the main underlying causes of ecological impairment of lotic ecosystems is the massive input of nutrients and pollutants such as pesticides or pharmaceuticals. However, the identification of significant sources of pollution and their contribution to the deficient status of water bodies is complex. For technical and economic reasons, current chemical monitoring methods are limited, resulting in the inability to analyse, detect and quantify the majority of the pollutants and mixtures of substances present in the aquatic environment.

The EffektMon project aims to overcome these limitations by investigating the application of numerous effect-based methods, such as bioassays and biomarkers, that provide an integrative approach to risk assessment, thereby detecting diverse effects or potentials from toxic chemicals. Together with an assessment of the structure of macrozoobenthos communities and the support of hydromorphological and physico-chemical quality components, it should be possible to identify either water contamination or structural deficits as the main drivers of the inadequate running water body status.

The project focuses on the river Alb in Karlsruhe, for which extensive information on the chemical load is available, along with restored and nearby non-restored streams sections selected in the Hessian region, Germany. The EffektMon project will thus allow to assess the extent to which water pollution counteracts the establishment of sensitive species in restored stretches of water bodies, where other main causes of impairment are mitigated, and how important this aspect is in a multi-stressor context for the non-achievement of good ecological status.

In this talk will be presented the project, its status and provided an overview of the first results we achieved from the first campaign.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Analyse der ökologischen Belastungen durch motorisierte Schifffahrt auf Seen in Deutschland: Erste Ergebnisse des Projektes SuBoLakes

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Die motorisierte Freizeitschifffahrt hat in den letzten Jahrzehnten einen stetigen Zuwachs erlebt. Eine Fortsetzung dieses Trends ist absehbar, was die Aufmerksamkeit von angewandter Umweltforschung und Gewässer- und Naturschutzbehörden erfordert, um diese Entwicklung möglichst umweltverträglich lenken zu können. Vor diesem Hintergrund fördert die Deutsche Bundesstiftung Umwelt (DBU) das Kooperationsprojekt SuBoLakes (Laufzeit 2021 – 2024; Kennz. 35825/01), das von der AG Umweltphysik am Limnologischen Institut der Univ. Konstanz (Koordination) und dem Referat W26 (Gewässerentwicklung) des Landesamts für Umwelt Brandenburg getragen wird (https://www.subolakes.de). Das Vorhaben wird durch zahlreiche „Assoziierte Partner“ aus unterschiedlichen Interessenbereichen unterstützt, darunter auch die Bodendenkmalpflege (UNESCO-Welterbestätten). Es hat zum Ziel, eine Datengrundlage zu schaffen, mit der die ökosystemaren Auswirkungen der motorisierten Schifffahrt auf Seen in Brandenburg und Bayern sowie am internationalen Bodensee abgeschätzt und bewertet werden können. Aufbauend auf diesen Ergebnissen werden Handlungsempfehlungen für Nutzerverbände, Umweltschutzorganisationen und Behörden erarbeitet. Das Projekt folgt einem interdisziplinären Ansatz und gliedert sich in fünf Arbeitspakete (AP), darunter die rechtlichen und organisatorischen Randbedingungen der Freizeit- und Fahrgastschifffahrt (AP1), die Neubewertung der bisherigen Faktenlage und Umweltbelastungen durch motorisierte Schifffahrt (AP2), die Messung und Modellierung von Schiffswellen (AP3), der Flächenverbrauch durch die ruhende Schifffahrt (AP4) sowie der Zusammenhang zwischen Uferstrukturveränderungen und den Metrics von Qualitätskomponenten der WRRL wie Makrophyten und Makrozoobenthos (AP5). Wir stellen vorläufige Ergebnisse zum rechtlichen Rahmen der motorisierten Schifffahrt, zu hydrophysikalischen Charakteristika unterschiedlicher Schiffswellentypen und zu Auswirkungen der ruhenden Schifffahrt durch Infrastruktur und Flächenverbrauch vor. Darüber hinaus zeigen wir, welche Seen in Brandenburg genauer untersucht werden sollen und warum. Diese Ergebnisse werden wir anhand ausgewählter Fallbeispiele und in Hinblick auf bestehende und künftige Konfliktpotenziale diskutieren.

S08: Plankton ecology

Suitability of Natura 2000 sites for threatened freshwater species under projected climate change

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Freshwater ecosystems already face an alarming rate of species declines and extinctions due to a multitude of human-mediated stressors. In Europe, for imperiled aquatic species listed under the Habitat Directive (HD), special areas of conservation (SACs) are designated to ensure a favorable conservation status. However, the ongoing rapid climate change could challenge and undermine the long-term effectiveness of these conservation efforts. Using environmental niche models (ENMs), we assessed habitat suitability of designated SACs for 24 Central European freshwater species for current and projected future climate conditions. ENMs were calibrated using species occurrence data reported under the HD. To estimate their long-term habitat suitablity, ENMs were projected to a range of potential future conditions, representing a gradient from effective climate protections measures to a worst-case warming scenario, in a multi-global-circulation-model approach. Under projected future climate conditions, the models showed a severe decline in habitat suitability in the SACs for two-thirds of the species, with the magnitude of decline worsening with the magnitude of projected climate change. This forecasted mismatch between designated SACs and suitable habitat conditions under projected end-of-century climate indicates the potential threat of climate change to species conservation efforts. Effective long-term conservation measures thus need to overcome this potential future 'conservation gap' by fostering climate resilience within existing SACs, restoring stream connectivity for natural dispersal to newly suitable existing SACs (or assisted migration where natural disperal is not possible), as well as designating new SACs within remaining climate refugia.

S06: Coupling biofilm biodiversity and biogeochemistry with habitat heterogeneity across spatio-temporal scales

Variable ripple migration velocity shapes heterotrophic community structure but does not influence community metabolism

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Migrating bedforms, such as ripples, are a naturally occurring phenomenon in sand-dominated lowland rivers with increasing extent and frequency due to anthropogenically enforced bank erosion. Single sediment grains in ripple structures undergo a continuous moving-resting-cycle as ripples migrate downstream. They are exposed to light during the mobile phase, but rest in darkness while they are buried underneath following sand grains. Ripple morphology, i.e. ripple dimension and migration velocity, determines the frequency and length of time period at which sediment grains are transported and exposed to light. Past studies documented that sediment migration in ripples lowers microbial community respiration and gross primary production in the biofilms associated to mobile sediment grains. We set up a microcosm experiment to investigate the influence of different shifting frequencies and light-dark cycles on microbial activity and structural composition. We sampled sediments from a lowland sand bed river (Spree, North-Eastern Germany) in July 2021 and exposed them to three treatments: (i) low shifting frequency (moving every 92 min during 19.3 min of light), (ii) medium shifting frequency (moving every 13 min during 3.8 min of light), and (iii) high shifting frequency (moving every 5 min during 1.8 min of light). We show that neither microbial activity nor abundance of phototrophs and heterotrophs was significantly affected by changing frequencies of moving-resting and light-dark cycles. However, the heterotrophic community structure was altered whereas the phototrophic community structure remained unchanged. Our results indicate that known constrains of sediment migration in ripples extend to further impacts on the heterotrophic but not on the phototrophic community structure.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

The impacts of phenotypic evolution for metacommunity diversity and structure

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Spatial connectivity and environmental variability can impact both the genetics of populations and the structure of communities. Researchers are increasingly able to identify the relative roles that spatial and environmental processes play in structuring metacommunities, but it is interesting to better understand the simultaneous impacts these processes have for phenotypic and genetic diversity. I developed a model to simulate the processes of growth, competition, and evolution in a spatially structured patchy landscape. I used model simulation experiments to explore how properties such as alpha and beta diversity are impacted by phenotypic evolution in resident species. I also applied a Hierarchical Modelling of Species Communities (HMSC) analysis to determine the relative importance of spatial, environmental, and evolutionary processes in driving variation in species abundances in the landscape. I found higher alpha and beta diversities in simulated metacommunities when adaptive evolution was possible, and also that the species diversity levels varied depending on the speed of adaptive evolution (modeled here by changing using trait heritability levels). However, as can be expected when so many processes are occurring simultaneously, the results can be complicated with numerous signals of driving variables. Visualizations and variance partitioning tools built into the HMSC framework were useful in isolating the relative importance of spatial, environmental, and evolutionary processes in structuring communities. The HMSC results also depend critically on data (simulated data in this instance) that might be difficult to monitor in real-time ecological experiments. I provide some additional results that can inform how data quality can impact the ability to identify signals of rapid evolution for metacommunity structure.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Looking closer at recolonization processes: Habitat development and species arrival drive succession of the benthic invertebrate community following stream restoration

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Stream restoration can cause major disruptions to the aquatic ecosystem and its benthic invertebrate community. Habitats may be removed, and new habitats created that have to be reoccupied by benthic invertebrates. However, the patterns of such recolonization processes following stream restoration remain largely unresolved. Existing studies lack detailed information on the macroinvertebrate communities prior to restoration. Therefore, it is difficult to determine which species and niches were already present before. Additionally, many recolonization studies only focus on a short timeframe. Here, we investigated an almost unique situation: A stream network that was mostly inhabitable for macroinvertebrates prior to restoration. The Boye/ Emscher catchment has a history of being used as open sewer. The release from wastewater was closely followed by restoration measures. Monitoring of the macroinvertebrate community was initiated afterward and continued for 10 subsequent years. The resulting data revealed how the community changes following succession. Directly after restoration, the community fluctuates strongly, due to new arriving or disappearing species. However, these changes decrease over time and the community stabilizes. We further investigated the successional processes on species level and detected the most important species that are responsible for the community changes. For these species we analyzed the trends in their abundances, determining the species that decrease or increase over time. For example, Cloeon dipterum and Agabus didymus occur early after restoration but are not able to establish a lasting population due to the changing habitat conditions. On the other hand, many trichopteran species, e.g., Glyphotaelius pellucidus arrive later due to the delayed development of suitable habitats. Lastly, we investigated the environmental variables that are responsible for the shifts in abundance. The amount of riparian vegetation cover is a major driver for species abundance. It increases with time since restoration and therefore is also responsible for changes in substrate composition.

A2: Seen und Feuchtgebiete

Ecological Status of Ternscher See (North Rhine-Westphalia, Germany) and its Phyto- and Zooplankton Communities

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In times of climate change increasing water temperatures combined with high nutrient input can lead to cyanobacteria blooms in lakes and still waters, which in turn can cause deteriorated water quality. Poor water quality can have adverse effects not only on the lake ecology, but also on economic aspects, e.g. bathing bans during the summer months. On account of this the ecological status of Ternscher See and its phyto- and zooplankton communities were assessed from January till November 2021. The lake is located near the town of Selm, Unna district, North Rhine-Westphalia, Germany (51°42'53.7"N, 7°25'54.4"E). This water reservoir is a groundwater-fed artificially created gravel pit excavated in the 1930s. It has an area of 13.2 ha and a maximum depth of ca. 12 m. As an artificial water body, Ternscher See is most similar to the German Lake Type 13, i.e., "A stratified lowland lake with a relatively small catchment area". The average seasonal chlorophyll-a concentration measured was 9.8 µg/L. The cyanobacteria played an essential role in the composition of phytoplankton at Ternscher See. The highest proportion of chlorophyll-a concentration from cyanobacteria with 93% was measured on the 15th of June 2021. The average seasonal Secchi depth was 2.44 m. The measured depth profiles of oxygen concentration and saturation showed very pronounced positive heterograde oxygen curves. During the summer stagnation, the anoxic hypolimnion layer reached a maximum width of 5 m. During the summer months, low zooplankton abundances and small average sizes of the different groups were measured. It could be assumed that the zooplankton community was under predatory pressure from fish. Based on measured phosphate concentrations and Secchi depth Ternscher See could not be rated with the good ecological potential in 2021, in accordance with the EU WFD.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Das wissenschaftliche Wasserkraft-Memorandum von 2021 und seine Rezeption

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Renaturierungen von Bächen und Flüssen sind überall dort praktisch nicht möglich, wo Wasserkraftwerke mit langfristigen wasserrechtlichen Lizenzen vorhanden sind, da diese räumliche Fixpunkte darstellen. Infolge der von Wasserkraftwerken ausgehenden Auswirkungen auf den Geschiebehaushalt und den Fischbestand wird auch der Erfolg von Renaturierungen benachbarter Gewässerabschnitte erheblich beeinträchtigt. Im Zuge der Energiewende besteht das Risiko, dass auch noch verbliebene frei fließende Fließgewässer oder Gewässerabschnitte durch den Bau neuer Wasserkraftwerke massiv beeinträchtigt werden. Im Vorfeld des Regierungswechsels haben daher 65 promovierte Gewässerökolog:innen und andere Fachwissenschaftler:innen aus 30 wissenschaftlichen Institutionen sowie auch das Präsidium der DGL ein wissenschaftliches Memorandum mit dem Titel „Energiewende nicht auf Kosten der aquatischen Biodiversität“ unterzeichnet.

Das Memorandum stellt die Auswirkungen von Wasserkraftwerken auf den Gewässerzustand und die wasserabhängige Biodiversität dar, und verdeutlicht andererseits den mit < 0,5% sehr geringen Beitrag der ca. 7800 Kleinwasserkraftwerke mit weniger als 1 MW Spitzenleistung zur Stromerzeugung in Deutschland. Es wird daher empfohlen, die Förderung der ineffizienten Kleinwasserkraftwerken aus EEG- oder Steuermitteln zu beenden. Die bisher verfolgte Strategie, auch Kleinwasserkraftwerke durch entsprechende Umbauten ökologisch verträglicher zu gestalten, ist wegen des Investitionsaufwands von jeweils mehreren Millionen Euro wirtschaftlich nicht tragbar. Zudem verbleiben die kaum vermeidbaren Beeinträchtigungen durch den Aufstau und Sedimentrückhalt. Staatliche Gelder könnten stattdessen zum Ausbau anderer erneuerbarer Energiequellen wesentlich effizienter eingesetzt werden. Sollte die Politik darüber hinaus größere Wasserkraftwerke weiterhin fördern wollen, raten die Unterzeichnenden dazu, dies von der ökologischen Durchgängigkeit der Anlagen und der konsequenten Einhaltung der gesetzlichen Vorgaben wie z.B. dem Wasserhaushaltsgesetz abhängig zu machen.

Das Memorandum empfiehlt sieben umweltpolitische Initiativen, um die Wasserkraftnutzung mit den gesetzlichen Zielen des Gewässer- und Biodiversitätsschutzes zu harmonisieren und so Zielkonflikte zwischen Klima- und Biodiversitätsschutz zu entschärfen. Erfreulicherweise wurden Teile der Empfehlungen (nur für neue Wasserkraftwerke) in den Gesetzentwurf "Osterpaket 2022" der Bundesregierung übernommen, was heftige Reaktionen der Wasserkraft-Verbände hervorrief.

S08: Plankton ecology

Consequences of nitrogen and phosphorus limited autotrophs for herbivores growth: an experiment testing co-limitation theory in the plankton community context

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Autotroph communities are often growth-limited by essential nutrients such as nitrogen (N) and phosphorus (P). The magnitude of limitation and whether N, P, or both are limiting growth depends on their supply and ratios. Previous studies identified single, serial or co-limitation as predominant limitation outcomes in phytoplankton communities. Little is known about consequences of such scenarios for herbivorous zooplankton and whether their growth is primarily affected by changes in phytoplankton quantity or nutritional quality. We grew a community of phytoplankton species of various food quality aspects at varying N and P concentrations resulting in three N:P ratios. At carrying capacity, N, P, both N&P or none were added to reveal what is limiting. The rotifer Brachionus calyciflorus was fed the nutrient-supplied communities to investigate how changing phytoplankton biomass and community composition affect zooplankton abundance. We found phytoplankton growth being limited either singly or serially by N, altering food available for rotifers. Rotifer growth showed a different response pattern compared to phytoplankton, suggesting an effect of food quality aspects apart from food quantity. While the combined addition of N and P to phytoplankton had generally a positive effect on zooplankton growth, adding non-limiting nutrients had a rather detrimental effect probably due to stoichiometrically imbalanced food in terms of nutrient excess. Our experiment shows that adding nutrients to phytoplankton communities will not always lead to increased phytoplankton and zooplankton growth, and that differences between phytoplankton and zooplankton responses under co-limiting conditions can be partly well explained by concepts of ecological stoichiometry.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Von Symptomen und Ursachen - Diagnose in der Fließgewässerökologie

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Ähnlich der medizinischen Diagnose verfolgt die Diagnose in der Fließgewässerökologie das Ziel, anhand von Symptomen potenzielle Ursachen einer Degradation zu identifizieren. Zusätzlich erfolgt eine Hierarchisierung dieser Ursachen entsprechend der Wahrscheinlichkeit, mit der sie die Degradation bedingen. In Fließgewässern stellen biologische Metrics die Symptome potenzieller Degradationsursachen des ökologischen Zustandes dar.

Basierend auf WRRL-Monitoring- und Landnutzungsdaten von 783 Gewässerabschnitten in Baden-Württemberg, wurden für die Fließgewässertypgruppen Mittelgebirgsbäche (n = 416), Mittelgebirgsflüsse (n = 246) sowie Bäche und Flüsse des Alpenvorlandes (n = 121) anwender:innenfreundliche Online-Werkzeuge zur Unterstützung der Diagnose von Degradationsursachen implementiert. Grundlage dafür waren Bayesische Netze (BNs), die Ursache-Wirkungsbeziehungen darstellen und unter Berücksichtigung von Unsicherheiten modellieren können. Expert:innen waren von der Entwicklung der BNs bis hin zur Testung der Online-Werkzeuge aktiv eingebunden.

Neben bewertungsrelevanten Metrics enthalten die drei BNs weitere diagnostisch nutzbare Metrics. Für einige Metrics konnten über alle Typgruppen hinweg gemeinsame Ursache-Wirkungsbeziehungen ermittelt werden (z.B. thermische Belastung und % Epirhithral-Besiedler oder veränderte Strömungsdiversität/Tiefenvarianz und Rheoindex). Andere Metrics zeigten Fließgewässertypgruppen-spezifische Reaktionen (z.B. % Landwirtschaft im Einzugsgebiet und % Pelal-Besiedler oder veränderte Breitenvarianz und % Zerkleinerer). Die BNs der Mittelgebirgsbäche sowie der Bäche und Flüsse des Alpenvorlandes umfassen 15 Metrics und zehn potenzielle Degradationsursache. Das BN der Mittelgebirgsflüsse berücksichtigt 13 Metrics und neun potenzielle Degradationsursachen.

Die Testung der Online-Werkzeuge durch die Expert:innen zeigte, dass die Unsicherheit bei der Diagnose potenzieller Degradationsursachen variiert. Während die Testung für einige Parameter eine gute Übereinstimmung zwischen Expert:inneneinschätzung und Diagnoseergebnis gab (z.B. veränderte Strömungsdiversität/ Tiefenvarianz oder erhöhter Feinsedimentanteil), ergab sie für andere eine mäßige bis geringe Übereinstimmung (z.B. thermische Belastung oder Breitenvarianz).

Die Diagnose potenzieller Degradationsursachen unterstützt die Ableitung von Maßnahmen zur Verbesserung des ökologischen Zustandes und gibt zusätzlich Hinweise auf eine potenzielle Maßnahmenhierarchisierung. Hierdurch kann eine bessere Abstimmung der Maßnahmenpläne auf die Monitoringprogramme erreicht werden.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Indirect evolutionary facilitation in a predator-prey system

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Genetic diversity is a fundamental requirement for adaptation and it has been suggested that evolution in an interacting species can buffer environmental perturbations to prevent population decline and extinction. However, the conditions for when and how this happens are not completely understood. Building on the concept of indirect evolutionary rescue (Yamamichi & Miner 2005), we present a study combing results from experiments and model simulations to introduce the idea of indirect evolutionary facilitation. Specifically, we present experimental results testing how genetic variation in defense (i.e., protection against the predator) and competitiveness (i.e., growth) traits in a prey population contributes to the rescue a predator population when exposed to a perturbation. We used different clones of the green algae Chlamydomonas reinhardtii that differ in their defensive and competitiveness traits as prey, the rotifer Brachionus calyciflorus as predator and microplastic particles as an external perturbation. The microplastics directly affects the predator food acquisition and thus indirectly its growth. We tested how the persistence of the predator depended on the combinations of traits and the strength of the perturbation. We found that microplastics reduced both ingestion and growth rates of the predator with different patterns depending on prey traits. We then found that large genetic variation in the prey population allowed the persistence of the predator population up to a certain amount of microplastics. Overall, the recognition of indirect evolutionary processes will provide important new insights for predicting the survival of populations after a disturbance and future responses to environmental changes.

S06: Coupling biofilm biodiversity and biogeochemistry with habitat heterogeneity across spatio-temporal scales

Life in a tumbling world - Microbial community structure and function in migrating streambeds

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The bed of running water ecosystems are hotspots of biodiversity and biogeochemical processes with global relevance. Lowland streams and rivers hold sandy sediments that are mobile already at low flow and typically form migrating ripples that can cover 20 to 100% of the bed area. In these bedforms, benthic microbial communities of bacteria and protists are exposed to frequent moving-resting cycles of the sediment grains. Laboratory experiments have shown that migrating ripples hamper benthic communities' abundance and metabolic functioning. This study aimed to characterize microbial community structure and their metabolic functions from migrating ripple and stationary sediment patches. We collected samples from five lowland streams in northern Germany between May and June 2020. Migrating ripple patches had coarser sediments with higher oxygen concentrations than stationary patches. We found that migrating ripple patches had significantly less organic matter, chlorophyll a, bacterial abundance, and fungal abundance (ITS gene copies) than stationary sediment patches. The pigment composition of migrating ripple communities was dominated by Fucoxanthin (common in diatoms), whereas stationary sediment communities were composed of Chl b, Lutein, beta-Carotin, and Zeaxanthin (common in green algae and cyanobacteria), and Fucoxanthin. Besides, metabarcoding revealed that the community structure of bacteria, fungi, and micro-eukaryotes, was shaped by bedform migration. In terms of metabolic function, net community production and potential extracellular enzyme activities were significantly lower in migrating ripples than in stationary patches, whereas community respiration and bacterial production remained comparable. Interestingly, migrating ripple communities required more nitrogen and phosphorous than carbon compared to stationary communities. Our results show that, by modulating the structure and metabolic functioning of microbial communities, migrating bedforms add an essential dimension to streambed heterogeneity with implications for the flow of matter through the benthic food web.

S01: Aquatic viruses

Indirect effects of abiotic conditions slow down eco-evolutionary dynamics of host and virus

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The pattern and pace of host-parasite coevolution can be affected by the abiotic environment if the host and/or parasite are poorly adapted to their local environment, for example when environmental conditions change. Because the completion of the parasite's life cycle depends on the fitness of the host, the evolutionary dynamics of the parasite are also indirectly influenced by the degree of host environmental maladaptation, even when the abiotic environment does not directly affect the parasites' fitness. The dependency of the parasites' evolution on the hosts level of maladaptation is not fully understood. Here, we examined the pattern (Arms Race Dynamics, Red Queen Dynamics), the repeatability and pace of host-parasite coevolution in an algal-virus system along a gradient of four abiotic conditions that directly affect the algal host. We followed the eco-evolutionary dynamics of host and virus in replicated populations over dozens of generations and determined host resistance and virus counter-adaptation through time-shift experiments. The evolution of the virus slowed as the host became more maladapted to its environment. At the same time, the pace of host resistance was unaffected, as the host population adapted quickly to the counter adaptations in the virus population, independent of the environmental gradient. In our experiments the failure of the host to adapt to the changed environmental conditions, resulted in differences in the overall population sizes of the virus. This suggests that limited mutation supply due to lower population sizes indirectly affected the adaptability of the virus population.

S08: Plankton ecology

Stocking with parasite pre-exposed brown trout to immunise feral trout populations to Proliferative Kidney Disease.

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Feral trout populations have shown significant declines in the last decades even after corrective habitat measures have been carried out. These recent declines have been attributed to ongoing global warming in combination with a temperature dependent proliferative kidney disease (PKD). The parasite that causes this disease (Tetracapsuloides bryosalmonae) has a wide European distribution. In order to save local populations, it is therefore urgent to test and develop methods that may mitigate the deadly effects of the disease.

In aquaculture, a working approach to lower PKD caused trout mortality, has been pre-treatment of standing stock with the parasite. Such parasite pre-exposed fish are kept at cool water temperatures (< 15 °C) at which the fish acquire resistance, while the parasites do not result in clinical disease. To extend this approach on PKD affected feral populations of brown trout (Salmo trutta), three trout streams in southern Germany were stocked with parasite- and control- treated brown trout in autumn 2020 and spring 2021. Exposure was carried out with local parasite spores at PKD sub-lethal temperatures (14 °C). The fish were then recaptured in summer and autumn to check for local establishment and PKD clinic.

A wetter than normal winter resulted in unexpectedly high local recruitment of feral trout. Over summer, these likely competed for space with the stocked experimental trout. Therefore, both the control and parasitized stocked trout showed very low recapture rates (< 1 %) in the study area, invalidating the statistical comparison between treatments. However, as expected, stocked parasite treated trout showed lower parasite prevalence and kidney clinic than control or feral trout. In the light of the urgency need to respond to climate change, this results thus calls for further development of this approach.

A1: Aquatic Ecotoxicology

Effects of the fungicide azoxystrobin and wastewater effluent on microbial communities and the key shredder *Gammarus fossarum* Koch, 1836

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Freshwater ecosystems are an important water resource and are under constant pressure due to human impact. Fungicides as well as wastewater are two of the major problems and their impact on aquatic communities is still not clearly understood. The aim of this thesis is to show the impacts of elevated nutrient concentrations and exposure to the fungicide azoxystrobin on *Gammarus fossarum* and leaf-associated fungal communities under laboratory conditions. The gammarids as well as leaves were exposed to stream water, wastewater and both, each with an azoxystrobin concentration of 40µg/L for three weeks. To determine the effects on the gammarids, the mortality, the feeding activity, and the respiratory electron transport system (ETS) were measured. Ergosterol as an indicator of fungal biomass and spore morphology for identification of the fungal community was used to assess the impact on the leaf-associated fungal communities. Due to a high number of deformed spores, this was used as another response variable. Results show a decrease in the feeding activity from stream water to stream water with azoxystrobin to the wastewater to wastewater with azoxystrobin. The ETS activity also shows a decrease in every treatment except of the wastewater with azoxystrobin. Regarding the fungal biomass, the wastewater as well as the fungicide does not seem to have a strong impact. The gammarids increase the spores per fungal biomass and day and decrease the relative amount of spore deformation. In conclusion, the wastewater seems to have a stronger influence on the gammarids than the fungicide, and the gammarids a stronger influence on the spores than the wastewater.

A non-invasive eDNA metabarcoding time series analysis provides phenological insights into stream invertebrate community dynamics

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The assessment of macroinvertebrates in streams still relies mostly on traditional sampling and processing methods, which are invasive and time-consuming and hence only carried out infrequently, for routine monitoring only once every 3-6 years. However, to uncover stream invertebrate community dynamics and phenological changes it is crucial to obtain continuous data throughout the year. With the help of eDNA metabarcoding the assessment can be done more frequently as the sampling is simple and minimally invasive. Here, we assessed the potential of eDNA metabarcoding to assess phenological patterns in a macroinvertebrate community at a long-term ecological monitoring list (River Kinzig, Rhine-Main-Observatory, LTER site). We sampled a near-natural sampling location in bi-weekly intervals for 15 months in 2017 and 2018 at three microhabitats within the stream: 1. surface; 2. riverbed; 3. riverbank. We used two different primer pairs for the analyses of our water samples: A more universal primer pair (BF2/BR2), which also amplifies non-target groups such as microalgae and bacteria, and a more specific one for aquatic invertebrates (fwhF2/EPTDr2n). The specific invertebrate primer pair much better characterized invertebrate biodiversity with 99.7% of the reads and 3825 OTUs (2840 aquatic/985 terrestrial) being assigned to invertebrates compared to the universal primer with 11.4% / 339 OTUs (273 aquatic/66 terrestrial) assigned to invertebrates. No differences between the three microhabitats sampled was detected but we found a strong seasonal pattern for the macroinvertebrates for both primer pairs. The highest number of macroinvertebrate species could be found in winter and the lowest number in summer, especially in August. For the invertebrate specific primer pair ß-diversity showed a cyclical pattern between sampling times. These results demonstrate the usefulness of eDNA metabarcoding in uncovering seasonal patterns and show that even between small timeframes shifts in ß-diversity can be detected.

S08: Plankton ecology

Suicidal cell death as a survival strategy by green algae

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The aquatic organisms, including green algae, are regularly experiencing high water temperatures. The high temperatures are partly because of global warming-induced climate change. The effect of increased water temperatures on aquatic organisms and their survival strategies are widely investigated. We are investigating the impact of high temperatures on green algae using Chlorella, Chlamydomonas, and other related algae as study organisms. These algae have been isolated from most parts of the world, and likely use different strategies to survive in different temperatures. Some algae are free-living, whereas others live in endosymbiotic (living inside other organisms) association with ciliates such as Paramecium. We exposed both the symbiotic and the non-symbiotic algae to high temperatures (45 °C) and followed the effect of heat shock after regular time intervals. We observed that the symbiotic algae were more sensitive to heat shock than the non-symbiotic algae. Heat shock led to a sharp decrease in the photosynthetic pigment of the symbiotic algae, and the cells became photosynthetically inactive. These changes were not observed in the non-symbiotic algae. Eventually, the heat shock induced cell death in the symbiotic algae. We used various molecular and cellular assays and found that the heat-shock-induced cell death appears suicidal (like programmed cell death in plants and animals). The media collected after cell death (cell-free supernatants) were beneficial for the clones of symbiotic algae and their host. These results suggest that algae use various strategies to survive at high temperatures, such as forming a symbiotic association with other organisms and suicidal cell death, which is beneficial for the rest of the population.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Modernes Lehren und Lernen in der Limnologie: Beispiel einer digitalen Lehreinheit zur Biodiversität der Protisten

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Digitale Lehr-/Lerneinheiten an Schulen und Universitäten sind nicht erst seit der Covid-Pandemie zu einem gängigen Mittel der Wissensvermittlung geworden.

Im geplanten Vortrag soll ein Beispiel für eine digitale Lehr-/Lerneinheit im Themenbereich eukaryotischer Zellen gezeigt werden, bei dem der Fokus auf der Diversität von Protozoen und einiger typischer mehrzelliger Eukaryoten in einem Gewässersystem liegt. In der digitalen Lerneinheit wird dargestellt, wie Studentinnen und Studenten sich dem Thema der Diversität eukaryotischer Zellen selbständig nähern können; es wird aber auch auf weitere Möglichkeiten zur selbständigen Erarbeitung dieses Themenbereichs eingegangen.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Stream food web restoration: The recovery trajectory from open sewers to mature urban streams

Alexandra Schlenker[1]; Mario Brauns[1]; Patrick Fink[1]; Armin Lorenz[2]; Anna Tausch[1]; Markus Weitere[1]

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Restoration of degraded ecosystems has never been more urgent, given the ongoing global deterioration of streams and rivers. Restoration success is commonly assessed via structural components, such as community diversity and composition. However, assessments of structural components alone often struggle to identify processes inhibiting recovery. Further, recovery of structure does not guarantee recovery of functions and water quality. Food web analysis provides a powerful tool to evaluate restoration success, as it links the community's structure to its functions. In addition to that, the effect of restoration age remains rarely studied, but it can take time post-restoration for communities and food webs to mature. Here, we analyse macroinvertebrate food webs along a recovery gradient to test if trophic niche width is related to the time since restoration. We studied streams in the Boye catchment (North Rhine-Westphalia, Germany), that had been transformed into open sewers with concrete beds to transport wastewater in the beginning of the 20th century. The restoration, which included the removal of wastewater inputs and channelization, and the reconstruction of near-natural river beds with riparian vegetation started in 1993. Macroinvertebrates from streams in the Boye catchment with different restoration ages were sampled annually since 2012. We analysed stable isotopes (δ13C, δ15N) from those archived samples, calculated food web indices to identify patterns of food web responses to restoration, and compared these indices to traditional functional feeding group metrics. Our data shows an initial increase in the proportion of predators, but this declined again approximately five years post-restoration. Moreover, food chain length appeared to increase with time since restoration. Overall, this talk will demonstrate the value of food web analysis and give insight how to identify trophic patterns for evaluating restoration success.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Habitats and macrozoobenthos in beaver-influenced low mountain streams with special focus on beaver dams

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Beavers and their dams, once common in small streams throughout the palearctic zone, are returning to their original range. The resulting beaver ponds, secondary streams, beaver meadows and a large amount of deadwood change and diversify the appearance and biocenosis of the stream ecosystems.

We studied how beaver activity affects the macrozoobenthos community 2018 and 2019 in low mountain streams in the northern Eifel (NRW), where beavers were reintroduced in 1981. In order to find out which macrozoobenthos communities colonise beaver-induced habitats and how these differ from beaver-uninfluenced stream sections, we investigated lotic and lentic habitats in water stretches with and without beaver influence. Habitats were differentiated by substrate type and flow velocity, and compared in terms of species composition, feeding types and flow preferences. One focus of the study was the beaver dams themselves, which were sampled taking into account their maintenance status. Nine different areas covering the top, middle and base zones of eight maintained and eight abandoned beaver dams i.e., dams that are still and no longer repaired by the beavers, were sampled using a specially designed suction device.

Our results show that the influence of the beaver leads to a higher diversity of the species community overall. Especially beaver dams, which offer a great diversity of environmental conditions and habitat types, turned out to be hotspots of biodiversity.

Here, taxa community composition reflected higher flow velocities in the middle and lower areas of a dam, where passive filter feeders predominate (e.g., Simuldidae, Hydropsychidae, Philopotamidae). The lack of maintenance reduces the flow velocity in abandoned dams, which leads to an increase in trickle areas and thus enables the occurrence also of species using atmospheric oxygen e.g., Dianous coerulescens. Within the top of a dam, on the other hand, shredders e.g., representatives of the Limnephilidae, were particularly common.

S08: Plankton ecology

Rotifer response to oligotrophication, warming and stickleback invasion

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Rotifers represent important components of pelagic food webs, but their responses to environmental changes are still poorly studied. Here we use the long-term data set of rotifers in Lake Constance to study the response of rotifer biomass and community composition to oligotrophication, warming, and the habitat expansion of sticklebacks. Rotifers were sampled in the Überlinger See, a fjord-like appendix of Upper Lake Constance during the 1985-1996, a period with still total high phosphorus concentrations, and during 2006-2018 with total phosphorus concentrations below 10 µg/L. The latter period can be divided in a period (2006-2011) in which whitefish was the dominant planktivorous fish in the lake and in a subsequent period (2012-2018) in which whitefish was replaced by sticklebacks as dominant planktivorous species. Comparison of these three periods thus will allow us to distinguish between the effects of bottom-up versus top-down forcing on a rotifer community. From the first study period (1985-1996) to the 2nd and 3rd study period (2006-2018) total phosphorus concentrations declined strongly resulting in an average ~ 50 % decrease of rotifer biomass during March-December. Rotifer biomass decreased despite warmer temperatures during early spring resulted in an earlier start of the rotifer population growth in the 2nd and 3rd compared to the 1st period. On average, most rotifer genera declined with oligotrophication, notable exceptions were Asplanchna, Kellicottia and Polyarthra. The habitat expansion of sticklebacks starting in 2012 did not change total rotifer biomasses, but resulted in changes in rotifer community structure. For example, Synchaeta spp. decreased further in biomass, whereas several genera (e.g. Gastropus, Filina, Ascomorpha) tended to increase again even to biomasses typical during the eutrophic period.

A1: Aquatic Ecotoxicology

A multiple-line of evidence approach to assessing the toxicological potential and ecological impacts of agricultural run-off in small streams

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Small streams and shallow ditches are wide spread components of agricultural landscapes and frequently exposed to agricultural mixtures of fertilizers and pesticides. Despite their importance as habitat for a wide range of organisms and provision of important ecosystem functions like primary production or the retention and transformation of pollutants, they are not included in regular monitoring programs like the water framework directive. Data on toxic effects of agricultural stressors are lacking, both, from an effect-based perspective as well as from field surveys of autochthonous communities.

This contribution outlines a 'multiple-line of evidence approach' merging different assessment strategies for phytotoxicity applied during the German-wide 'small-stream monitoring program' from 2018 to 2021. Effect-based monitoring was performed using a diagnostic high-throughput algal assay assessing the phytotoxic potential of >100 SPE-samples taken during rain events and showed good correlations with toxic units of site-specific pesticide profiles. The benthic diatom assemblages from 65 sampling sites were characterized using a metabarcoding approach revealing a total of 4008 ASVs (identified as 208 species). Multivariate statistics based on ASVs discriminated clusters for sites characterised by high toxicity or nutrients. We conclude (a) that agricultural streams are exposed to a high phytotoxic risk and (b) that diatom communities in agricultural landscapes reflect the effects of pesticides and/or nutrients. The multiple-line of evidence approach will be discussed in terms of the applicability for monitoring to assess impacts from agricultural run-off on small streams.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Mikroplastik im Wasser – Modellexperimente für die Umweltbildung und einen interdisziplinären Unterricht in den naturwissenschaftlichen Fächern

Wolfgang Schmitz

PH Karlslruhe

Als Mikroplastik werden Plastikteilchen bezeichnet, die kleiner als 5mm sind. Mikroplastikpartikel entstehen, wenn Kunststoffmüll durch den Einfluss von Sonnenstrahlen, Luft oder Wasser in kleine Einzelteile zerfallen. Schon seit längerem sind die hohen Konzentrationen von Mikroplastikpartikeln in den Ozeanen bekannt mit erheblichen bis sogar tödlichen Auswirkungen auf Meerestiere. Bekannt sind Bilder von Albatros-Kadavern, deren Mägen voller Plastik sind. Auch Berichte über Wale, in deren Verdauungstrakt meterlange Kunststoff-Folien gefunden wurden, gingen durch die internationale Presse. Aber auch in Binnengewässern konnten Mikroplastikpartikel nachgewiesen werden.

Bekannt, aber von vielen kaum wahrgenommen ist die Tatsache, dass Mikroplastikpartikel für die Produktion zahlreicher Kosmetikartikel, wie beispielsweise Duschgele sowie Peelings, eingesetzt werden. Diese Mikroplastikpartikel werden in der Regel nicht aus den Abwässern entfernt und gelangen so ungehindert in Seen, Flüsse und Meere. Diese Thematik ist derzeit hochaktuell in der Umweltforschung.

Zu dieser hochaktuellen Thematik werden Modellexperimente entwickelt [1-3], die einen Beitrag zu einer besseren Umweltbildung darstellen sollen. Aktuelle Forschungsergebnisse aus den Umweltwissenschaften können so mit Hilfe dieser Experimente dem Bildungssektor für die Aus-, Fort- und Weiterbildung zur Verfügung gestellt werden.

Aber auch Lösungen dieser Problematik sind gefragt [2,3] und werden im Vortrag angesprochen.

Die entwickelten Experimente eignen sich, um Aspekte der Chemie, der Umwelttechnik und der Lebenswelt mit Hilfe von Basiskonzepten des Chemieunterrichts anschaulich zu verknüpfen.

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S09: Auen

Benefits of multifunctionality in Floodplain Restoration: An ecosystem service approach to assess the Case Study “Lebendige Luppe” - Restoration Project in Leipzig’s Urban Floodplain Forest (Elbe Catchment/Germany)

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With the European Biodiversity Strategy and the goal of restoring at least 25,000 km of free-flowing European rivers by 2030, an important political step has been taken. In the Elbe catchment many projects for floodplain and river restoration have started, but only a few have been finished. One of the larger projects in Germany is the revitalisation project “Lebendige Luppe” in the Leipzig agglomeration started in 2012. The objective is the revitalization of the floodplain ecosystems, with one of the largest urban floodplain forests in Germany. One of the main objectives is to improve floodplain dynamics by inundation to increase the quality of the habitats for plants and animals, and to maintain and increase its ecosystem services for people. Unexpected events like the flooding events in 2011 and in 2013 inundated the study area and showed the potential of the former river dynamics in the project area.

The presentation will give a short overview of floodplain restoration projects in the German Elbe catchment and present more in detail the project “Lebendige Luppe” with its planning challenges and related ecosystem services in a strongly modified hydrological river and floodplain network in an urban context.

Possible hydrological scenarios describe the future situation and allow the future performance of these ecosystem functions and services to be estimated (e.g. habitat provision, flood and nutrient retention, carbon sequestration or cultural services like nature based recreation).

A3: Grundwasser und Quellen

Quellschutz in der Praxis – Aktivitäten des LBV zu Optimierung und Erhalt von Quellstandorten in Bayern

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Landesbund für Vogelschutz (LBV)

Einleitung

Der bayerische Naturschutzverband LBV setzt sich bereits seit Anfang der 1990er Jahre für einen flächendeckenden Quellschutz in Bayern ein. Während zu Beginn zunächst kleinere regionale Projekte im Fokus standen, wurden bereits wenige Jahre später mehrere große Quellschutzprojekte mit verschiedenen Kooperationspartnern durchgeführt (darunter ein LIFE-Natur-Projekt (2004-2007), ein Waldquellenprojekt (2007-2011) und das Aktionsprogramm Quellen (2001 bis 2008).

Als zentrales Ergebnis des Aktionsprogramms Quellen, das in Kooperation mit dem Bayerischen Landesamt für Umwelt (LfU) durchgeführt wurde, wurde eine Handlungsanleitung für den Quellschutz erarbeitet und veröffentlicht. Diese enthält unter anderem einen Maßnahmenkatalog für den Quellschutz, der konkrete Maßnahmen und Umsetzungsmöglichkeiten für beeinträchtigte Quellen aufzeigt. (www.bestellen.bayern.de).

Aktuelle Tätigkeiten

Das Projekt „Quellschutz in Bayern“ wird seit Anfang 2009 durchgeführt. Es ist das Nachfolgeprojekt zum Aktionsprogramm Quellen. Eine wesentliche Zielsetzung des Projektes ist es, möglichst umfassend Maßnahmen zu initiieren, die den Erhalt, die Optimierung oder die Wiederherstellung von Quellen sowie deren Umfeld und der Oberläufe zum Ziel haben. Die Erfassung des Ist-Zustandes und die Erarbeitung von Maßnahmenvorschlägen gehen dem voran.

In den vergangenen Jahren konnten bereits zahlreiche Maßnahmen an verschiedensten Quellstandorten in Bayern initiiert und umgesetzt und so ein wesentlicher Beitrag zum Schutz und Erhalt von Quellen und der auf sie angewiesenen Tier- und Pflanzenwelt geleistet werden. Dabei hat es sich bewährt, dass der LBV bei geplanten oder zur Umsetzung anstehenden Quellschutzmaßnahmen zur Unterstützung herangezogen werden konnte. Dies wurde sowohl von den Fachbehörden, aber auch von den Ämtern für ländliche Entwicklung, Kommunen, dem Forst oder auch Privatpersonen in Anspruch genommen.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Effects of multidimensional light fluctuation on phytoplankton growth and community structure

Brian Schulze[1]; Nils Hintz[2]; Maren Striebel[2]; Alexander Wacker[1]

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Light is one of the basic resources used by autotrophic organisms, but its quality (spectrum) and quantity are not constant and fluctuate over different spatio-temporal scales. While the effects of light intensity and its fluctuations on phytoplankton were investigated, the effects of light quality, especially its variation, are rarely considered. We disentangled the effects of light quality and quantity on a natural phytoplankton lake community by exposing it to different constant and fluctuating light intensity and quality conditions: Treatments followed a two-factorial design combining an intensity gradient with different spectral regimes, based on underwater light attenuation conditions. We found that under constant conditions (1) phytoplankton biomass was mainly influenced by light intensity, while (2) the spectral composition was a good predictor for the ratio between chlorophytes and cyanobacteria, representing the two dominant groups. Our results demonstrate that changes in light intensity and shifts in the light spectrum within natural systems will likely affect phytoplankton growth and community composition, depending on the species' light-harvesting strategies. Results from the constant conditions were used to calculate predicted outcomes under fluctuating conditions and compared to measured results. These findings may be the first step to improving knowledge about the importance of fluctuating light conditions for phytoplankton growth and competition, not only in intensity but also in the quality of light.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Effects of agricultural land use on river biota – a meta-analysis

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Agriculture, the world's most dominant land use type, burdens freshwater biodiversity with a multitude of stressors such as diffuse pollution and hydromorphological alteration.

However, it is difficult to directly link agricultural land use with biota response as (1) agricultural stressors can also be caused by other drivers, (2) there is also evidence for positive effects of agriculture for organisms, (3) agricultural stressors affect organism groups at different severity, and (4) agricultural response differs strongly with organism groups, biological metric and study region.

Against this background, our study aimed at assessing, if agricultural land use has a consistent effect on river biota across temperate climate zones.

We conducted a meta-analysis based on a systematic literature search, yielding studies for which effects of agricultural land use on freshwater biota could be calculated. For 24 studies and 40 relationships of agricultural intensity and aquatic organism groups, we calculated the standardized mean difference Hedge´s g and ran a (three level) meta-analysis with subgroup analysis.

We detected a strong overall effect of agricultural land use on freshwater biota, which was independent from organism type and ecoregion, and which accounted for a difference of nearly 1 standard deviation between treatment and control groups. Differences in biota response could be observed between sensitive and tolerant macroinvertebrates, with sensitive taxa being strongly impaired and tolerant taxa even benefiting.

This meta-analysis provides a quantitative literature overview on the impact of agriculture on freshwater organisms and renders detailed information on metrics best suited to assess agricultural response.

Monitoring the ‘ecological reanimation’ of a stream: environmental DNA metabarcoding time series at the river Emscher

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The river Emscher was formerly known as the dirtiest river of Europe, serving as an open sewage system for the past 170 years. With the paradigm change in restoration and nature conservation efforts and the end of coal mining in the Ruhr area, one of the largest river restorations is ongoing. A key event was the implementation of an underground wastewater sewer in December 2021, which banned pollutants to the sewage channels. The rate and order of the returning flora and fauna to the river system is of particular interest and offers a unique opportunity for understanding river restoration and repopulation. The analyses of DNA traces left behind by organisms in their environment offers a time and cost-efficient way of monitoring the changing Emscher. This so-called ‘environmental DNA metabarcoding’ (eDNA metabarcoding) allows for the detection of multiple taxonomic groups from water samples and therefore multi-trophic analyzes with minimal sampling effort. In a first study, we monitored the Emscher before the complete elimination of wastewater. At that time, different river sections were in different ecological and restoration stages. We compared the detected fish, invertebrate and diatom community to the nearby natural river Lippe and then between different sections within Emscher. We found significant differences in the community composition between these sites across the three taxonomic groups, underlining the potential of eDNA metabarcoding for bioassessments. Since the wastewater elimination in 2022, we started monthly sampling 18 river sites for a fine scaled monitoring of the ongoing change. With the data from the first study, we have a baseline to which we can compare the future biodiversity development. This will allow for a detailed documentation of species return of a formerly highly impacted river.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Investigations concerning a population of *Chondrostoma nasus* in the river Nidda, Hesse

Louis Sollinger

The common nose carp *Chondrostoma nasus*, a in Europe broadly distributed member of the cyprinid-family and inhabitant of medium to large sized rivers, got extinct in the river Nidda near Frankfurt am Main in the 1960s due to habitat degradation and water pollution. Goal of my research was to verify if a reintroduction program initiated in the 1980s was successful and whether the species now inhabits it whole former habitat range within the river Nidda.

During my master thesis I worked with a comparative dual method approach including conventional electric and seine-net fishing as well as a newly refined method using grazing plates to analyse distribution and habitat use of C. nasus in the river Nidda. Additionally, I tried to correlate the influence of biofilm maturation and chlorophyll-a grammage on the grazing substrata to feeding preference of the *C. nasus* population.

My results indicate a successful reintroduction of C. nasus in the river Nidda, even though not the whole historical habitat range was repopulated due to a lack in habitat quality. Detection of *C. nasus* populations by placing artificial grazing substrata proved to be a reliable method for verifying the presence of the species. The advantages of the method are a cost-efficient, easy-to-use setup, the relative less disturbance caused in the habitat and the fact that no permission is required for using it. Interestingly *C. nasus* individuals seem to have a preference for a certain succession stage of benthic biofilms. According to my results chlorophyll-a grammage doesn't seem to be the cause and I'll discuss other possible reasons for this shortly.

S08: Plankton ecology

Cyanobacteria-mediated food quality affects responses of *Daphnia magna* life history traits and heat tolerance to elevated temperature

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Warming surface waters can push aquatic organisms closer to their thermal tolerance limits. Cyanobacteria, however, are expected to increase with rising temperature, enhancing the likelihood of poor-quality food available for herbivorous zooplankton. Zooplankton can adapt locally by genetic differentiation or via adaptive phenotypic plasticity to increasing temperatures, but there is limited knowledge on how these processes may be affected by food quality limitation imposed by cyanobacteria. To test the effects of cyanobacteria-mediated food quality on local temperature adaptation, we measured juvenile somatic growth and reproduction of Daphnia magna clones from different latitudinal origin grown on varying food qualities at different temperatures. We additionally estimated short-term heat tolerance, measured as knockout time at lethally high temperature, of clones acclimated to different temperatures and food qualities to test for the effects of food quality on adaptive plastic responses. Southern clones showed in average better somatic growth and reproduction than northern clones at elevated temperatures. However, the difference in somatic growth diminished with increasing cyanobacteria in the food, suggesting constraints on local genetic adaptation under predicted increases in food quality limitation. Short-term heat tolerance generally increased with increasing acclimation temperature. However, heat tolerance of animals acclimated to the highest temperature was larger when grown at medium than at good food quality, whereas the opposite pattern was observed for animals acclimated to the lowest temperature. This suggests a better adaptive phenotypic response of animals to elevated temperatures under higher cyanobacteria abundance. Thus, we demonstrate that food quality limitation can mediate responses of *D. magna* life history traits and heat tolerance to increasing temperatures in different directions depending on the time scale studied, i.e. mid-term (somatic growth) vs. short-term (acute heat tolerance). These aspects will need further attention in light of how zooplankton adapts to future global warming.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Life in beaver dams - A study focusing on macroinvertebrates in beaver dams in a lowland region in Germany

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Universität Duisburg-Essen, Campus Essen

The ongoing spread of beavers in Germany comes along with fundamental changes in the appearance of streams. Beavers increase the heterogeneity of ecosystems, as their dam building activity transforms streams into mosaics of standing and flowing sections. Additionally, beaver dams themselves are three-dimensional structures which provide suitable habitat to several organisms. A variety of studies have already been conducted regarding the influence of beavers on other organisms. Still, only a handful of them focused on organisms directly inhabiting the beaver dams. Following a newly established method and pattern for macroinvertebrate sampling in beaver dams, which was applied in a study on macroinvertebrate communities in beaver dams in a mountainous region, the aim of this study was to gain insight into macroinvertebrate communities in beaver dams in a lowland region with particular focus on macroinvertebrates in different vertical dam areas. Therefore, several aspects of the macroinvertebrate communities were studied, such as abundance, taxa richness, community composition, diversity and functional groups. Additionally, environmental, dam, pond and water parameters were protocolled to allow for a characterization of the conditions at each site. A total of eight beaver dams were sampled by taking seven subsamples per dam: three in the bottom, three in the middle and one in the top dam area. 23,089 macroinvertebrate individuals belonging to 123 taxa were identified. Distinct differences between the dams were found in regard to the macroinvertebrate community composition, whereas overall similarities existed in terms of functional community characterization. The macroinvertebrates inhabiting the beaver dams seem to be not only influenced by the dams themselves but also by other environmental parameters. Contrary to that, no distinct differences appeared regarding the community composition and functional groups of the three dam areas, indicating similar environmental conditions in different vertical beaver dam areas.

S08: Plankton ecology

Predator mediated feedback effects in natural plankton communities

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Biodiversity loss due to climate change is unquestionable and, in some areas, irreversible. While some species cope less well with higher water temperatures, others benefit. A well-known predator in planktonic systems is *Chaoborus sp.*. While this predator normally occurs in cycles, its presence is more and more constant throughout all seasons. As a very efficient but also selective predator in zooplankton, increased abundance can lead to shifts in the composition and diversity of the zooplankton community. These changes in the zooplankton can have lasting effects on nutrient recycling in the food web. For example, resources such as nitrogen and phosphorus are used differently by the respective zooplankton genera and are thus less or more available to the primary producers. This in turn can lead to changes in the composition of the primary producer communities, resulting in a shift in traits of the primary producers. The presence or absence of a predator can thus have a major impact on feedback mechanisms in plankton communities. While direct predator-prey effects are well known, there is a lack of knowledge about the above-mentioned feedback effects in natural plankton communities. Here, we present experimental data from eight different lakes that mainly show the changes in nutrient availability for phytoplankton caused by predator-mediated shifts in zooplankton communities. We discuss the resulting community compositions as well as phytoplankton biodiversity and possible implications for the food web.

A6: Nebiota und invasive Arten

Response of the pelagic food web to stickleback habitat expansion in Lake Constance

Dietmar Straile[1]; Pia Mahler[2]; Sabine Schmidt-Halewicz[3]; Angelika Seifried[2]; Karl-Otto Rothhaupt[2]

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Sticklebacks were first observed in Lake Constance in the 1950s and until 2012 they were found almost exclusively in the littoral zone. Since then sticklebacks colonized in increasing numbers the pelagic zone of the lake and dominate the pelagic fish community. In this contribution we compare differences in the biomass, composition, and size structure of the pelagic food web before and after 2012, i.e., differences possibly associated with the stickleback habitat expansion. Our results suggest that sticklebacks did not strongly change overall plankton biomass, but the composition and size structure of the food web.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Environmental stoichiometry mediates phytoplankton diversity effects on communities' resource use efficiency and biomass

Maren Striebel[1]; Miriam Gerhard[1]; Alexandra Schlenker[2]; Helmut Hillebrand[1]

[1] ICBM, Carl von Ossietzky Universität Oldenburg ; [2] UFZ - Helmholtz Centre for Environmental Research

Positive biodiversity-ecosystem functioning (BEF) relationships are predicted to increase in strength when high environmental variability allows for complementarity between resource use strategies in diverse communities. This environmental variability can be represented by spatial or temporal variation in nutrient ratios, but resource use efficiency (RUE) and therefore biomass build up might be restricted when nutrient ratios are highly imbalanced (i.e., limitation by one nutrient and beyond optimal ratios for growth). Whereas the linkages between ecosystem functioning, diversity and nutrient availability are theoretically well understood, we lack experimental evidence on how phytoplankton diversity affects resource use and biomass under variable nutrient ratios (N:P ratios).

Combining a mesocosm and a microcosm experiment we tested diversity effects on ecosystem functioning by exposing a species diversity gradient generated by the loss of rare species in a natural community to different N:P ratios (uniform vs a gradient). The N:P supply ratio gradient also allowed us to evaluate responses across balanced and imbalanced ratios.

We found that increased species diversity led to increased community RUE (and biomass) when supplied a gradient of N:P ratios. However, diversity did not affect RUE under uniform nutrient ratios. Thus, our results suggest that the effect of rare phytoplankton species losses on community RUE and biomass can be compensated by the persistent species when nutrient ratios are uniform, but leads to decreases in ecosystem functioning under variable nutrient ratios.

S09: Auen

Effects of lateral floodplain connectivity on biodiversity: high connectivity is associated with near-natural communities of flora and fauna in the floodplain

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Lateral river-floodplain connectivity, i.e., the hydrological connection between a river and its floodplain, is a key feature for functioning floodplain ecosystems. However, the relation between lateral connectivity and floodplain biota is not fully understood. The research project ElBiota examined if and how floodplains of different lateral connectivity differ in their biotic communities, and which environmental variables best explain these differences.

We chose four floodplain sections of the river Elbe as study areas, two of which are incised with the floodplain disconnected from the river, and two characterised by little erosion, allowing for higher lateral connectivity. In each of these sections, three different organism groups were surveyed along an inundation gradient: plants, ground beetles and molluscs. Soil samples and modelling of environmental conditions provided a high number of abiotic variables for each study plot.

For all three organism groups, species composition differed between regions with low and high connectivity as well as along the inundation gradient. PC axes representing local hydrology (e.g., inundation duration) and substrate type were best explaining community composition, followed by variables reflecting connectivity. In those regions with high connectivity, we found higher numbers of floodplain-specific species, indicators of wet grassland for all organism groups and, for ground beetles and molluscs, more red-list species. These results show that floodplains with a higher lateral connectivity do harbour a more near-natural, floodplain specific flora and fauna. Enhancing connectivity is therefore considered a key restoration measure for floodplains.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Theoretical implications on the energetic role of parasites and its benefits for the ecosystem

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Parasites play an important, yet often neglected role in plankton community dynamics via direct control of host species as well as indirect effects through community feedbacks. So far, only a few studies have investigated host-parasite interactions in a community context with most food web studies solely focusing at predator-prey interactions. Consumption of parasites can create additional energy pathways to consumers from otherwise inedible host species. One well-known example from aquatic systems is the consumption of the infectious stage of parasitic fungi, i.e. zoospores, by zooplankton following the infection of otherwise inedible phytoplankton hosts (mycoloop pathway). Therefore, we theoretically investigated the influence of parasite-mediated trophic interactions on energy flow and community dynamics in a simplified food web consisting of parasitic fungi, host and non-host phytoplankton species, and zooplankton feeding on non-host phytoplankton and parasitic fungi. The results show an increasing importance of energy flow through the mycoloop with increasing nutrient availability. In accordance with empirical observations, the model predicts that fungi can contribute up to 50% to total zooplankton diet. Differentiating susceptible and infected host cells in our dynamic model increases the abundances of species involved in the mycoloop and the possibility of boom-bust dynamics, where long periods of a quasi-stable community state with dominance of non-host phytoplankton are interrupted by abrupt changes in community composition. The results highlight the critical role of parasites for community dynamics with important implications for energy flow and species coexistence, in eutrophying ecosystems.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Flow reduction and biodiversity decline affect periphyton structural and functional characteristics

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The reduction of flow caused by climate change alters river ecosystems' biodiversity and functioning. In this work, we assessed how changes in flow velocity alter periphyton structural and functional characteristics and how these effects vary in the presence or absence of a diverse macroinvertebrate community. We grew periphyton on tiles in 8 experimental flow channels at two velocities: a "normal" flow of 0.25 m/s and an "extreme low" flow of 0.05 m/s. With this we assessed changes in periphyton structural (ash-free dry mass, chlorophyll-a, and taxonomic biodiversity) and functional characteristics (primary production -GPP, ecosystem respiration-ER, and dissolved oxygen isotope ratios). In 4 of the 8 channels, we added a diverse macroinvertebrate community, to test their effect on primary producers. Flow reduction changed the biofilms' structural characteristics producing a more heterotrophic biofilm compared to the autotrophic biofilm under a "normal" flow. The presence of a diverse macroinvertebrate community buffered the effects of flow reduction by enhancing the autotrophic component of the biofilms. Our results suggest that a healthy and biodiverse benthic community might mitigate the effects of climate-change-related shifts in flow velocity on ecosystem metabolism

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Man-made pond networks as a restoration measure for wetland biodiversity

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Wetlands are a major reservoir for continental freshwater and are among the richest ecosystems in terms of biodiversity and biomass, providing numerous ecosystem services to societies. Yet, the surface area of wetlands in Europe has decreased by 90% since the 18th century. In an effort to mitigate the loss of wetland habitats and associated biodiversity various restoration measures have implemented. One of the measures implemented to restore wetland habitats is the creation of pond networks.

However, the evaluation of man-made pond networks as management tool is hampered by a lack of understanding of the spatial biodiversity patterns in these networks. In the Emys-R project, the biodiversity patterns in two contrasted pond networks are investigated. One of these networks is located on the French-German border in the former floodplain of the Rhine, and one in Latvia in the Sitas Lake area close to the Belarus border.

In the PhD project of Karina A. E. van der Zon, we aim to understand how local environmental variables, ecological succession and connectivity influence the biodiversity in these created pond networks. Local environmental variables taken into account concern pond morphology, water quality and land use around the ponds. In order to study the alpha, beta and gamma biodiversity of the pond networks, traditional macrophyte and macroinvertebrate surveys are combined with macroinvertebrate, amphibian and fish eDNA analyses of water samples. The contribution of the individual ponds to gamma- and beta-biodiversity is assessed.

With this research, we aim to optimise the creation of pond networks as a method to restore wetland biodiversity. First results on spatial macrophyte patterns will be presented here.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Unintended consequences: how biomass-trait feedbacks can limit the benefits of phenotypic plasticity

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Phenotypic plasticity can increase individual fitness when environmental conditions change over time. Inducible defenses are a striking example, allowing species to react to fluctuating predation pressure by only expressing their costly defended phenotype under high predation risk. However, the benefit of this plasticity critically depends on whether plastic species can accurately assess current conditions and thereby estimate the costs and benefits of expressing the defended phenotype. Incorrect assessments may result in maladaptive phenotype expression, which will reduce fitness rather than increasing it. Here we demonstrate several distinct ways by which the feedback between inducible defenses and predator-prey dynamics can cause this maladaptive scenario to emerge. For example, by changing the amplitude or shape of predator and prey cycles, the cues used by the prey to determine phenotype expression may become less reliably associated with fitness; thus, an inducible defense that was initially beneficial may become detrimental in the long run, through its own impact on ecological dynamics. In this way biomass-trait feedbacks, in this case the feedbacks between inducible defense and predator dynamics, may impose a natural limit on the benefits of plasticity. This in turn has consequences for the plastic species itself, but potentially also for the species (competitors and predators) that it interacts with, and for community-level properties such as stability, productivity and coexistence.

A3: Grundwasser und Quellen

Etablierung eines Klimawandelmonitorings an Quellen in den bayerischen Mittelgebirgen

Sebastian Vogel

Bayerisches Landesamt für Umwelt

Quellen bilden ökologische Sonderstandorte mit einer hohen und spezifischen Artenvielfalt und sind daher von großer, naturschutzfachlicher Bedeutung. Als Übergangszone zwischen Grund- und Oberflächenwasser besitzen sie weiterhin eine besondere Zeigerfunktion für den Wasserhaushalt einer Region und somit auch die zu erwartenden Auswirkungen des Klimawandels. Bislang fehlte es jedoch an standardisierten Langzeituntersuchungen über verschiedene hydrogeologische Teilräume, um umfassende Aussagen treffen zu können. Zwischen 2017 und 2020 wurde daher für Bayern ein Monitoringleitfaden erarbeitet, um diese Lücke zu schließen. Entwickelt wurde der Monitoringleitfaden während dieser Zeit in den beiden bayerischen Nationalparks, seit 2021 wird er auch außerhalb in vier weiteren Regionen Bayerns (Fichtelgebirge, Rhön, Spessart und Steigerwald) angewandt und evaluiert. Diese Regionen sind in Teilen bereits heute stark vom Klimawandel betroffen, was insbesondere die letzten Dürrejahre verdeutlicht haben. Das neu begonnene Dauermonitoring ist zunächst auf 10 Jahre ausgelegt, wobei bis zu viermal jährlich verschiedene abiotische und biotische Parameter erhoben werden. Durch die Übertragung des Monitoringleitfadens auf weitere Regionen außerhalb der Nationalparke konnten bereits wichtige Erfahrungen für eine flächige Etablierung gesammelt werden. Diese betreffen unter anderem die Auswahl geeigneter Standorte als auch die Durchführung der Messungen vor Ort. Im Rahmen dieses Beitrags sollen der angewandte Monitoringleitfaden als auch das neu begonnene Dauermonitoring kurz vorgestellt und ein Ausblick auf weitere Vorhaben gegeben werden.

S13: Imaging Plankton

The usage of a zooplankton digitization software to study plankton dynamics in freshwater fisheries

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To better understand anthropogenically induced shifts of lake nutrient dynamics and subsequent consequences for fish and their zooplankton food sources, an increased spatial and temporal resolution of zooplankton monitoring data is needed. The Zooscan, an instrument mainly used in marine research, enables digitalization of zooplankton samples, and thereby substantially decreases the effort for zooplankton analysis. We present Zooscan analyses of zooplankton from the water column and in whitefish (*Coregonus sp.*) stomachs from Lake Starnberg (Germany, Central Europe), a large oligotrophic pre-alpine lake. Digitalized manual and automated analyses of important zooplankton parameters such as abundance, species composition, size development and reproductive measures of different taxa are given. The obtained results from automated and manual Zooscan analyses allow drawing conclusions on population dynamics, size developments and zooplankton food preferences by whitefish. In particular, we highlight the advantages of assessing reproductive cycles based on the documentation of egg-bearing individuals of e.g. cladocerans, which are of less importance in marine environments. While the results of automated analysis of stomach content were generally inaccurate, manual validation of digitized images was efficient for identification. Digitized images offer the possibility of fast access and convenient storage of zooplankton samples.

A2: Seen und Feuchtgebiete

PHOENIX See: Die Folgen des Starkregenereignisses im Juli 2021 für den See und seine Ökologie

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Der ca. 23 ha große PHOENIX See in Dortmund (NRW) wurde auf einem ehemaligen Stahlwerksgelände künstlich angelegt und im Jahr 2011 von der Emschergenossenschaft geflutet. Seitdem obliegt ihr die Gewässerüberwachung. Trotz der ursprünglichen industriellen Nutzung der Fläche, hat der PHOENIX See sich ökologisch sehr positiv entwickelt. So erreichte er seit der Anwendung der Bewertung nach EG-WRRL bis 2020, zusammenfassend für beide Probestellen betrachtet, stets das „gute“ oder „sehr gute“ ökologische Potenzial. Der PHOENIX See wurde auch als Hochwasserrückhaltebecken angelegt. Er hat ein Fassungsvermögen von 840.000 m³, wovon 240.000 m³ als Reservevolumen für den Hochwasser-Rückhalt aus dem urban geprägten Einzugsgebiet der oberen Emscher dienen. Nach dem Starkregenereignis im Juli 2021 wurde es erstmals notwendig, die Rückhalte-Funktion zu nutzen. So nahm der PHOENIX See in der Zeit vom 13. bis 14. Juli ein Gesamtwasservolumen von 160.000 m³ aus der Emscher auf. Die Nährstofffracht des Abschlags führte zu einem Anstieg der Gesamtphosphor Konzentrationen. Infolge dessen kam es zu einer starken Erhöhung des Chlorophyll-a Gehalts bzw. zu einem verstärkten Phytoplankton Wachstum, welches sich auch auf die Bewertung nach EG-WRRL (Phyto-See) auswirkte. Im Vortrag stellen wir die Entwicklung der wichtigsten chemisch-physikalisch Parameter und des Phytoplanktons seit der Flutung des PHOENIX See vor und beschreiben, wie sich der Abschlag der Emscher im Juli 2021 auf den See auswirkt.

A3: Grundwasser und Quellen

Biodiversität, Nutzung und Schutz von Quellen im Biosphärengebiet Schwarzwald

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Naturnahe Quellen sind weltweit einem starken Nutzungsdruck ausgesetzt. Sie werden vor allem als Trinkwasserspender für Mensch und Tier und unscheinbare oder gar «störende» nasse Stellen in der Landschaft wahrgenommen. Ihre Bedeutung als Habitat für speziell angepasste Organismen ist dagegen kaum bekannt. Ihrer Bedeutung als Lebensraum für Spezialisten wird ihr momentaner Schutzstatus nicht gerecht: obwohl Quellen per Gesetz geschützt sind, werden sie weiterhin verbaut und es gibt kein landesweites oder gar europaweites Monitoring von Quellen. Im Schwarzwald sind naturnahe Quellen erstaunlich schlecht untersucht. In einem Projekt im Biosphärengebiet Schwarzwald werden nun erstmals in Süden des Schwarzwalds Quellen systematisch erfasst, strukturell bewertet und faunistisch wie floristisch untersucht. Es wurden bisher 186 Quellen im Einzugsgebiet der Brugga, der Menzenschwander Alb und der Kleinen Wiese erfasst, davon sind 75 % in einem natürlichen Zustand, ein Viertel ist gefasst. Bei den meisten Quellen handelt es sich um rheokrene Waldquellen. Die sehr unterschiedlichen geologischen Gegebenheiten führen zu einem interessanten Mosaik der Umweltbedingungen in den Quellen. So liegt der pH in manchen Quellen nahe 5; solche Quellen sind kaum besiedelt. Dennoch scheint für die Besiedlung der Quellen vor allem die Substratzusammensetzung von Bedeutung zu sein. Faunistisch ist das Vorkommen der Badischen Quellschnecke Bythinella badensis hervorzuheben, in den Höhenlagen ist der Alpenstrudelwurm Crenobia alpina anzutreffen. Viele Quellen weisen einen starken Bewuchs mit Milzkraut auf. Strukturelle Schädigungen sind häufig auf Viehtritt durch Kühe oder Verrohrungen zurückzuführen. Ziel des Projektes ist es den Quellschutz im Schwarzwald, aber auch ein europaweites Monitoring-Programm voranzutreiben und ein langfristiges Monitoring von ausgewählten Quellen zu etablieren.

S11: Blue Nature-based solutions: co-benefits for nature and people

ESS study on dam removal: results of an ESS analysis on the river Lahn

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The ecological condition of many rivers and their floodplains in Germany are still substantially deviate from the goals of the Water Framework Directive. Addressing those challenges will require considerable efforts. At the same time, the urgency and societal relevance of more free flowing rivers, is increasingly promoted, most recently by European Commission's guidance on Barrier Removal for River Restoration.

An example of ongoing initiatives to advance river restoration for people and nature is the integrated EU LIFE project "Living Lahn - one river, many interests" (for more information, see https://www.lila-livinglahn.de/). This ongoing project focusses on the navigable part of the river Lahn, located in the Federal States of Hesse and Rhineland-Palatinate.

Looking across the results for an ESS study of three (out of twenty-nine) dams along the river, scenario 2 (good ecological status with mandatory dam removal, emerged as the more advantageous option with regard to achieving the objectives of the WFD and a range of ecosystem services considered. This scenario effectively reflects the development goal of "restoring rivers and floodplains" proposed in the federal "Blue Belt" programme for tributary waterways. At the same time, this scenario also yields higher monetary ecosystem services values than the scenario 1 (good ecological potential with retention of the dam).

The study made clear that state investments in aquatic ecosystem restoration including dam removal could achieve considerable long-term benefits with good cost-benefit ratios through targeted investments.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Predicting phytoplankton community composition under top-down control based on position in trait space

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The functioning of aquatic ecosystems highly depends on their phytoplankton community compositions. In recent years, trait-based approaches have gained increasing importance for understanding phytoplankton communities. We present results from experimental tests where we used phytoplankton traits to predict coexistence in the presence of a predator. Specifically, we measured competitive ability as growth rate and ingestion rate of the predator (rotifer *Brachionus calyciflorus*) for 13 phytoplankton species. We used these traits to construct a competition-defense trait space and predicted based on the phytoplankton position in trait space whether species can coexist when combined in communities of 5 in replicated microcosms. We tracked the composition of these communities for 20 days using imaging and image analyses. According to our predictions, species persisted in communities when species covered a larger range of the trait space, i.e., when competitive and defended specialist were initially present. Intermediate types were only present in low frequencies or were not detectable. When communities were started with species that are close in trait space, communities were dominated by one species or two species. The latter observation is likely explained by fitness equality and little niche separation as predicted by the modern theory of coexistence. Overall, we show that constructing trait space can be a useful tool to predict phytoplankton community composition in the presence of a predator.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Light fluctuations: Phytoplankton community responses in fatty acid profiles

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We study the community responses towards environmental fluctuations in light intensity combined with nutrient limitation, which can emerge as alterations in physiology, biomass and biochemical composition in communities. Specifically, we were interested how light intensity and variability under two nutrient conditions might influence the fatty acid profiles of phytoplankton communities. We assembled communities consisting of five phytoplankton species belonging to different taxonomic groups and exposed them to constant light intensity at different intensity levels. To estimate the effect of light intensity fluctuations, further variable light intensity treatments were conducted. Certainly, the fatty acid profiles were strongly affected by the nutrient availability and light condition and light fluctuations also shaped the fatty acid profiles, important for potential consumers.

DE: Wir untersuchen die Reaktionen von Gemeinschaften auf Umweltschwankungen bei der Lichtintensität in Verbindung mit Nährstoffbeschränkungen, die sich in Form von Veränderungen der Physiologie, Biomasse und biochemischen Zusammensetzung der Gemeinschaften äußern können. Insbesondere interessierte uns, wie Lichtintensität und Variabilität unter zwei Nährstoffbedingungen die Fettsäureprofile von Phytoplanktongemeinschaften beeinflussen könnten. Wir stellten Gemeinschaften aus fünf Phytoplanktonarten zusammen, die zu verschiedenen taxonomischen Gruppen gehören, und setzten sie einer konstanten Lichtintensität bei unterschiedlichen Intensitätsstufen aus. Um die Auswirkungen von Schwankungen der Lichtintensität abzuschätzen, wurden weitere Behandlungen mit variabler Lichtintensität durchgeführt. Während die Fettsäureprofile stark von der Nährstoffverfügbarkeit und den Lichtverhältnissen beeinflusst wurden, war die Fettsäurezusammensetzung, die für potenzielle Konsumenten in Nahrungsnetzen wichtig ist, auch von den Lichtschwankungen geprägt.

S11: Blue Nature-based solutions: co-benefits for nature and people

Decision-making in urban hydroscape management: comparing the degrees of project sophistication and citizen participation

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The urban hydroscape, including rivers, streams, lakes, wetlands, ponds, canals, is exposed to manyfold user interests and types of human impact. This makes decision-making about the restoration, de-novo implementation, or sustainable management of these hydrosystems a complicated task. In addition to the experts, technicians and administrative persons involved in these processes, the participation of the citizens is of great importance, as they may support or oppose to projects or managment options. Contributing to UNESCOs North-South-South dialogue, SDG 6 and IHP IX, our workgroup analyzes options to improve the ecological and social quality of urban hydrosystems, and studies the processes and conditions that are responsible for success or failure of restoration projects worldwide.

Here we present examples from the Global South (Latin America: Columbia, Brazil; Africa: Senegal, Congo DR; Asia: India, China, Taiwan) and the Global North (Europe: France, Germany, Switzerland) showing how nature-based solutions such as restoration of urban streams, wetlands and lakes were performed as local solutions to globally similar problems. Specifically, we are interested in how the urban population has interacted with the project and which types of motivation and social processes (bottom up vs. top down mechanisms, political background) were most promising in relation to the degree of complexity and sophistication of the administrative and technical context of the project. The overall goal is to identify communalities between projects that may enhance the worldwide science/policy transfer.

S09: Auen

Effects of lateral floodplain connectivity on biodiversity: Which environmental factors related to connectivity could characterize biodiversity in the River Elbe floodplain?

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Many river and floodplain restoration projects aim to improve connectivity between river and its surrounding floodplain. But what is this connectivity? How can it be measured and which variables shape environmental conditions to improve floodplain biodiversity?

To answer these questions we set up the ElBiota project and sampled soil, vegetation, mollusks and ground beetles in four differently connected areas of the River Elbe floodplain. Furthermore, we modelled environmental conditions for 80 randomly chosen sites stratified by hydrology. The final set of environmental data (soil characteristics, nutrients, organic and inorganic contaminants, hydrology, distance measures, land use and topography) contained 500 variables, being too much for any meaningful, interpretable statistical analysis and correlation to biodiversity data. Cluster- and principal component analysis were used to group, correlate and reduce the number of environmental variables in a stepwise procedure.

Finally, the number of environmental variables was reduced to 38 with explanatory value along the first five PC axes. A varimax rotation allowed to optimally align the environmental factors to the first three PC axes. Nutrients and grain sizes aligned with PC axis 1, hydrology with axis 2 and axis 3 aligned with site-specific differences possibly related to riverbed incision.

The extraction of the PCA scores along the first three axes provided three synthetical environmental variables summarizing the most important environmental variability found across the sampled areas. These synthetical scores capturing soil properties, hydrology and site-specific differences can help to improve and simplify a homogeneous statistical analysis of vegetation, mollusk and ground beetle biodiversity patterns.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Ecological effects of recreational boating activities on freshwater ecosystems

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Recreational boating is popular in people's leisure time. Lush and diverse waterbodies attract high numbers of people, especially on weekends and holidays and under fair weather conditions. While motorized boating is associated with speed, noise and damage to nature, manual, non-motorized boating is promoted with individual health benefits and environmental awareness. However, hardly predictable user-dynamics can exert pressure on freshwater ecosystems on few peak-usage days also by these activities, leaving plain damage to constituents of nature and impacting the biodiversity that contributes to the attractiveness of the waterbody.

A systematic analysis of >90 original studies revealed that evidence of the impacts of motorized boating by far outweighed that of other boating modes and studies on manual boating prevalently focused on behavioral or physiological responses of wildlife, while there is a paucity of studies on effects at the level of populations and communities which are however crucial for ecosystem impact assessments.

We tie in with the transpired need for more evidence of the effects of non-motorized boating activities and present results from the Spreewald UNESCO biosphere reserve, one of the most popular paddling destinations in Germany. More than 69,000 boats were counted during our observation period from May to October 2021 and we related this impact to macrophyte and bird communities at nine streams with differing levels of boating intensities.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Spatial distribution strategies in single-species systems – Experiments with the ciliate Tetrahymena pyriformis

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All organisms are distributed in space, but large differences occur in the way they use space and in the time-scale of its use. Spatial distributions of populations are known to have a high impact on the establishment of high biodiversity and the coexistence of multiple species. Patterns of the spatial distribution of organisms provide important clues on the underlying mechanisms that structure ecological communities and, therefore, provide a high maintenance of biodiversity. Although studies showed that even single-species systems can exhibit chaotic behaviors, the causes and consequences of chaotic dynamics and their relation to spatial distributions in single-species models are still unknown. Microcosm experiments for measuring spatial distribution, working with a chamber of interconnected habitat patches, was performed using the model organisms of the ciliate genus Tetrahymena. Preliminary results of the spatial distribution experiments illustrated that dispersion can be highly affected by environmental conditions. The results demonstrated that Tetrahymena dispersal and movements can be highly complex. Still, there is a lack of knowledge in the spatial distribution in single-species systems. Understanding their causes and consequences is, therefore, of high interest to understand spatial dynamics in populations. Furthermore, the developed experimental set-up offers potential for more complex experiments with multiple-species systems to further investigate distribution patterns and predator-prey dynamics.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

The role of benthic invertebrates in river biomanipulation – a driving force or passively benefiting?

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Biomanipulation of river food webs via increasing biomass of herbivorous nase (Chondrostoma nasus) and omnivorous chub (Squalinus cephalus) is a potentially suitable tool to improve ecological quality. In a large-scale experiment, high fish stocks were previously shown to increase the oxygen availability and thereby the habitat quality of the hyporheic zone of a eutrophic low-mountain river. The 4-year study was conducted in a BACI design to account for natural differences between the experimental stretches and interannual differences between and during the two experimental phases. In the turn of this experiment, benthic invertebrate community was repeatedly sampled to deduce whether the invertebrates, especially grazers, were a driving force of the success of the biomanipulation. As an additional hypothesis, it was also tested whether they were merely profiteers of the improved habitat conditions, and thus indicators for the successful biomanipulation.

We hypothesized that high densities of large fish affect abundance of small zoobenthivorous fish species, thereby releasing benthic invertebrates from predation pressure. Benthic invertebrates in general and the highly predation susceptible benthic grazers specifically should therefore increase in biomass, leading to higher grazing rates. Through that mechanism, increasing the stocks of nase and chub was assumed to have an additional positive on algae removal, thus increasing the effects of biomanipulation. Another possibility is that benthic invertebrates merely profited from the biomanipulation by reacting to the improved habitat quality. In that case we expected an increase in the abundances of sensitive species. Thereby biomanipulation should lead to an improved ecological quality score in the evaluation according to European water framework directive.

In the talk we will present results of the large-scale experiment regarding the reaction of benthic invertebrate community to fish stock manipulation in a eutrophic low-mountain river to elucidate the role of benthic invertebrates in river biomanipulation.

S03: Responses of aquatic ecosystems to anthropogenic stressors

On-line measurement of the impact of combined sewer overflows in small waterbodies

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Emschergenossenschaft / Lippeverband

The discharges of combined sewer overflows are important point sources of nutrients, solids and organic matter in waterbodies. Smaller streams with urban catchment areas are in particular affected. Since 2019 the Emschergenossenschaft continuously monitors the chemical-physical composition of small streams and the upper river Emscher. In addition to the standard parameters, water temperature, pH, turbidity, conductivity and oxygen, ortho-phosphate and ammonia-N are also measured. A measurement period is at least one year long. Macroinvertebrates are monitored upstream and downstream of each discharge site using PERLODES. PERLODES metrices were rather poorer in the upstream part of the river Emscher, than downstream. This is in contrast to the morphological status, being better upstream. However, the continuous measurements in combination with discharge and overflow measurements helped to understand the PERLODES results. While in the upper part of the Emscher several events with oxygen deficits < 5 mg/L with an overall duration of more than two days were detected, the monitoring downstream showed only one event with a duration of one hour. Oxygen deficits mainly occurred in summer evenings or nights, often linked to discharges of combined sewer overflows. Therefore, the oxygen deficits would not have been recorded during the regular measurements according to the water framework directive, which usually take place during the day in dry weather conditions.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

How to model horizontal diversity in complex systems?

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Core ecological questions address the consequences of environmental changes on biodiversity, biogeochemical cycling and ecosystem functioning which are approached using large ecosystem models. In these models, it is a challenge to realistically represent the diversity within trophic levels (i.e. horizontal diversity), which influences the strength of trophic interactions and functions such as biomass distributions, resistance against perturbations, and trophic transfer efficiency. Horizontal diversity is often represented using different functional groups with predefined static functional properties within one trophic level, although choosing an optimal number is difficult. A high number of functional groups may not coexist and reduces the tractability of the model behavior Oppositely, too few groups may not reproduce appropriately the naturally high trait diversity. Additionally, horizontal diversity can also arise from trait variation within functional groups. Thus, what is a good balance between the number of functional groups and their internal trait variation? We extended Klauschies et al. (2016)'s model, which defines functional groups by using two traits: prey edibility and predator selectivity. These traits are involved in trade-offs: an edible producer grows quickly and has a low natural mortality rate, and a specialist herbivore has a higher grazing rate. The strength of trophic interactions between producers and herbivores are determined by preference functions depending on both traits. Horizontal diversity at the producer trophic level is modeled by a variable number of functional groups (2, 3 or 5) and by controlling the trait variation within each group. This allowed us to compare different scenarios, such as a model with few functional groups and high trait variation or a model with many functional groups and little/no trait variation, in terms of model robustness, biomass distribution, trophic transfer efficiency and stability against environmental changes.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Revealing phytoplankton population and selection dynamics to assess mechanisms of adaptation towards climate change

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Trait adjustments of phytoplankton communities to changing environmental conditions can take place through physiological and evolutionary responses on several fundamental ecological levels: a single genotype, a population of the same species, and the entire multi-species community. Which of these different levels responds to environmental change can have large ecological and biogeochemical implications, but especially in protists, these levels are extremely difficult to disentangle. Arctic phytoplankton, being the base of the foodweb in one of the most rapidly changing regions on the planet, is especially faced with large transformations, but often show a high resilience. Among these transformations are more frequent and intense heatwaves, which expose organisms to vast temperature fluctuations. In dedicated experimental setups of different ecological complexity, we are investigating how phytoplankton responds and adjusts to heatwaves, and on which of the mentioned levels shifts can be observed. A special feature of this project is the resolution of intraspecific diversity and selection dynamics within species, the analysis of which still poses a large challenge, but can be an important mechanism of adjustment. Using a novel molecular approach to efficiently examine the composition of protist populations in diverse contexts, we are investigating how phytoplankton communities respond to stable and fluctuating temperature scenarios, physiologically and ecologically.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Transport of nutrients and phytoplankton biomass along river-connected lake systems

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Worldwide, freshwater ecosystems are impacted by anthropogenic forcing including global warming-induced alteration of hydrological regimes and land use changes. For river systems, these changes might have far-reaching consequences as nutrients received from the terrestrial surrounding upstream may unfold both short and long-term effects downstream through system-wide changes of water residence time. River-connected lakes may modulate the spatial spread of eutrophication events throughout an aquatic network. However, studies on river-connected lake systems are scarce and limited by low temporal and spatial resolution. We investigated how local nutrient loading affects phytoplankton development along river-connected lake chains on a regional-scale by linking theoretical models with experimental and observational field studies. We specifically studied how local nutrient inputs drive phytoplankton growth and how nutrients and phytoplankton propagate along the aquatic network modulated by flow regime and lake size, both influencing water residence time. In a mesocom experiment we manipulated connectivity, simulating short and long residence time in lake chains. Our field study encompassed 19 lakes in NE-Germany, contrasting strongly river-connected lakes along the Upper Havel with weakly connected lakes. High temporal and spatial resolution was achieved by combining water constituent measurements and automated in-situ probes with ground-based, space- and airborne reflectance measurements. Our results suggest that - depending on flow regime, lake characteristics and residence time - similar point sources lead to profoundly different maximum intensity, spatial range and regional-scale magnitude of eutrophication events in lake chains. We also highlight the potential of combining in-situ measurements with remote sensing to improve lake meta-ecosystem monitoring.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Competition-driven divergence in heterogeneous environment

Zhijie Zhang; Lutz Becks

Limnological Institute, Konstanz University

Interspecific competition has long been posed to select for increased niche difference, promoting coexistence. However, fitness difference, another component of coexistence, has rarely been considered in emprical studies. Still, the prevalance of evolution of niche and fitness differences, their impact on coexistence and their environmental dependency remain largely unexplored. Here, we tracked evolutionary changes of competing algal species in either homogeneous or heterogeneous environment over c. 150 generations. We found that, in both environments, interspecific competition selected for increased fitness difference, impeding species coexistence. Meanwhile, interspecific competition rapidly selected for increased niche difference in heterogeneous environment, stablizing increased fitness difference therein. The results support and complement the classical view: competition drives niche divergence, when provided environmental heterogeneity (i.e. more potential niches). It also reveals the prevalence of evolution of increased fitness difference, explaining the prevalence of species dominance in the real nature from an evolutionary perspective.

Erfassung benthischer Diatomeen mittels DNA-Metabarcoding und Lichtmikroskopie als Effektmonitoring zur Überwachung von Oberflächengewässern unterhalb von Klärwerken

Jonas Zimmermann[1]; Petra Werner[2]; Antje Köhler[3]; Demetrio Mora[4]

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Kommunale Kläranlagen stellen eine Punktquelle für Oberflächengewässer in Bezug auf Nährstoffe, anorganische und organische Schadstoffe sowie Krankheitserreger und antibiotika-resistente Keime dar. Chemisch-analytische Messungen von aufbereiteten Abwässern verdeutlichen, dass die biologischen Reinigungsprozesse in konventionellen Kläranlagen nicht ausreichen, um Mikroschadstoffe in ausreichendem Maße zu entfernen. In der Literatur sind zahlreiche Studien zu finden, die beeinträchtigende Wirkungen von Abwassereinleitungen bei Wirbellosen, Fischen, Amphibien, Vögeln und Säugetieren und der aquatischen Flora nachweisen. Diese unerwünschten biologischen Wirkungen (z.B. gentoxisch, mutagen endokrin, reproduktionstoxisch) in Oberflächengewässern führen zur Veränderung in der Artenzusammensetzung und damit des Nahrungsnetzes im Gewässer. Aus Untersuchungen der benthischen Diatomeen vor und nach einer Kläranlage sind Änderungen in der Artenzusammensetzung und Dichte bekannt. Die Zählmethode und taxonomische Bestimmung der „eingestuften“ Arten mit Hilfe der Lichtmikroskopie bezieht sich vorrangig nur auf die Abweichung der Biozönose vom trophischen Referenzzustand des gewählten Gewässertyps und stuft entsprechend den ökologischen Zustand des Fließgewässers anhand der relativen Häufigkeiten von Indikatortaxa ein.

Ziel des Projektes ist der Aufbau einer Methode zur Erfassung benthischer Diatomeen sowohl mittels DNA-Metabarcoding als auch anhand der Lichtmikroskopie als Effektmonitoring zur Überwachung von Oberflächengewässern unterhalb von Klärwerken mit 4. Reinigungsstufe in Berlin in den Jahren 2019 und 2020. Dafür werden vier Messstellen vor und fünf hinter Klärwerkszuflüssen eines Fließgewässers dreimal im Jahr analysiert. Einmal wird so die Gewässergüte bzw. die ökologische Zustandsklasse anhand der herkömmlichen PHYLIB Standardmethode bestimmt, zum anderen eine neue Methode für das Effektmonitoring erarbeitet.

Zwar eignet sich die PHYLIB-Methode zur Bestimmung der ökologischen Zustandsklasse eines Fließgewässers, aber insgesamt zeigt sich die Limitation der PHYLIB-Methode als Effektmonitoring der Klarwassereinflüsse. Zum Beispiel besitzen viele seltene Taxa keine Indikatorwerte und exotische Taxa erkennt die Methode nicht. Diese Taxa reduzieren lediglich die Summe der Referenzarten, gehen also nur indirekt in die Bewertung ein.

Poster

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Evaluierung von Renaturierungsmaßnahmen in hessischen Fließgewässern anhand biologischer Qualitätskomponenten

Katharina Bach[1]; Andrea Sundermann[2]; Ariane Moulinec[2]; Matthias Oetken[1]; Sarah Hörchner[1]

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Die anthropogene Nutzung der Oberflächengewässer hat die Gewässer morphologisch, stofflich und hydraulisch stark verändert, wodurch oftmals erhebliche Defizite bezüglich der ökologischen Funktionsfähigkeit entstanden sind. Zur Sicherung der aquatischen Biodiversität und ihrer Lebensräume wurde im Jahr 2000 die europäische Wasserrahmenrichtlinie verabschiedet. Als ein zentrales Ziel dieser gilt nun das Erreichen des guten ökologischen und chemischen Zustands aller europäischen Fließgewässer. Jedoch erreichen derzeit 90 % der hessischen Fließgewässer nicht den guten ökologischen Zustand. Zur Verbesserung des Zustands wurden zahlreiche Renaturierungsprojekte an degradierten Gewässern durchgeführt. Diese strukturellen Aufwertungen sollen die biologischen Qualitätskomponenten positiv beeinflussen, indem naturnahe Habitate die Wiederbesiedlung fördern. Renaturierungen sollten daher das Artenvorkommen messbar verbessern und damit einhergehend auch die ökologische Zustandsklasse. Bisher konnten viele Studien jedoch nur geringfügige Effekte auf die biologischen Qualitätskomponenten durch Renaturierungen darlegen.

Um speziell den Erfolg von Renaturierungsmaßnahmen zu messen, wurde ein angepasstes Handbuch zur Bewertung dieser Maßnahmen entwickelt (LAWA-Projekt O 8.18 2020). In dieser Arbeit soll erstmals dieses Handbuch in Hessen angewendet werden. Hierzu wurden sechs Renaturierungen unterschiedlichen Alters und verschiedener Gewässertypen untersucht. Dabei wurden die Komponenten Makrozoobenthos, Fische, Makrophyten und die Gewässerstrukturgüte in renaturierten und nahe gelegene, nicht renaturierte Gewässerabschnitten erhoben. Zusätzlich werden weitere Renaturierungen im Rahmen eines effektbasierten Monitorings, gefördert vom Umweltbundesamt (EffektMon, FKZ: 3721242030), untersucht. Mit dieser Monitoringmethode soll überprüft werden, inwiefern stoffliche Belastungen renaturierter Gewässerabschnitte dem Erreichen des guten ökologischen Zustands entgegenwirken. Ziel ist es damit mögliche Treiber, welche die Wiederbesiedlung nach einer Renaturierung hindern, zu identifizieren und zukünftig zu beheben. Im Beitrag werden das Projekt und erste Ergebnisse vorgestellt und kritisch diskutiert.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Ecoevolutionary feedbacks of phenotypic plasticity in monoclonal tritophic systems

Verena Bamberger

Ruhr Univesität Bochum

Trophic interactions in aquatic communities are significantly affected by the performance of their interacting partners. Explicitly, different performance levels can be due to trait variations which significantly affect population dynamics and community structures. Trait variability may result from either phenotypic plasticity or genetic diversity and has been shown to foster population stability and promote persistence. We here want to examine if trait variation (in form of inducible defences) on the consumer level may stabilize trophic dynamics more than trait variation on two (consumer and predator) trophic levels within a tritrophic system.

We performed monoclonal tritrophic long-term experiments with the predators (*Lembadion spp*. (plastic) and *Stenostomum* (non-plastic)), and three different Euplotes species (which differ in body size), in which Euplotes is fed with the algae *Chlorogonium elongatum*. *Lembadion spp*. and *Stenostonum* show differences in their feeding rates when offering smaller species of Euplotes. Whereas Euplotes differ in their reaction norms to their predators. Comparison of the plastic and the non-plastic predator showed that plasticity on one trophic level (consumer) seems to stabilize the system more than plasticity on two levels (consumer and predator). We further want to investigate if polyclonal communities on the consumer level increase or decrease population stability compared to monoclonal systems. For that we established a simplified method visualizing all important species classification patterns focused on species identification in the genus Euplotes. When performing polyclonal experiments with ciliates, individuals of different species have to be distinguished and counted. Since ciliates are unicellular organisms, DNA quantity can be used to determine the number of individuals in an experiment. Using RAPD-fingerprint method, we identified unique DNA sequences of our target species of Euplotes. With these genetic markers it is possible to perform a qPCR standard curve of each species and to determine precise numbers of individuals in long-term polyclonal experiments.

S03: Responses of aquatic ecosystems to anthropogenic stressors

eDNA analysis as an effective tool for assessing the distribution and taxonomic status of endangered and cryptic living spined loaches (genus: Cobitis L.) in south-western Germany

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The loss of biological diversity in aquatic environments is a global issue that has been observed now for decades. According to the red list of freshwater fishes in Germany, currently 36 % of the assessed species are classified as endangered or even extinct. Thus, appropriate conservation measures are crucial to preserve endangered species and consequently diversity. The foundation of an effective species-level management of freshwater fishes is the knowledge about their distribution. However, this can become a challenge as traditional detection methods, such as electrofishing, have proven to be ineffective for certain species due to their hidden lifestyle and isolated occurrence. Furthermore, in the case of cryptic species, it is not always possible to perform a species-level assignment in the field. New DNA-based approaches, such as the analysis of environmental DNA (eDNA), are therefore becoming increasingly important for species conservation. As non-invasive methods, they are particularly suitable for endangered species. The current study investigated the use of eDNA to study the distribution of spined loaches (genus: *Cobitis L.*) in the federal state of Baden-Württemberg (south-western Germany). Spined loaches are small, ground-dwelling fish which burrow during daytime in the sediment and the members of this genus are hardly distinguishable by morphological traits. They are currently classified as "critically endangered" in Baden-Württemberg and, except for the Rhine system, occur only in isolated places in the Danube catchment. Furthermore, the taxonomic status of the local spined loach populations is still unclear. An eDNA-assay was developed that targeted several spined loach species and utilized on a large scale for the analysis of water samples from their main distribution areas. The results illustrate how DNA-based methods can efficiently reveal the distribution of hidden and cryptic species, provide reliable species assignment, and thus are an important tool for future conservation measures.

A2: Seen und Feuchtgebiete

Changes in fossil chironomid and cladoceran assemblages along water depth gradients

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Lakes are complex systems that host many different habitats and niches, which are important to aquatic invertebrate communities. Notably, the near-shore shallow environments have steep ecological gradients, and the communities of invertebrates reflect the environmental conditions of those habitats. Paleoenvironmental reconstructions based on lake sediment records rely on proxies including the remains of aquatic invertebrates to interpret environmental change over long-time scales. Fossil aquatic invertebrates are also used increasingly in archaeological studies, particularly for assessing the impacts of lake-shore dwellings on nearshore lacustrine environments. This project attempts to provide a new surface sediment dataset describing how the distribution of fossil aquatic invertebrate remains changes across lake basins and in different lacustrine environments to aid the interpretation of such palaeoecological studies. For this purpose, surface sediment samples from the supralittoral to the profundal of Swiss lowland lakes including Bodensee, Moossee, Burgäschisee, Lützelsee, Thunersee and Zürichsee will be sampled and analysed. The analysis will include the identification of chitinous invertebrate remains from 10 to 12 samples per transect, with a particular focus on chironomid and cladoceran assemblages. The results will be used to describe how invertebrate assemblages preserved in sediments change with water depth and habitat conditions(e.g. macrophytes, sediment composition) and allow an assessment as to how species composition and biological indices (diversity, ratio of planktonic / benthic or deep water / shallow water taxa) in downcore palaeolimnological studies can be used to reconstruct past environmental changes in shallow water environments of lakes. This poster will present the overall project structure and results from a first transect from Bodensee sampled in March 2022.

S11: Blue Nature-based solutions: co-benefits for nature and people

Urban river restoration under China's Sponge City program and their social-ecological impacts

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In Global South, urban rivers and streams are often buried, modified, and polluted due to rapid socio-economic development and intense urbanisation, increasing the impervious surface area and resulting in growing inundation risks under climate change. In China, years of flood events in big cities have shifted the policy priority of the national government to flood risk management: the concept of Sponge City (SC) was proposed in 2013, and the national Sponge City Program (SCP) was launched in 2015. More than 30 pilot cities were selected to receive 400-600 million CNY (approx. 55.6 – 83.4 million EUR) investments each from the central government. The SC was designed by upscaling Nature-based Solutions (NbS) to absorb excessive rainfall during floodings while releasing the preserved water during the drought. The construction of 'Sponge' infrastructures includes restoring rivers and floodplains, transforming wetland parks, installing sunken green spaces, rainwater tanks, and permeable pavements, etc.

With the SCP gradually implemented across the country, different types of streams have been restored in Chinese cities, and the water quality in surface water bodies continues to enhance by a series of pollution control policies. Besides the regulating services, the restored hydrospaces also maintain habitats, support functioning ecosystems, create recreational values, and benefit human wellbeing. In China's cultural context, the re-established human-nature interactions help urban citizens retrieve the 'harmony between humanity and nature', a core in traditional Chinese culture. Urban rivers and streams therefore constitute social-ecological systems, reflecting an interconnected relationship between society and ecosystems. This study presents China's SCP on urban river restoration as an example of blue NbS implementation in the Global South and their social-ecological impacts. Several representative SC projects and the city of Wuhan are selected for case analysis. With desk research, interviews, and a public survey, we assess the restored ecological integrity of urban streams as well as their broader social impacts by studying how the public perceives and values the restored waterscape and generating suggestions with participatory approaches. Furtherly we analyse the current challenges to SCP's long-term effectiveness and formulate recommendations for sustainably managing the social-ecological systems in future.

A3: Grundwasser und Quellen

Hydrogeochemie von Schwarzwaldquellen aus Deutschland: Einblicke aus physikalischen und hydrogeochemischen Parametern, stabilen Isotopen und Makroinvertebraten

Thomas Dürrenberger; Stefanie von Fumetti

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Hydrogeochemische Untersuchungen von Quellen können wichtige Informationen über den Zeitpunkt der Grundwasseranreicherung, die Wechselwirkung zwischen Wasser und Gestein, die Durchmischung verschiedener Grundwasserkörper und deren Einfluss auf die darin lebenden Wirbellosen liefern. Der Südschwarzwald weist eine große Vielfalt an geologischen Einheiten und Quellentypen auf. Makroinvertebraten, Quellschüttung, pH, Temperatur, Leitfähigkeit, stabile Isotope (δ18O, δ2H, δ13DIC) und 24 chemische Variablen wurden über einen Zeitraum von einem Jahr an 24 Standorten untersucht. Bei den auf einem südöstlichen Längsprofil gelegenen Quellen im Schwarzwald handelt es sich um Gewässer, welche durch die chemische Verwitterung paläozoischer, mesozoischer und känozoischer Gesteinsschichten beeinflusst werden. Die geologischen Formationen bestehen aus Muschelkalk, Brekzien, Tonstein, Granit, Gneis, Schiefer, Porphyr, Vulkaniten und sauren Pyroklasten. Die Studie umfasste Probenahmen der Makroinvertebraten und in-situ-Messungen physikalisch-chemischer Parameter, gefolgt von hydrochemischen Laboranalysen und Analysen stabiler Isotope der Quellwasserproben. Die kanonische Korrespondenzanalyse (CCA) wird zur Bewertung der Beziehungen zwischen Gesteinsschichten, Makroinvertebraten sowie Umweltbedingungen eingesetzt. Erste vorläufige Ergebnisse zeigen, dass sich die Quellabflüsse in Bezug auf die hydrologischen Bedingungen wie die Wassermenge sowie die Konzentrationen von gelöstem Sauerstoff, gelösten Kationen und Schwermetallen unterscheiden. Zu verstehen, wie Anreicherungsprozesse und hydrogeochemische Vorgänge die Wirbellosengemeinschaft und die hydrochemische Entwicklung von Quellen beeinflussen, ist primäres Ziel der Studie. Darüber hinaus sollte es möglich sein, Quelltypen mit einzelnen Gruppen wirbelloser Wassertiere in Verbindung zu bringen und die Lebensraumanforderungen von Quellarten besser zu verstehen. Angesichts der hohen Produktivität und Artenvielfalt von Quellen und ihres bedrohten Status kann die Ermittlung geomorphologischer wie hydrogeochemischer Ähnlichkeiten zwischen Quellen für die Erhaltung dieser wichtigen Ökosysteme von Bedeutung sein.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Bedeutung der Gewässerstruktur für den ökologischen Zustand des Makrozoobenthos in Abhängigkeit der Abschnittslänge

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Die Gewässerstruktur zählt neben der stofflichen Belastung eines Gewässers zu den wichtigen Umweltfaktoren für die Ausprägung der Artengemeinschaften. Analysen konnten jedoch zeigen, dass das Ergebnis der Gewässerstrukturgütekartierung eines 100-Meter langen Abschnittes nur bedingt mit biozönotischen Metrics korreliert. Vor diesem Hintergrund stellt sich die Frage, ob a) eine differenziertere Betrachtung, biologisch relevanter Einzelparameter, (vgl. Habitatindex) und b) die Betrachtung längerer Abschnitte einen besseren Zusammenhang mit den nach WRRL bewertungsrelevanten Metrics aufzeigt.

Die Untersuchungen wurden an 28 Gewässerabschnitten in Hessen durchgeführt. Hierbei wurde an allen Stellen das Makrozoobenthos aufgenommen, die entsprechenden Bewertungsergebnisse nach PERLODES berechnet und die Gewässerstrukturgüte aufgenommen. Zudem wird auf Strukturgütedaten des Hessischen Landesamtes für Naturschutz, Umwelt und Geologie (HLNUG) zurückgegriffen, die eine Gewässerstrecke bis zu zwei Kilometer oberhalb der Makrozoobenthos-Probestelle abdecken. So können Zusammenhänge zwischen der Gewässerstruktur an unterschiedliche langen Abschnittslängen und dem Makrozoobenthos aufgezeigt werden. Neben der Gesamtbewertung und den einzelnen Hauptparametern der Strukturkartierung wurde auch das strukturelle Defizit berechnet, welches lediglich die strukturellen Einzelparameter mit dem größten ökologischen Einfluss berücksichtigt. Ziel ist es, die für das Makrozoobenthos relevanten Strukturparameter und Abschnittslängen zu identifizieren. Im Beitrag werden die Ergebnisse der verschiedenen Vergleiche vorgestellt und diskutiert.

Eingebettet sind die Untersuchungen in das Forschungsprojekt DECIDE, welches von der Deutschen Bundesstiftung Umwelt (DBU) gefördert wird (Förderzeichen: AZ 35663/01).

A1: Aquatic Ecotoxicology

Online Biomonitoring of water quality and fish health with the Multispecies Freshwater Biomonitor (MFB)

Almut Gerhardt

LimCo International GmbH

Aquaculture represents a growing food sector worldwide. Due to population growth, climate change and the need to reduce meat consumption, the interest in aquaculture products is rising, including both invertebrates and fish, marine and freshwater, in situ and land-based farming. Animal health and welfare is of growing concern in aquaculture farming and increased importance for consumers. To improve animal welfare in aquaculture real-time biomonitoring of survival and fitness of the breeding animals is essential. The Multispecies Freshwater Biomonitor (MFB) has been used in numerous ecotoxicity studies with invertebrates and fish, recording behaviour and survival of individual organisms exposed to chemical stressors. Recently the MFB was applied in tanks allowing the test fish to move free through the “open” sensor chambers in the whole tank, hence not affecting their normal behaviour. This 1st study with the new test design represents a proof-of-concept that the MFB with “open” chambers arranged in the tank records quantitatively the behaviour of guppies (Poecilia reticulata) passing through the sensors. In 12 experiments (1 exp./day of 2 hours) five guppies were exposed in the tank, which was divided in two halves with 8 sensor chambers, 4 connected to the MFB and 4 without connection. The fish were recorded with the MFB and simultaneously visually observed, i.e. the fish passages were counted by eye, too. The results show, that the guppies pass through the chambers equally often independent of their electrical connection to the MFB. They swim rapidly through or spend more time for exploration, creating sufficient behavioural signals to evaluate their fitness (signal amplitude, frequencies for locomotion, ventilation, etc.). This set-up allows to (1) count) and (2) analyze the fish fitness in aquaculture tanks.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Neu im Flussgebiet der Oker – Aktuelle Vorkommen von *Taeniopteryx schoenemundi* (Insecta: Plecoptera) in der Region Braunschweig

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Taeniopteryx schoenemundi galt aufgrund von Gewässerverschmutzung und -ausbau in Deutschland großflächig als verschollen. In jüngerer Zeit mehren sich jedoch Wieder- und Neufunde der Art, auch in der zuvor kaum besiedelten Nordhälfte Deutschlands (Niedersachsen, Sachsen-Anhalt). So gelang im Herbst 2019 der erste Fund der Art in der Wabe in Braunschweig (Niedersachsen, Einzugsgebiet der Oker). Bei einer anschließenden Exuviensuche wurde von Februar bis April 2020 und 2021 im nördlichen Harzvorland (Städte Braunschweig und Salzgitter, Landkreise Goslar, Wolfenbüttel, Harz, Gifhorn und Hildesheim) entlang der Oker und der Innerste inklusive Nebenflüssen die aktuelle Verbreitung der Art untersucht. Zwischen Januar und Mai 2022 wurde eine quantitative Exuvienerfassung an sieben Probestellen entlang der Oker zwischen der Wolfenbütteler und der Braunschweiger Innenstadt durchgeführt, um die Individuendichte der Art zu ermitteln.

Taeniopteryx schoenemundi wurde 2020/21 an 23 Stellen im Einzugsgebiet der Oker sowie an vier Stellen an der Innerste mit insgesamt 520 Exuvien nachgewiesen. Die meisten Funde stammten aus der Oker, einzelne auch aus den Nebenflüssen Ilse, Radau, Wabe und Altenau. Vom 28.01.2022 bis 16.05.2022 wurden zwischen Wolfenbüttel und Braunschweig 2412 Exuvien der Art eingesammelt, wobei die Individuendichte zwischen den Probestellen stark variierte und an den Fischtreppen der Wehre Wolfenbüttel/Marktstraße (33,3 Individuen/m) und Braunschweig/Eisenbüttel (28,1 Individuen/m) am höchsten war.

Die Funde im Oker-Einzugsgebiet lassen zusammen mit der aktuellen Literatur annehmen, dass *T. schoenemundi* sich derzeit in Ausbreitung befindet und über die Fulda und Leine ins Okersystem vorgedrungen ist. Die zahlreichen Fundstellen und teils hohen Exuvienzahlen legen nahe, dass die Art aktuell weiter verbreitet sein könnte, als bisher dokumentiert wurde.

S03: Responses of aquatic ecosystems to anthropogenic stressors

The development of water quality and properties due to environmental changes - An analysis of chemo-physical and biotic long-term data of the Wahnbach Reservoir

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Temperature and stratification dynamics of water bodies are influenced by environmental changes. This is already known from previous studies and applies also to the Wahnbach Reservoir [1]. This reservoir is an important source of drinking water supply in the region Bonn/Rhein-Sieg/Ahr. The quality of raw water is partly dependent on a seasonal stratification of the system.

The availability of long-term data collected by the Wahnbachtalsperrenverband (WTV) enables a precise analysis of water quality and quantity. Investigating the development of key parameters along their depth profile over time helps to understand underlying processes and interdependence with environmental changes.

In this project, the data of the last decades of the Wahnbach Reservoir were compiled to take a closer look at the shift in stratification and mixing ratios due to temperature change. The initial situation shows an increase in surface temperature in summer and elongation of stratification [1]. It is expected that this will lead to an increased primary production and consequently to an increased consumption of oxygen in deeper water layers. In this case, iron, manganese, and phosphate will re-dissolve and will have an impact on the deterioration of water quality. The focus here will be on the manganese cycle. For further research, data on temperature, oxygen, manganese, and iron content will be analyzed and correlated. In addition to abiotic factors, biotic factors are relevant as well. The not yet fully researched microorganism “Metallogenium” is regularly discovered in deeper water layers reaching the highest numbers at the end of the summer stagnation period [2]. What is known so far is the impact of “Metallogenium” on the conversion of different metals such as manganese. This could be relevant for element cycling in the Wahnbach Reservoir.

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A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Umsetzung und Evaluation von Schutzmaßnahmen zur Rettung der Flussperlmuschel (*Margaritifera margaritifera*) im Rahmen des Verbundprojektes MARA

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Technische Universität Dresden

Die Flussperlmuschel (FPM, *Margaritifera margaritefera*) ist eine vom Aussterben bedrohte Art, deren Bestände auch im sächsischen Vogtland durch anthropogene Stressoren im Laufe des 20. Jahrhunderts massiv zusammenbrachen. Der Verlust von Gewässerstrukturen, intensive landwirtschaftliche Nutzung und die damit verbundene Kolmation der Gewässersohlen haben sowohl negative Effekte auf die kritische Jungmuschelphase im Sediment als auch auf den im Vogtland einzigen Wirtsfisch, die Bachforelle (*Salmo trutta fario*).

Hier setzt die Margaritifera Restoration Alliance (MARA) an: ein Verbundprojekt mit sieben deutschen Partnern aus Sachsen, Bayern und Nordrhein-Westfalen. Die Ziele des Verbundvorhabens sind die erfolgreiche Nachzucht und Etablierung reproduktionsfähiger FPM-Bestände sowie die Verbesserung der Lebensräume von FPM und Bachforelle durch gezielte Maßnahmen an angrenzenden Flächen sowie in den Gewässern selbst.

Im sächsischen Teilprojekt, dass sich insbesondere mit der Umsetzung und Evaluation von FPM-Schutzmaßnahmen beschäftigt, kommen Vertreter*innen der Sächsischen Landesstiftung Natur und Umwelt (LaNU), dem Vogtlandkreis sowie der Technischen Universität Dresden zusammen.

In Kooperation mit einem Biolandwirtschaftlichem Betrieb sollen an gewässernahen, landwirtschaftlich genutzten Flächen Maßnahmen zur Reduktion des Feinsediment- und Nährstoffeintrages realisiert werden. Diese Maßnahmen sollen sowohl ökologisch als auch agrarökonomisch begleitet und evaluiert werden sowie Kosten und Nutzen in einem Best-Practice-Handbuch weiteren Anwendern zur Verfügung gestellt werden.

In den Auswilderungsgewässern sind Maßnahmen zur Erhöhung der Strukturvielfalt, Sicherstellung eines Mindestwasserabflusses sowie zur Wiederanbindung an die Auen geplant. Die Etablierung eines Fernwarnsystems in den Gewässern soll die effiziente Überwachung der Gewässerquantität und -qualität sicherstellen und bei Extremsituationen die rechtzeitige Evakuierung der FPM ermöglichen.

Die bereits bestehende Nachzucht und Auswilderung sowie das Biomonitoring der Aufzucht- und Auswilderungsgewässer wird weitergeführt.

A1: Aquatic Ecotoxicology

Ecotoxicological assessment of water and sediment in the Schwarzbach River using Potamopyrgus antipodarum

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Goethe Universität Frankfurt

The European Water Framework Directive aims to achieve a good ecological status for all German surface waters by 2027. However, about 90% of German surface waters do not meet the criteria of the EU-WFD. A potential cause for this are pollutants that come from industry, agriculture or surface runoff, but also the effluents of waste water treatment plants play an important role to the pollution of surface waters. Investigation of the different sources of contaminants and the biological effects in the freshwater ecosystems is essential to take expedient measures. The DECIDE Project deals with the further development and implementation of an ecotoxicological assessment system for rivers in order to quantify the contribution of chemical pollution to the deficient ecological status of water bodies and to enable a targeted prioritization of measures.

The present study has been carried out at 7 sampling sites in the Schwarzbach River during April, 2022. Effects of the pollutants were investigated in active biomonitoring campaigns and in laboratory experiments with the freshwater mudsnail, Potamopyrgus antipodarum. The focus was particularly on the assessment of the estrogenic activity in the water and sediment, using in-vitro and in-vivo testing. The snails were assessed for mortality (empty shells or no reaction) and reproduction (number of embryos in the brood pouch). Water and sediment samples were extracted first and then analysed using in-vitro assays. Therefore the yeast estrogen screen (YES) and yeast dioxin screen (YDS) were performed. In addition, the mean grain size and organic compound were determined in sediment samples for each sampling site. Finally, all activities found will be compared with chemical analyses carried out at the same time and examined for possible correlations.

The DECIDE project is funded by the German Federal Environmental Foundation (DBU) (funding code AZ 35663/01).

Modellierung von Schwermetallen und Arsen in der Elbe bei extremem Niedrigwasser

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Im Sommer und Herbst der Jahre 2018 und 2019 war die Wasserführung der Elbe außerordentlich gering. Die Wasserbeschaffenheit beider Niedrigwasserereignisse wurde im Rahmen des „Messprogramms für hydrologische Extremereignisse an der Elbe“ der FGG Elbe durch die in das Programm eingebundenen Landesinstitutionen untersucht. Ergänzend zu diesem Gütemonitoring wurde durch die BfG die Wasserbeschaffenheit der Elbe ereignisbezogen modelliert.

Verwendet wurde das deterministische Gewässergütemodell QSim der BfG mit der Modellinstanz Obere und Mittlere Elbe von Schmilka an der deutsch-tschechischen Grenze bis zum Wehr Geesthacht. Die Berechnung erfolgte eindimensional unter Einsatz des QSim-Schwermetallmoduls. Einbezogen wurden alle Zuflüsse > MQ 0,5 m^3/s, direkt in die Elbe einleitende große Kläranlagen sowie Direkt-Einleitungen aus Industrie und Altbergbau. Letztere wurden nach dem „Pollutant Release and Transfer Register“ des Umweltbundesamts in Ansatz gebracht. Die Aufteilung der Schwermetalle und von Arsen auf einen gelösten und einen an Feststoffe gebundenen Anteil erfolgte anhand elementspezifischer Verteilungskoeffizienten. Bei einer Berechnungsvariante variierten diese dynamisch in Abhängigkeit von pH-Wert und Schwebstoffkonzentration, bei der anderen blieben sie konstant.

Die Wasserführung der Elbe wurde vom Modell in beiden Jahren sehr gut wiedergegeben. Tendenziell zeigten die überwiegend gelöst aufgetretenen Elemente (wie Uran, Nickel und Arsen) die beste Annäherung an die Messergebnisse. Wie auch vom Modell berechnet, lagen Nickel und Arsen bei beiden Niedrigwasserereignissen an mehreren Messstellen in relativ hohen Konzentrationen vor. Für eine detaillierte Bewertung bzw. Validierung der Modellergebnisse inklusive der unterschiedlichen Berechnungen des Verteilungskoeffizienten war das Messwertgerüst nicht ausreichend. Die deutliche Beeinflussung einzelner Messstellen durch oberhalb einmündende Zuflüsse mit noch unvollständiger Querprofileinmischung erschwerte zusätzlich die Beurteilung. Um die Modellierung weiter zu verbessern, kommen einem erweiterten Prozessverständnis des komplexen schwebstoffbasierten Schwermetalltransports und der entsprechenden modelltechnischen Umsetzung Schlüsselfunktionen zu.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Reconstructing Holocene vegetational changes and early anthropogenic impacts on Lake Constance communities

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Lake Constance is a pre-Alpine oligotrophic water body that has a long history of human occupation. Its rich archeological record, with a high density of neolithic and bronze-age settlements, especially around the sub-basins Gnadensee and Überlinger See suggests a rather early human impact on the landscape. In the past 100 years, the lake experienced an intense phase of eutrophication during the 20th century as a consequence of increasing nutrient load with a subsequent re-oligotrophication due to increased management efforts. However, little is known about the effects of earlier disturbances on the lacustrine community and if past ecosystem changes can be attributed to anthropogenic pressures or natural Holocene climatic variations. In this study, we extracted sedimentary ancient DNA (sedaDNA) from a 7 meters core collected at the Gnadensee (Lower Lake Constance) with the aim to reconstruct past lacustrine and terrestrial community changes throughout the core and attempt to put this in the context of early-human settlement history in the core catchment. By employing a metabarcoding approach we performed reactions for both vascular plants and mammals to track terrestrial vegetation and livestock that, in combination with archeological data, will be used to detect potential anthropogenic impacts in the catchment area.

A1: Aquatic Ecotoxicology

DECIDE - Ökotoxikologische Bewertung von Fließgewässern im Hessischen Ried anhand von Gammarus fossarum und Potamopyrgus antipodarum

Aleksandra Jurewicz; Delia Hof; Jörg Oehlmann; Matthias Oetken

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Die Europäische Wasserrahmenrichtlinie (EU-WRRL) hat das Ziel, dass bis zum Jahr 2027 alle oberirdischen Gewässer Deutschlands einen guten ökologischen Zustand aufweisen. Derzeit erreichen rund 10 % der Gewässer in Deutschland diesen angestrebten Status. Als primäre Ursachen gelten eine Belastung mit Nährstoffen und Umweltschadstoffen sowie eine morphologische Degradation infolge einer intensiven Umlandnutzung.

Im Rahmen des DECIDE-Projekts wird ein ökotoxikologisches und wasserrahmenrichtlinien-konformes Bewertungssystem entwickelt, um wasserwirtschaftliche Maßnahmen priorisieren zu können. In der Praxis soll das Bewertungssystem als Entscheidungshilfe dienen, ob stoffliche Belastungen und ihre Auswirkungen oder Faktoren, wie eine defizitäre Gewässerstruktur und intensive Landnutzung, die Hauptursache dafür sind, dass der gute ökologische Zustand in einem Oberflächengewässer nicht erreicht wird.

Als Untersuchungsgebiet wird das Hessische Ried ausgewählt, das nicht nur intensiv landwirtschaftlich genutzt wird, sondern auch der Metropolregion Rhein-Main als Trinkwassergewinnungsgebiet dient. Um die Wirkung der anthropogen eingeleiteten Schadstoffe auf die aquatischen Organismen und die Gewässergüte zu prüfen, werden im Rahmen eines effektbasierten Monitorings In-vivo-Tests mit G. fossarum und P. antipodarum durchgeführt. Des Weiteren werden Wasser- und Sedimentproben mittels In-vitro-Tests auf ein gentoxisches, neurotoxisches und basistoxisches Potential getestet, um das Ausmaß der möglichen Effekte zu erfassen.

Das DECIDE-Projekt wird von der Deutschen Bundesstiftung Umwelt (DBU) gefördert (Förderkennzeichen AZ 35663/01).

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Die große Bedeutung der kleinen Gammariden beim Laubabbau

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Nach einer 2018 durchgeführten Revitalisierung eines Gewässerabschnitts im Stadtgebiet von Waldheim konnte anhand hydromorphologischer Parameter und der Bewertung nach WRRL eine Verbesserung des ökologischen Zustands verzeichnet werden.

Um die Wirkung der Renaturierung auf die Verbesserung grundlegender Ökosystemfunktionen zu quantifizieren, wurden im Frühjahr und Herbst 2020 Versuche zum Laubrückhalt und Laubabbau durchgeführt.

Das Laubrückhaltevermögen stellt einen wichtigen Beitrag zur Bereitstellung von Habitaten und Nahrung dar und wurde mittels eines release-recapture-Experiments untersucht. In den für den Laubbabbau nötigen Habitatstrukturen wurden Laubabbauraten von *Alnus glutinosa* mithilfe von groben und feinen Laubsäckchen über einen Zeitraum von 28 Tagen jeweils im Frühjahr und Herbst erhoben.

Im Vergleich zu Daten von 2016 (vor Renaturierung), konnte sowohl eine Verbesserung des Laubrückhaltevermögens als auch eine Erhöhung der Laubabbauraten am revitalisierten Gewässerabschnitt gezeigt werden.

Verglichen mit dem naturnahen Referenzabschnitt im Untersuchungsjahr 2020 zeigt das Laubrückhaltevermögen an den revitalisierten Stellen keinen signifikanten Unterschied. Jedoch unterschieden sich die verantwortlichen Strukturen, an denen Laub zurückgehalten wird, maßgeblich. Obwohl die nötigen Strukturen und Schlüsselhabitate vorhanden zu sein scheinen, weisen die revitalisierten Abschnitte sowohl im Frühjahr als auch im Herbst signifikant niedrigere Laubabbauraten auf als am natürlichen Referenzabschnitt. Weder taxonomische noch funktionale Diversität können die hohen Differenzen erklären.

Bedeutung kommt jedoch der Abundanz der Shredder Gilde zu. Dominiert von *Gammarus fossarum* (87-98%) sind die Unterschiede bzgl. der Abundanz zwischen den Abschnitten signifikant, wobei sich die Biomasse von *G. fossarum* nicht maßgeblich unterscheidet. Auffällig sind hier Unterschiede der Größenklassenverteilungen zwischen den Abschnitten. Während die Anzahl der großen Individuen in beiden Abschnitten gleich groß ist, weist der Referenzabschnitt wesentlich mehr kleine und mittlere Individuen auf als die revitalisierten Abschnitte.

Somit zeigt sich die hohe Relevanz der kleinen Gammariden für den Laubabbau. Um auch an den revitalisierten Abschnitten eine erfolgreiche Reproduktion dieser zu ermöglichen, bedarf es eines höheren, dauerhafteren Rückhaltevermögens von grobem organischem Material.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Mehrskaliges Monitoring von Cyanobakterienblüten in der Mosel durch fernerkundliche und in situ Methoden

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Cyanobakterienblüten in Fließgewässern können auf Grund ihrer toxinbildenden Eigenschaften eine Gefahr für Mensch und Ökosystem darstellen. In der Mosel kam es in den Jahren 2017 bis 2020 zu ausgeprägten Blüten der Cyanobakteriengattung Microcystis. Für ein verbessertes Management der Cyanobakterien bedarf es ihrer automatisierten und flächendeckenden Erfassung. In Ozeanen ist es bereits etablierter, mittels Satellitendaten Chlorophyllkonzentrationen großflächig zu bestimmen. In Binnengewässern müssen jedoch Satelliten mit höherer Auflösung eingesetzt werden, zum Beispiel Sentinel-2 aus dem ESA/Copernicus Programm, welche aber die relevanten Spektralbereiche nicht optimal abdecken. Dies führt zu Herausforderungen bei der Trennung von anderen optisch wirksamen Substanzen wie den in Binnengewässern häufigen Schwebstoffen beziehungsweise der von ihnen verursachten Trübung. Im Projekt „Mehrskaliges Monitoring“ (MeskalMon) soll ein Werkzeugset mit möglichst automatisierten Auswerteroutinen entwickelt werden, das es ermöglicht, Trübung und Chlorophyll (insbesondere von Cyanobakterien) in Flüssen optisch voneinander zu trennen und quantifizieren zu können. MeskalMon verknüpft dafür in situ Punktdaten mit Fernerkundungsdaten auf verschiedenen Raumskalen (in situ Messung – Kamera – Drohne – Satellit), um spektrale Eigenschaften genauer zu untersuchen sowie um Skalen- und Atmosphäreneffekte zu verstehen und auf andere Raumskalen übertragen zu können. Das fertige Produkt soll es ermöglichen, Cyanobakterienblüten verlässlich abzubilden und Fernerkundungsdaten für das Monitoring und Management von Bundeswasserstraßen und anderen Binnengewässern nutzen zu können.

Flussperlmuschel-Monitoring mittels eDNA: Variabilität der DNA-Abgabe und Detektionswahrscheinlichkeit

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Nachhaltiger Schutz bedrohter Großmuscheln erfordert zwingend Kenntnisse über deren Verbreitung und Bestandsentwicklung. Um rechtzeitig auf Bestandseinbrüche reagieren zu können, müssen Existenz und Bestandsentwicklung möglichst flächendeckend überwacht werden. In der Nister, einem Mittelgebirgsfluss im Westerwald, existiert vermutlich ein Reliktvorkommen der vom Aussterben bedrohten Flussperlmuschel. Da dies das letzte Vorkommen des genetisch isolierten Rheinclusters in Deutschland ist, wäre das Auffinden weiterer Individuen von großer Bedeutung für Zuchtmaßnahmen. Ihre versteckte Lebensweise macht die visuelle Erfassung von Muschelbeständen, besonderes bei geringen Populationsgrößen kosten- und zeitaufwendig. Seit kurzem werden eDNA-Analysen erfolgreich zur Detektion bedrohter Muschelarten eingesetzt und es können auch sehr kleine Populationen detektiert werden. Abiotische und biotische Faktoren können die Detektion jedoch beeinflussen und in Feldversuchen zeigt sich eine hohe Variabilität der Signalstärke. Um dieses Verfahren zur Detektion von *Magaritifera magaritifera* in der Nister zu optimieren und die Detektionswahrscheinlichkeit (DWK) weiter zu erhöhen, wurden Modifikationen der Laboranalysen etabliert und die DNA-Abgabe durch die Muscheln unter verschiedenen Umweltbedingungen in standardisierten Experimenten untersucht.

Dafür haben wir die Variabilität der DNA-Abgabe in mehreren Experimenten im Tagesverlauf sowie in Abhängigkeit der Faktoren Nahrungsangebot und Temperatur untersucht. Für die Versuche wurden in drei Edelstahlrinnen je 27 Jungmuscheln in Enclosures unter verschiedenen Umweltbedingungen im Durchfluss gehältert. An je 2 Stellen pro Rinne wurden alle 4 Stunden Wasserproben entnommen wobei die DNA direkt an Filtermaterial gebunden und konserviert wurde. Nach der DNA-Extraktion wurden alle Proben mittels qPCR unter Verwendung eines optimierten Ansatzes in Triplikaten analysiert und die DWK als Maß für die Variabilität der DNA-Abgabe bestimmt. Die Ergebnisse zeigen eine erhöhte DWK der Muschel-DNA bei verringertem Nährstoffangebot, allerdings nur direkt hinter dem Enclosure, während die Temperatur keinen Effekt auf die Detektionswahrscheinlichkeit hatte. Da die Unterschiede bereits am Ende der Rinne nicht mehr nachweisbar waren, ist zu vermuten, dass auch die Nahrungsversorgung für den Detektionserfolg bei einem Monitoring im Gewässer irrelevant ist.

S09: Auen

Evaluation of the ecological status of the River Danube and its floodplain in Germany by implementing the macrozoobenthos based assessment by Graf and Chovanec (2016)

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Over the past centuries rivers and their floodplains have been altered worldwide resulting in a shift in freshwater communities. The Water Framework Directive (WFD) targets to achieve a “good ecological status” of the rivers in the EU. Benthic invertebrates are sensitive to habitat loss, general habitat degradation and other impacts. Hence, they build one group of indicators used by the WFD for the evaluation of the ecological status of surface waterbodies. On the one hand, there is a lack of knowledge about the composition of benthic invertebrates of large European rivers before intensive stream modifications. Reference sites to close this gap can solely be found for small streams. On the other hand, fluvial dynamics of river floodplains create habitat mosaics and connectivity gradients, resulting in key areas for biodiversity and ensuring diverse ecosystem functions.

Graf and Chovanec (2016) have developed a WFD compliant assessment for large river floodplains based on benthic invertebrates for the River Danube in Austria. Therefore, species of Mollusca (molluscs), Odonata (dragonflies) and Trichoptera (caddisflies) were classified according to their preferences for the different types of floodplain waterbodies according to Amoros et al. (1987). The occurrence of these species indicates the presence of target habitats in the investigated floodplain.

The purpose of this study is to attempt the assessment by Graf and Chovanec (2016) for its applicability and adaptation for a stretch of the German Danube and its floodplain. Data used in this study were gathered for the EU-study on the upgrading of the Danube waterway between Straubing and Vilshofen founded by the Federal Ministry for Transport and co-founded by the European Union (IVL 2012a, b, c).

S08: Plankton ecology

Trophic improvements in the epilimnion are reflected by the colonisation of lakes by phototrophic sulfur bacteria

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Remediation measures in the catchments lead to a decrease in trophic levels in the long term and thus to an improvement in underwater light conditions. As many stratified lakes still have oxygen-free conditions with hydrogen sulfide formation in the hypolimnion, we postulate that increased euphotic depth favors the formation of deep chlorophyll maxima (DCM) of phototrophic sulfur bacteria (PSB) below the chemocline. To test this hypothesis, we compared data from campaigns at four dimictic lakes in the Scharmützelsee region (1996, 2003 and 2020). In addition to vertical profiles of light, temperature, O2 and H2S, these also include investigations of the absorption spectra of pigment extracts from different depths, which allow a rough quantification of PSB biomass.

The timing and degree of improvement in the epilimnion varied. While Tiefer See has remained almost unchanged at mesotrophic levels since 1996, Scharmützelsee (SCH) and Großer Glubigsee (GGL) have improved since the early 2000s, but Springsee (SPR) only after 2010. In all lakes PBS have been detected since 1996, except SCH only in 2020. Due to reduced primary production in the epilimnion, less detritus was mineralized, resulting in lower sulfide concentrations that shifted the DCM to greater depths. Despite the downwards shift of the chemocline by 4m in GGL, 6m in SPR and 7m in SCH, the biomass of PBS was rather higher. An increased BChla to BChle ratio indicated a species shift within the PBS due to improved underwater light conditions and reduced H_2S concentrations. Thus, we were able to detect complex and trophic relevant changes in the plankton communities below the metalimnion.

Potential of eDNA as a tool to track waterbird populations in Lake Constance and surrounding

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Birds have long been a popular field of research as they play an important role in ecosystem maintenance, and waterbirds are an integral part of aquatic communities and food webs. Therefore, they are closely monitored and can serve as early indicators of changes in the ecosystem. With aquatic ecosystems under severe anthropogenic stress and changing rapidly, new, time-efficient methods are called for. Here, we investigate the utility of eDNA from water and sediment as a tool to track waterbird populations in the present and the past at Lake Constance and surrounding water bodies. We are investigating this method in the well-monitored Lake Constance, where there is a high occurrence of wintering waterbirds, and where we can compare the eDNA data with monitoring time series. We aim to obtain a high taxonomic resolution and investigate, how well eDNA can be used to deliver quantitative data on waterbirds. This could become especially important in regions essential for nature conservation, where no bird monitoring is performed or possible. For this we use a combination of species-specific quantitative reaction and metabarcoding approaches. We are currently completing the aquatic eDNA waterbird investigation, spanning a sampling period of two winters. The investigation of bird DNA in sediment cores from Lake Constance and additional analysis of other groups, such as Neozoa or pathogens, can potentially deliver information on the historic role of waterbirds as vectors of dispersal in limnic systems.

A2: Seen und Feuchtgebiete

15,000 years of aquatic invertebrate assemblage changes in two Swiss lowland lakes (Bichelsee and Hüttwilersee)

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It is uncertain how small lakes will react to climatic changes and human modifications in the future. Retrospective studies can give us insights on how these ecosystems have responded to decadal and long-term environmental changes in the past. Some chitinous remains of aquatic invertebrates (e.g. chironomids, cladocerans, bryozoans) preserve well in lake sediments for thousands of years and can be identified to better understand the long-term development of lakes. In Switzerland, very few studies have focused on aquatic invertebrate assemblages of small low elevation lakes during the Holocene, a time of varying climatic conditions and many changes due to human land modifications. Here we present a study describing aquatic invertebrate assemblages over the past 15,000 years from two Swiss lowland lakes (Bichelsee and Hüttwilersee, canton of Thurgau). In Bichelsee, the chironomid fauna was dominated by species preferentially found in the profundal of meso- to eutrophic lakes, with a shift to more nutrient loving taxa in younger sediment layers. The presence of Chironomus and Chaoborus suggest that deepwater environments may have already been limited before the most recent land use changes. In Hüttwilersee, a major shift in the chironomid assemblage occurs at the transition between the Lateglacial and the beginning of the Holocene with the cold-indicative species being replaced. Already as early as 8,000 – 4,000 years ago, the deepwater environments of this lake were probably characterised by low oxygen conditions, as suggested by high abundances of Chaoborus relative to chironomids. Finally, the concentration of chironomids strongly increases around 500 years ago when hemp retting seems to have affected Hüttwilersee. The aquatic invertebrate assemblages of these two lakes indicate distinct changes in in-lake conditions during the Holocene due to environmental changes and human influences well before industrialization and the subsequent eutrophication phase of Swiss lakes in the 19th and 20th centuries.

Das TrendDNA-Projekt: Dem Biodiversitätswandel auf der Spur mit der Umweltprobenbank (UPB) des Bundes

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Die Umweltprobenbank des Bundes (UPB) ist ein zentraler Teil der Langzeit-Umweltbeobachtung in Deutschland. In der UPB werden, teils seit den 1980er Jahren, systematisch unterschiedlichste Proben verschiedener Organismen und Ökosysteme (Meeres-, Süßwasser-, Landökosysteme) gelagert, anhand derer die Qualität der Umwelt überwacht werden kann. Die Lagerung auf Flüssigstickstoff archiviert ebenfalls die molekularen Bestandteile, insbesondere die DNA und RNA dieser Proben, nachhaltig. Durch technologische Entwicklungen im Bereich des genetischen Umweltmonitorings können die Proben der UPB wichtige Informationen zum Zustand und zur Veränderung der biologischen Vielfalt (Biodiversität) liefern - und das aufgrund der systematischen Probenahme über lange Zeiträume retro- und prospektiv. Die Proben der UPB bieten dadurch enormes Potenzial für ein breites Spektrum von Biodiversitäts-Analysen - von der Ebene der Population über die Ebenen der Arten und Artengemeinschaft, von Mikroorganismen über wirbellose Tiere zu Wirbeltieren und höheren Gefäßpflanzen, in terrestrischen, marinen und limnischen Habitaten. Mittels der modernen Technik des DNA-Metabarcodings und der Metagenomik können Veränderungen von ganzen Artengemeinschaften charakterisiert werden. Das gilt für Umwelt-DNA von Makroorganismen, als auch für mikrobielle Gemeinschaften, die mit der Probe assoziiert sind. Populationsgenomische Analysen innerhalb von Arten erlauben es zudem, rezente evolutionäre Veränderungen zu entschlüsseln, z.B. im Zuge des Klimawandels. In diesem Beitrag stellen wir neben dem Projekt die ersten Ergebnisse zur Untersuchung von Fisch- und Makroinvertebratentrends am Rhein über Umwelt-DNA vor. Mithilfe zweier Genmarker (Cytochrom-c-Oxidase I, 12S rDNA) wurde die Spezifität und Sensitivität der Methode sowie die Plausibilität der Artenliste beurteilt und ein erster Vergleich der Faunenveränderung von 2005 bis 2016 vorgenommen. Abschließend zeigen wir relevante Schnittstellen des Projekts für Monitoringprogramme im behördlichen Umwelt- und Naturschutz auf.

S01: Aquatic viruses

Long-term environmental survival in algal viruses

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One of the key factors shaping the population dynamics of viruses is their survival outside the host. For phytoplankton viruses, which occur in fluctuating abiotic environments and encounter variations in host availability, this environmental survival should be particularly important. Phytoplankton viruses are generally assumed to decay at a constant rate, but we recently demonstrated that many chloroviruses (viruses infecting freshwater “chlorella-like” green algae) have a biphasic decay pattern. Roughly half of 35 chlorovirus strains were found to have ‘robust’ virions that resisted decay for at least 1 month. Here, we extended this experiment for four chlorovirus strains that were grown under different conditions. All of the strains produced robust virions that could survive at least 4 months in a brightly-lit, room-temperature environment. The proportion of robust virions varied across virus strains; effects of the growth conditions were not immediately apparent. The production of extremely robust virions may be a way for chloroviruses to persist in their natural temperate habitats. More broadly, our results demonstrate the importance of testing for long-term persistence in aquatic viruses.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Microbial biodiversity compared to macrozoobenthos biodiversity in a restored lowland creek

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Biolog EcoPlates are used in studies on heterotrophic bacterial communities as a tool for community level physiological profiling (CLPP). In this study they are used in a novel way to study the ecological status of two urban freshwater streams located in the vicinity of Kamp-Lintfort, Nordrhein-Westfalen. The feasibility of the method was tested in practice on sediment samples from lotic environments and the gathered data was evaluated using calculated biodiversity indices. Additionally to the functional responses of the bacterial communities, biotic and abiotic characteristics were recorded. Since the Biolog EcoPlates include various carbon substrate resources, the community structure was found through selected sets of alpha and beta diversity indices. This data was compared with data from a previous study on benthic invertebrates from one of the creeks with a history of restoration after the closure of the local mining site. A kinetic trend investigation by fitting logistic curve provided information which distinguished communities. Also, physicochemical differences were found between the locations. These were compared with carbon source utilization pattern (CSUP) of the communities to find correlations. The applicability if the method was found to be quick and cheap however the bioassay is prone to bias if the parameters such as inoculum cell density are not measured prior to the incubation. For the ecological application of the method, e.g. to investigate renaturation success of the creeks, historical data before and after remediation or continuous monitoring is needed for full optimization of the method.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Linking community dynamics of bacteria and phytoplankton in response to different nutrient scenarios

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Phytoplankton co-occur in symbiotic association with heterotrophic bacteria that provide vitamins and micronutrients while receiving organic carbon and other nutrients from the autotrophs. It is known that different phytoplankton groups show distinct associated bacteria communities and that different stages of bloom succession are characterized by different types of bacteria providing different functions. We here investigate (i) whether different genotypes of the same species are also characterized by unique associated bacteria and (ii) how the associated microbiome of an experimental phytoplankton community shifts in different nutrient regimes and community configurations.

The experimental community consisted of two coexisting phytoplankton Chaetoceros affinis (diatom) and Emiliania huxleyi (coccolithophore), each consisting of nine genotypes. The two species grew separately and together in a semi-continuous batch cycle system for 182 days at three nutrient regimes with increasing nitrate concentration. Prior to the onset of the community experiment we assessed the microbiome of each genotype in isolation and in the following monitored species and genotype sorting over time and analyzed the bacterial composition with 16s rRNA gene sequencing at the start and end of the experiment. We connected relative bacterial composition to quantitative flow cytometer measurements of total bacterial abundance and by this gained a deeper understanding of the interplay between the closely linked community dynamics of phytoplankton and their associated bacteria.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Responses of microphytobenthic communities to anthropogenic stressors in the Boye and Kinzig Catchments, Germany

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A variety of anthropogenic stressors are impacting inland rivers, including climate change, chemical pollution, and physical habitat disturbances. Microphytobenthic communities form the most abundant group of autochthonous primary producers in rivers. Diatoms are the best-studied organisms in these communities. They respond swiftly to human influences and have been used as important indicators in water quality assessments around the world for decades. Yet, our knowledge of diatom community compositions in recently restored catchments, as is the case for Boye (tributary to the Emscher), or in the otherwise well-studied Kinzig catchment, is still very limited. This way, we aim to characterize the effects of anthropogenic stressors in lowland streams (Boye) and low mountain ranges (Kinzig). Digital microscopy and DNA metabarcoding technologies are being used to analyze field samples collected in spring 2021 and 2022 in these two river catchments, in addition to functional trait measurements (chlorophyll fluorescence). The first results of this ongoing investigation suggest that both river catchments had a high diatom diversity in spring 2021. The most dominant diatom taxon in the Boye catchment was the low profile Achnanthidium minutissimum. The high profile Navicula lanceolata dominated in the Kinzig watershed. Analysis of variance of in situ chlorophyll fluorescence measurements taken during the 2021 field sampling campaign revealed no significant differences in diatom biomass between sites in both catchments (ANOVA $p > 0.05$). However, the comparison of the two catchments indicated that diatom biomass was significantly higher in the Kinzig network (ANOVA $p < 0.001$) than in the Boye system, suggesting multiple stressors much less affect the former. The Kinzig catchment results will round the already deep pool of ecological data. The characterization of the Boye streams will further shine a light on the time series of diatom communities in response to restoration and show how quickly the community can recover.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Wie wirken sich verschiedene Ufersicherungen entlang von Bundeswasserstraßen auf Uferökosysteme aus? - Analyse anhand von Vegetation, Laufkäfern, Spinnen, Makrozoobenthos und Fischen

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Aufgrund der intensiven Nutzung der Gewässer und Auen, sind die Mehrzahl der Flussufer in Deutschland und besonders an Bundeswasserstraßen weit entfernt von einem guten ökologischen Zustand. Begradigungen, Vertiefungen und technische Uferbefestigungen, zum Schutz der Ufer vor hydraulischen Belastungen durch Schifffahrt und Hochwasser, haben die Uferlebensräume stark beeinträchtigt oder zerstört.

Ingenieurbiologische Ufersicherungen können eine Alternative zu konventionellen Ufersicherungen, wie z.B. die Verwendung von Schüttsteinen, darstellen. Als Ersatz von Steinschüttungen können sie Ufer ökologisch durch eine höhere, naturnähere Struktur- und Lebensraumvielfalt aufwerten und als ökologische Trittsteine den Biotopverbund fördern.

Im Forschungs- und Entwicklungsprojekt „BEconnect“ werden die Effekte von unterschiedlichen Ufertypen (Ufer mit Steinschüttungen, mit Weidepflanzungen, entsteinte Ufer und Auwaldrelikte) an Bundeswasserstraßen, auf die Flora und ausgewählte Tiergruppen untersucht. So soll das ökologische Potential von Weidenpflanzungen als Ufersicherung erfasst und bewertet werden.

In den Jahren 2017 und 2018 wurden dafür Daten zu Vegetation, Laufkäfern, Spinnen, Makrozoobenthos und Fischen an drei Bundewasserstraßen (Main, Weser, Aller) erfasst. Je Fluss wurden die vier verschiedenen Ufertypen untersucht. Hierzu wurden 25 Probeflächen mit einem Abmaß von 100 m parallel und 10 m senkrecht zur Uferkante untersucht. In jeder Untersuchungsfläche wurde in drei 1 m breiten Linientransekten parallel zum Ufer (1 m, 5 m und 10 m zur Uferkante) die Vegetation, Laufkäfer und Spinnen beprobt. Zusätzlich wurden Boden- und Wasserproben genommen. Die Fische und MZB sind in Ufernähe (max. 2 m) erfasst worden.

Zur Analyse werden neben klassischen Biodiversitätsparametern funktionale Organismeneigenschaften („traits“) und der Einfluss abiotischer Faktoren vergleichend betrachtet. Die bisherigen Ergebnisse zum Vorkommen und der Verteilung von Vegetation und Laufkäfern zeigen Unterschiede in der Artenzusammensetzung der Auwaldreliktflächen gegenüber den anderen Ufertypen. Eine ähnliche Tendenz weisen die Spinnen-Gemeinschaften auf. Stärkster Einflussfaktor ist durchgehend der Faktor Fluss. Die Anzahl hygrophiler Spinnen sowie Laufkäfer und Fische mit Auenbindung, Rote-Liste Arten sowie die Diversitätsparameter unterscheiden sich statistisch nicht.

S08: Plankton ecology

Living ‘on the breadline’: Does *Autumnella lusatica* sp. nov. overcome carbon limitation in acidic mining lakes by CO_2 diffusion from atmosphere?

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In acidic mining lakes, the green alga *Autumnella lusatica* converts the limiting resources carbon and phosphorus into biomass extremely efficiently. It was identified as the dominant species in acidic mining lakes in autumn, e.g. in Lake Halbendorfer See, where it formed high biovolumes (up to 20 mm^3/L and 50 µg Chl a/L) at pH around 3 under oligotrophic nutrient conditions, although inorganic carbon concentrations are limiting and TIC is below the saturation concentration of 0.5 mg/L. Laboratory experiments showed that the addition of dissolved organic and inorganic carbon and phosphorus stimulated biomass production up to a Chla concentration between 100 and 200 µg/L, and it was suggested that the species is potentially mixotrophic.

In this study, we investigate the question to what extent the carbon demand of algae can be met by the replenishment of CO_2 through atmospheric diffusion. Assuming that epilimnion and euphotic depth of acidic lakes are mostly undersaturated by CO_2 due to photosynthetic activity, we focus on physically induced carbon fluxes from the atmosphere into the epilimnion of Lake Halbendorfer See. For this purpose, modelling studies were carried out with PhreeqC at an initial TIC concentration of 0.01 mg/L for different water temperatures, epilimnion depths and CO_2-exchange coefficients. The calculated CO_2 flux by atmospheric diffusion ranges between 0.012 - 0.048 mg TIC/(L·d) under boundary conditions used in the model approach. How much of the high biomass production is explained by this term is presented in the form of scenario calculations, taking into account the methodological challenges and uncertainties in measuring and calculating primary production at such low TIC concentrations.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Flächenverbrauch durch die Sportschifffahrt am Bodensee

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Nicht nur die fahrende, sondern auch die ruhende Schifffahrt in Steganlagen, Häfen und Marinas führt zu Umweltbelastungen (Ausbaggerungen, Strömungsveränderungen, künstliche Substrate, Antifouling-Wirkstoffemissionen, Flächenumwandlungen, Lichtemissionen usw.). Um die Umweltfolgen modellieren zu können, ist eine Quantifizierung der Bootsstationierungsanlagen (Anzahl, Fläche, räumliche Verteilung) einschließlich der Infra- und Suprastruktur in den jeweiligen Wassersportrevieren notwendig.

Der Bodensee gehört zu den größten Wassersportrevieren Mitteleuropas mit einem registrierten Bestand von etwa 61.200 Sportbooten sowie weiteren 457 gewerblich genutzten Arbeitsbooten und Schiffen (Stand 2020, Amt der Vorarlberger Landesregierung). Die Zahl der behördlich erfassten Wasser- und Landliegeplätze wird mit etwa 15.200 (Stand 2011, IGKB) angegeben.

Wir haben einen überregionalen hierarchischen Katalog der Bootsstationierungseinheiten (BoStA) entwickelt und am Bodensee erprobt. Auf der Grundlage vorhandener, jedoch nicht einheitlich durchgeführter Erfassungen haben wir mittels GIS die Anzahl, die Flächengröße und die regionale Verteilung der BoStA ermittelt.

Insgesamt nehmen die BoStA eine land- und wasserseitige Fläche von 4,5 km^2 ein. Davon entfallen 54 % auf Häfen (BoStA mit künstlichem Wellenschutz), 23 % auf Bojenfelder, 11 % auf nicht wellengeschützte Bootssteganlagen und -einzelstege sowie 2 % auf landwärtige Trockenlager. Im Mittel entfallen auf jeden Uferkilometer 2,1 Einheiten unterschiedlicher Größe. Die ermittelten Flächen wurden stichprobenartig anhand eigener Luftbild-Kartierungen und Geländebegehungen (ground truth) überprüft. Gleichzeitig wurden die Ausstattungselemente der Anlagen erfasst und quantifiziert.

Vergleichbare Erhebungen sollen auch an ausgewählten bayerischen und brandenburgischen Seen durchgeführt werden, um die Unterschiede zwischen unterschiedlichen Wassersportrevieren herauszuarbeiten.

Ziel ist die liegeplatzspezifische Ermittlung des Flächenverbrauchs einschließlich aller Infra- und Suprastrukturflächen als Grundlage für die räumlich hoch aufgelöste Klassifikation (i) der hydromorphologischen Qualitätskomponente „Uferstruktur“ der EG-Wasserrahmenrichtlinie und (ii) der ökologischen Auswirkungen (HMS-Verfahren). Aus den ermittelten Daten sollen Empfehlungen zur Begrenzung und Reduzierung der Umweltauswirkungen abgeleitet werden.

Die Erhebungen finden im Rahmen des Forschungsprojekts SuBoLakes (https://www.subolakes.de) statt, das mit Mitteln der Deutschen Bundesstiftung Umwelt (DBU) gefördert wird (Kennz. 35825/01).

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Effects of incomplete sampling on macroinvertebrate secondary production in a forested headwater stream

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Unbiased estimates of secondary production depend on the efficiency of sampling methods in capturing abundances and body lengths of the entire macroinvertebrate community. The efficiency of common sampling method in fulfilling these criteria remain still poorly understood. We compared the effects of a Surber sampler (250 µm mesh size) and freeze core (without mesh) in capturing abundance, biomass and secondary production of macroinvertebrates in a forested headwater stream. We furthermore studied how mesh size and mesh retention efficiency affect production to find the most effective sampling strategy to obtain an unbiased estimate of total secondary production. Abundance was three times lower and biomass three times higher with the Surber sampler than with the freeze corer. None of the methods captured the entire length distribution and incomplete sampling of body lengths and abundances led to an underestimation of total secondary production by 50% (Surber sampler) and 44% (freeze corer). Reducing the mesh size to 100µm enables the collection of the smallest individuals and may reduce the production bias to ~10%. Our results help to improve the efficiency of common sampling methods to reliable quantify the role of macroinvertebrate to stream ecosystem functioning.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Robustness of planktonic food webs against a nutrient pulse perturbation depending on the functional diversity

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Diversity provides the potential for communities to adapt to changing environmental conditions. Such adaptations are particularly relevant when communities are subject to pulse perturbations. A recent modelling study of a tritrophic food web with the potential for trait adjustment at each trophic level showed that the robustness of the system, i.e. the resistance, resilience and elasticity, to pulse perturbations increased with the functional diversity (Wojcik & Ceulemans 2021). For example, at low diversity a pulse perturbation may cause extinctions, whereas the corresponding system with higher diversity generally had a higher buffer capacity. This implies that the current loss of diversity and increase in frequency and intensity of perturbations can lead to a self-enforcing feedback loop.

To test these model results empirically we conducted a chemostat experiment, where we could maintain a complex community comprising three green algae and a cryptophyte as primary producers and four rotifer species differing in their food preferences as herbivores for 70 days. After a transient period we imposed a strong nutrient pulse which was buffered by the diverse community. The herbivores imposed a top-down control on all algal species that prevented a substantial algal biomass increase and profound changes in species compositions and the excess nutrients were mostly washed out. To further explore the effect of functional diversity on the robustness of multi-species communities to pulse perturbations we are running further chemostat experiments with varying levels of diversity.

A2: Seen und Feuchtgebiete

Methane emissions from gas seeps in Lake Constance

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Methane emissions from lakes are a major source in the global atmospheric methane budget. The release of methane from lakes occurs via diffusive transport across the water-atmosphere interface and via ebullition of methane-rich gas bubbles. The ebullition flux is typically very sporadic and triggered by short-term events such as local disturbances of the sediment or pressure changes in shallow waters due to waves. An exception are natural gas seeps that release methane-rich gas bubbles over extended periods of time. Here we quantify the ebullition flux from natural gas seeps in Upper Lake Constance and investigate the temporal variability of the ebullition flux from three continuously active methane seeps. The hourly mean ebullition flux from two seeps located at 10-12 m water depth changes by less than 15% within an up to 3 month time period, whereas the temporal change of the ebullition flux from a shallower seep (5m depth) is substantially larger. At all sites, the ebullition flux shows a significant negative correlation with total pressure at the seep. On short time scales, fluctuations of ebullition fluxes were closely linked to variations in atmospheric pressure, whereas on monthly time scales changes in water level altering hydrostatic pressure were the dominant factor. The sensitivity of the ebullition flux to pressure changes was larger at the shallow than at the deep sites. Furthermore, the data from the shallow site suggest that seeps may start or cease ebullition.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Phototrophic communities of shallow lakes gain tolerance towards herbicides after exposure to agricultural run-off

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Shallow aquatic ecosystems are often impacted by agricultural run-off consisting of pesticides and nutrients and increasing water temperatures as a consequence of climate change. Especially the competition between phototrophic communities can be affected by these stressors potentially leading to regime shifts from macrophyte to phytoplankton or periphyton dominance. Microalgal communities can adapt quickly to stressors via selection of more tolerant species resulting in pollution induced community tolerance. In contrast, macrophyte communities with longer generation times cannot adapt as quickly and are thus potentially at disadvantage in the competition compared to microalgal communities. In a mesocosm experiment mimicking shallow aquatic ecosystems we tested tolerance acquisition of periphyton, phytoplankton and macrophytes during long-term exposure (8 weeks) to agricultural run-off, including herbicides, at ambient and elevated (+4°C) water temperatures. Dose-response models revealed that periphyton and phytoplankton increased their herbicide tolerance by a factor 12 and 4, respectively, when exposed to agricultural runoff. Surprisingly, the macrophyte Myriophyllum spicatum showed an even higher increased herbicide tolerance than the microalgal communities (factor 14). Increased water temperatures had only a minor effect. Our study indicates that not only long-term adaption of periphyton and phytoplankton via species selection and succession, but also physiological acclimation of macrophytes needs to be considered when assessing the effects of pesticides on shallow aquatic ecosystems. Further insights into the mechanisms of physiological acclimation of macrophytes were derived from metabolomics showing shifts in metabolic fingerprints after exposure.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Long-term shift in phosphate loading exposes emergent tradeoffs in mean phytoplankton community traits

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Phytoplankton biomass shows considerable resilience to changes in phosphate concentrations in both eutrophic and oligotrophic systems. Typically, the response of phytoplankton biomass to a reduction in phosphate is delayed, and in some lakes, e.g. Lake Constance, annual mean biovolume exhibits a regime shift characterized by a resilient high biomass state at high phosphate concentrations and a rapid transition to a resilient low biomass state when phosphate concentrations decrease significantly. These observations suggest that the functional character of the phytoplankton community changes with trophic change, supporting resilience of biomass to nutrient change, whereby this adjustment to trophic change may break down during short transition times, resulting in a regime shift.

Here we investigate the long-term development of annual mean community composition and traits in response to eutrophication and oligotrophication. Our analysis is based on data from large and deep Upper Lake Constance covering substantial parts of the eutrophication and re-oligotrophication phase in this lake. We address the questions whether traits develop in parallel with trophic state or phytoplankton biomass. We investigate whether the changes in community mean traits are dominated by changes in the species composition within taxonomic groups or by changes between taxonomic groups. Furthermore, we identify trade-offs between community traits and relate these trade-offs to the environmental conditions during trophic change.

S13: Imaging Plankton

Applying image-based approaches for biomass and biodiversity assessment of macroinvertebrates

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Biodiversity loss is proceeding at an alarming pace. To counteract it, we need quick and reliable tools to identify and monitor taxa of interest, particularly in the most vulnerable environments like freshwater ecosystems where extinction rates are extremely high. However, reliable species identification poses a major challenge for swift bioassessment and monitoring of biological quality elements such as macroinvertebrates, fish and diatoms as proposed in the Water Framework Directive. The current standard identification procedures rely mostly on morphological identification, which requires substantial time and taxonomic expertise. As an alternative, recent advances in machine learning enable reliable species identification by high-accuracy image classification. However, automated image-based approaches remain understudied for identifying species in biodiversity research. In our upcoming project, we plan to test image-based morphological identification and biomass estimation of stream macroinvertebrates, including multiple keystone species, using the semi-automated imaging device BIODISCOVER. We intend to use extensive material from a recent outdoor field experiment, where we tested the impact of multiple stressors on macroinvertebrate communities. The first results indicate that semi-automated imaging can help to train deep learning networks for accurate species identification, while also providing information on species' biomass. Cross-validated with high-throughput species identification via DNA metabarcoding, the proposed approach provides a promising solution for rapid and reliable species identification while providing detailed information about community composition.

S12: Flexibility matters: Interplay between trait diversity and eco-evolutionary dynamics using aquatic communities as model systems

Genotype variability and phenotypic plasticity determine intraspecific variation in cell size and particulate nutrients in the diatom *Chaetoceros affinis*

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Intraspecific trait variability may originate from among genotype variability and intragenotypic plasticity, which are both attributed important. To better understand the two origins of phytoplankton intraspecific trait variability, we here investigated among genotypes and plasticity-driven variability of cell size, cellular particulate organic carbon (POC), and nitrogen (PON), stoichiometry and their interrelations of the diatom *Chaetoceros affinis*. We designed an experimental set-up in which nine genotypes of *C. affinis* were individually treated for 7 days with a nutrient gradient spanning seven different nitrate concentrations while phosphate was held constant, covering N-limited to Redfield conditions. We hypothesized to find (i) intraspecific variability in the response variables, (ii) which can be attributed to both plasticity and among genotype differences. Furthermore, we hypothesized (iii) that cell size likely explains both plastic and intergenotypic variations in cellular POC, PON and stoichiometry. Across all genotypes, we found U-shaped responses of cellular POC and PON and hump-shaped responses of cell size and C:N to increased nutrients. Additionally, we found intraspecific variability in cell size and C:N in the form of the reaction norms on both the plasticity level, indicated by significantly different reaction norms of the genotypes, and among genotypes in response to the nutrient regime. As cell size positively correlated with C:N across and within genotypes, we suggest that cell size plays a crucial role to explain the stoichiometric response to nutrients.

A1: Aquatic Ecotoxicology

Responses of aquatic invertebrates to wastewater: conventional versus ozone treatment

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Micropollutants challenge conventional wastewater treatment. Treatment with ozone represents one option to further reduce micropollutant levels, however, may produce toxic transformation products. EPT taxa (Ephemeroptera, Plecoptera, Trichoptera) are bioindicators for a good ecological status of streams. This study evaluates the potential effects of ozonated vs. conventionally treated wastewater on different EPT-taxa in the Ruhr, NRW.

The test species *Ephemera danica, Leuctra geniculata, Hydropsyche incognita*

collected in the Ruhr, were submitted to 19 experimental exposures in flow-through systems with Ruhr water and diluted wastewater (conv., ozone) of 14 d duration.

Locomotory activity of the individual organisms was recorded in real time with the Multispecies Freshwater Biomonitor, while survival and biomarkers were analyzed at the end of the exposures. Biomarkers included: Catalase, Glutathione-S-transferase, Acetylcholin-Esterase, Glykogen, Lipd, Lipdperoxidase.

Micropollutant analysis was performed in 24h samples, detecting 186 substances from 8 substance classes.

Ozonation resulted in additional reduction of micropollutants up to 65 % depending on the substances. Levels of agricultural substances were high in Ruhr water showing pesticide background stress.

No adverse effects of the different wastewater treatments on survival of the EPT-taxa were found.

Behaviour responses to the different wastewater treatments were dependent on the test species and varied between experiments and years. Overall, *H. incognita* showed increased activity in ozonated water.

Biomarker responses also varied between experiments and years, whereas overall effects of water treatment were not clear.

A detailed multivariate analysis of different substance classes and their effects on the EPT-taxa is ongoing to evaluate substance-specific effects.

A5: Gewässermanagement/EG-Wasserrahmenrichtlinie

Herausforderungen der TP-Bestimmung in pH-neutralen Tagebauseen

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Im Rahmen eines DBU-geförderten Projekts werden empirische Phosphor-Retentionsmodelle für pH-neutrale Tagebauseen (TBS) entwickelt, mit denen eine Abschätzung der tolerierbaren P-Belastung möglich ist. TBS zeichnen sich v.a. auf Grund bergbaulich bedingter Einträge von Eisen durch ein höheres P-Retentionsvermögen im Vergleich zu natürlichen Seen aus, so dass die bekannten empirischen Modelle (z. B. Vollenweider) TBS nicht anwendbar sind.

Dieser Beitrag widmet sich der Bestimmung der seeinternen P-Konzentrationen (PSee) als wichtige Eingangsgröße für die Modellentwicklung. Im Rahmen einer Metadatenanalyse wurden 45 neutrale TBS aus dem Lausitzer und Mitteldeutschen Braunkohlerevier ermittelt, die für die Modellanpassung in die engere Wahl kamen. Die Analyse von Langzeitmonitoringdaten verschiedener Quellen für den Zeitraum 2010 – 2020 ergab, dass der langjährige Mittelwert von PSee nur in 25 % der ausgewählten Gewässer über 10 µg L-1 Gesamtphosphor (TP) lag. Was zunächst für eine sehr gute Wasserqualität der TBS spricht, erweist sich für die Modellentwicklung als große Herausforderung. Ein Problem ist, dass die analytische Bestimmungsgrenze (BG) für TP der meisten Labore bei < 10 oder < 5 µg L-1 lag. Das hat zur Folge, dass der Anteil von TP-Werten unter der BG in 16 der ausgewählten TBS über 50 % und in 9 TBS sogar über 75 % betrug.

Für die PSee-Berechnung sind Datensätze mit hohem Anteil von Werten < BG ungeeignet. Daher wurden 2019/20 Messkampagnen mit hohem analytischen Aufwand durchgeführt, um für ausgewählte TBS reale TP-Werte im Bereich der BG zu ermitteln. Die TP-Analysen erfolgten manuell als Autoklavenaufschluss mit Peroxidisulfat und anschließender photometrischer Bestimmung nach der Molybdänblau-Methode. Durch äußerst große Sorgfalt bei der Reinigung von Probegefäßen, Laborgeräten und beim Handling sowie Mehrfachbestimmungen konnte eine BG um 3 µg L-1 erreicht werden. In diesem Beitrag werden Probleme der TP-Analytik in niedrigen Konzentrationsbereichen thematisiert sowie Empfehlungen für die Analytik (Photometrie vs. ICP-MS), aber auch die Probenahme, Probenkonservierung und –lagerung gegeben.

S08: Plankton ecology

Einfluss der Cyanobakterien *Microcystis aeruginosa* NIVA 43 und *Microcystis aeruginosa* PCC 7806 auf die physiologische Leistungsfähigkeit von *Daphnia magna*

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Der Klimawandel und die damit verbundene Temperaturerhöhung begünstigt die Zunahme von Cyanobakterienblüten in aquatischen Systemen. Eine massenhafte Entfaltung von Cyanobakterien könnte sich durch eine Veränderung des trophischen Gefüges des Nahrungsnetzes von der untersten Ebene (Primärproduzenten) bis zur höchsten Ebene (Tertiärkonsumenten) auswirken. Dabei ist die Rolle des filtrierenden Zooplanktons von signifikanter Bedeutung. Besonders Daphnien besitzen eine wichtige Ökosystemfunktion sowohl als Dezimierer des Phytoplanktons und somit Verwerter und Reiniger der Gewässer als auch Nahrung für planktivore Fische. Ist das Vorhandensein von Daphnien durch Stressoren gestört, könnte dies eine Destabilisierung von aquatischen Systemen zur Folge haben.

Auf der Grundlage der Schlüsselfunktion von Cladoceren wurden die Auswirkung bzw. Einflüsse der Cyanobakterienstränge *Microcystis aeruginosa* NIVA Cya 43 und *Microcystis aeruginosa* PCC 7806 auf die physiologischen Eigenschaften des Modellorganismus Daphnia magna untersucht. Sekundärmetabolite in *M. aeruginosa* NIVA 43 inhibieren die Serinprotease Chymotrypsin. *M. aeruginosa* PCC 7806 dagegen enthält Inhibitoren der Verdauungsprotease Trypsin. Die Untersuchung zeigten, dass der Strang PCC 7806 einen signifikant negativeren Effekt auf die physiologischen Lebensparameter von Daphnien ausübte. Aber auch eine Exposition mit NIVA Cya 43 erwies sich als verminderte Nahrungsqualität für diese Vertreter des herbivoren Zooplankton. Die Expositionen mit beiden Cyanobakterien zeigten eine erhöhte Mortalitätsrate, verminderte Reproduktion und geringen Körpergrößenzuwachs innerhalb von 21 Tagen Versuchsdauer. Durch die Hemmung der Verdauungsproteasen konnte *Daphnia magna* die aufgenommene Nahrung nicht vollständig verdauen und somit wurden Nahrungsproteine nicht genutzt. Ein in der Folge herabgesetzter Stoffwechsel führte zur Verzögerung der Lebensverlaufsmerkmale der Tiere. Dieser Effekt zeigt sich ebenfalls im schnellen Abbau der Kohlenhydratreserven, die als kurzfristige Energiespeicher fungieren. Als letzte Reserveeinheiten werden die Lipide und Proteine weniger gezehrt. Weiterhin konnte durch die Untersuchung der Proteaseaktivität festgestellt werden, dass durch *M. aeruginosa* PCC 7806 eine höhere Inhibition der Serinproteasen ausgelöst wurde im Vergleich zu *M. aeruginosa* NIVA Cya43. Die Ergebnisse vertiefen das Verständnis der Herausforderungen auf molekularer und physiologischer Ebene, denen Zooplanktonorganismen durch die Aufnahme von Cyanobakterien ausgesetzt sind.

A1: Aquatic Ecotoxicology

Planktothrix rubescens as a low abundant taxon in deep-water, red-pigmented cyanobacterial maxima in Lake Überlingen

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Recurring blooms of filamentous, red-pigmented and toxin-producing cyanobacterium *Planktothrix rubescens* have been reported in numerous deep and stratified prealpine lakes, with the exception of Lake Constance. In a 2019 and 2020 Lake Constance (Lake Überlingen part) field campaign, we collected samples from a distinct red-pigmented biomass maximum below the chlorophyll-a maximum, which was determined using fluorescence probe measurements at depths between 18 and 20 m. Here, we report the characterization of these deep water red pigment maxima (DRM) as cyanobacterial blooms. Using 16S rRNA gene-amplicon sequencing, we found evidence that the blooms were, indeed, contributed by Planktothrix spp., although phycoerythrin-rich Synechococcus taxa constituted most of the biomass (>96% relative read abundance) of the cyanobacterial DRM community. Through UPLC-MS/MS, we also detected toxic microcystins (MCs) in the DRM in the individual sampling days at concentrations of ≤1.5 ng/L. Subsequently, we reevaluated the fluorescence probe measurements collected over the past decade and found that, in the summer, DRM have been present in Lake Constance, at least since 2009. Our study highlights the need for a continuous monitoring program also targeting the cyanobacterial DRM in Lake Constance, and for future studies on the competition of the different cyanobacterial taxa.

S03: Responses of aquatic ecosystems to anthropogenic stressors

Biodegradability of novel polyethylene-like bioplastic materials by Lake Constance microbiota

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"Bioplastics", i.e. plastics that are synthesized from renewable biological sources and/or are regarded as biodegradable, have received much attention over the past years as a more sustainable alternative to conventional plastic. However, the characteristics of such materials are often inferior to conventional plastics. Recently, novel bioplastics, synthesized from plant oils and exhibiting similar characteristics as high density polyethylene (HDPE), while at the same time allowing for energy efficient chemical recycling via its monomers, were developed at the University of Konstanz. Due to their sustainable production and improved recyclability, these polymers constitute an attractive alternative to conventional HDPE materials and their biodegradability is of strong interest when considering the potential post-consumer fate of these materials in the environment.

This work aims to evaluate the biodegradability of these novel bioplastics, in comparison to conventional (bio)plastics, by the Lake Constance microbiota under oligotrophic conditions in field trials, as well as under laboratory conditions. To this end, film samples of the plastic materials were placed into HYDRA test frames and deposited in the littoral zone, and samples are retrieved after in-situ exposure times of several months and years, for which potential degradation and biofilm formation is being assessed via microscopy and analytical chemistry, while microorganisms colonizing the polymers will be analyzed through sequencing approaches. Additionally, aerobic enrichment cultures were initiated, containing the plastic material as the sole source of carbon and energy under different nutritional conditions (e.g. P in excess or in limitation). Our preliminary results to date, will be presented at the DGL conference.

A6: Nebiota und invasive Arten

Rolle von Häfen für Eintrag und Verbreitung von nicht-einheimischen Arten – Weiterentwicklung, Erschließung und Erprobung von Methoden zur Früherkennung

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Invasive Arten (IAS) sind gebietsfremde Tier- und Pflanzenarten (Neobiota), welche negative Auswirkungen auf die Biodiversität, die menschliche Gesundheit oder die Wirtschaft haben. Aufgrund der globalisierungsbedingten zunehmenden Handelsströme und des Klimawandels wird zukünftig mit einer Zunahme der durch IAS verursachten Probleme gerechnet.

Das Bundesministerium für Digitales und Verkehr (BMDV) hat 2016 ein behördenübergreifendes Ressortforschungsformat das BMDV-Expertennetzwerk „Wissen – Können – Handeln“ geschaffen. Dieses erforscht unter anderem im Themenfeld 2 „Umwelt und Verkehr“ die Ausbreitungspfade über die Verkehrswege und die Ansiedelungsräume auf Verkehrsnebenflächen. Einige Faktoren, die zur Ausbreitung im aquatischen führen, sind aber noch nicht abschließend verstanden. Dies betrifft unter anderem die Verbreitungswege über die Binnenwasserstraßen und die Rahmenbedingungen für den Ansiedlungserfolg in Häfen.

Im Zuge dieses Forschungsvorhaben soll anhand von Hafenuntersuchungen festgestellt werden, inwieweit die kommerzielle Binnenschifffahrt die Ausbreitung von Neobiota begünstigt. Hierzu werden verschiedene Taxagruppen sowohl morphologisch als auch genetisch ((e)DNA Metabarcoding) untersucht. Ebenfalls soll festgestellt werden, ob ein praktikables Untersuchungskonzept basierend auf den „Joint HELCOM/OSPAR GUIDELINES“ von Hochseehäfen für die Binnenschifffahrt erarbeitet werden kann. Durch regelmäßige Beprobungen und Maßnahmenkataloge stellen diese eine internationale Vereinbarung zur Vermeidung von Verschleppung invasiver Arten zwischen Hochseehäfen dar.

Für eine erste Untersuchung wurden im August 2021 Proben des Phytobenthos, Phytoplankton, Zooplankton, Makrozoobenthos und Umwelt-DNA im Duisburger Hafen genommen. Als größter Binnenhafen der Welt ist der Binnenhafen Duisburg ein wichtiger Knotenpunkt und logistische Schaltzentrale in der Rheinschifffahrt und dem Güterverkehr. Die Probenahme wurde mit Unterstützung der WSA Rhein im Hafenkanal und den Becken A bis C durchgeführt.

Wir stellen hier die ersten Ergebnisse für die Auswertungen des Makrozoobenthos vor. Die Mischproben wurden sowohl differenzialmorphologisch bestimmt, als auch genetisch über DNA Metabarcoding.

A4: Diversität und Ökologie aquatischer Lebensgemeinschaften

Feldsölle – Eine interaktive Virtual-Reality-Tour (VR-Tour) über die Biodiversitätshotspots in einer gleichförmigen Agrarlandschaft

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Aufgrund von Corona-bedingten Einschränkungen fand die Methode der VR-Tour als Ersatz für Exkursionen in den vergangenen Semestern an der Hochschule für Nachhaltige Entwicklung Eberswalde (HNEE) Anklang, sodass diese Methode nun auch weiterhin genutzt wird. Studierende des

Moduls „Feuchtgebietsmanagement“ (Masterstudiengang Nachhaltige Regionalentwicklung - Management - Naturschutz) erarbeiten im Sommersemester 2022 nach der Methode „Forschendes Lernen“ eine VR-Tour als digitales Format für die Hochschullehre sowie die Wissenschaftskommunikation.

Die Tour widmet sich den Feldsöllen: Die Kleingewässer mit einer Größe von < 1 ha sind und können ein wichtiger Lebensraum für seltene Arten in einer gleichförmigen Agrarlandschaft sein. Ihr Zustand wirkt sich maßgeblich auf Flora und Fauna in und um Feldsölle aus. Dieser hängt von neben natürlichen auch von anthropogenen Faktoren wie umliegender und direkter Nutzung ab. Um eine erhöhte Sensibilisierung für Feldsölle als naturschutzfachlich relevante Lebensräume zu erreichen, spielt die Wissenschaftskommunikation eine wichtige Rolle, die mit der VR-Tour mit Einsatz von u.a. 360-GradAufnahmen als Darstellungsmöglichkeit umgesetzt werden soll. Nutzer des Formates können eine Art virtuellen Spaziergang unternehmen, in dem sie selbstständig Feldsölle als Biotope und Trittsteine im Biotopverbund in der Agrarlandschaft erkunden können.

eDNA metabarcoding applicability for biodiversity assessment in a nature protection area

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In the face of global change, novel monitoring methods are immensely important in biodiversity assessment and preservation in protected areas. In particular, the detection of species from environmental DNA (eDNA) is gaining traction in biodiversity assessments as well as in conservation practices due to standardized, cost-effective, and user-friendly implementation. The eDNA-based biodiversity detection methods have especially large potential to be regularly implemented in biodiversity assessments and conservation actions of protected areas because species detection is based on DNA from environmental samples like water, sediment, soil, air or organic material and has a broad application scope with fast, non-invasive, and comprehensive species identification. Here, we present a case of biodiversity assessment based on eDNA metabarcoding approaches conducted in the frame of our project BioMONITec. We tested practical aspects of the eDNA metabarcoding method in the protected wetland habitats, with the aim of developing protocols that can be easily and efficiently used by nature protection area managers for biodiversity assessment. In particular, we tested the efficiency of different sampling approaches (syringe/pump water sampling), compared performance of three eDNA extraction methods, compared sample processing methods in the field and in the laboratory, and time-, cost-, and outcome-efficiency of tested approaches. We determined biodiversity indices of assessed habitats and compared them to samples acquired by traditional sampling methods and indices acquired by metabarcoding of these bulk samples. The results reveal the potential of eDNA metabarcoding to supplement traditional monitoring approaches and contribute to more precise and effective decision-making in protection areas monitoring. The methodological and scientific outcomes of the project will be included into the monitoring global guideline (MoniGloG) and communicated to the managers of protection areas and stakeholders who will apply these methods to their monitoring practices in biosphere reserves and national parks.

A3: Grundwasser und Quellen

Change of freshwater spring microbial functional diversity along environmental gradients

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Alpine springs are sensitive ecosystems with characteristic environmental conditions containing highly adapted organisms. Primarily microorganism communities are known to show species compositions and functions directly determined by environmental parameters. Furthermore, they play an essential role in biogeochemical cycles. However, relatively little is known about spring-inhabiting microbial communities, and faunistic investigations predominantly focus on macroinvertebrates. Therefore, we aimed to characterise microbial species communities in springs and investigated their diversity and composition along environmental gradients. We sampled biofilm and sediment of three freshwater springs above and below the tree line to examine the influence of putatively different phototrophic regimes and N-sources on microbial species communities. Biofilm and sediment sample DNA was extracted and subsequently processed using primers targeting the V4 and V5 regions of the 16S rRNA gene. Amplicon libraries were sequenced, analysed with DADA2 to obtain amplicon sequence variants (ASVs), and matched against the SILVA database for taxonomic assignment. Results showed that the microbial community compositions varied depending on the location above or below the tree line but were relatively homogenous between springs within a specific phototrophic regime. Photoautotrophic taxa showed increased abundance in the springs above the tree line, whereas nitrifying microbial taxa were more abundant in springs below. Therefore, we conclude that spring-specific trophic regimes influence spring-inhabiting microbial community compositions directly. The influence of other abiotic and biotic factors such as human-induced pollutants or agricultural stressors on spring microbial communities is likely, and further research is needed to understand their interactions better.

S09: Auen

Erfolgskontrollen von Renaturierungsmaßnahmen innerhalb des Bundesprogramms „Blaues Band Deutschland“ - Ein Beispiel aus der Praxis

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Deutschlands große Flüsse und ihre Auen sollen im Zuge des Bundesprogramms „Blaues Band Deutschland“ renaturiert und naturnäher gestaltet werden. Ziel ist es, durch die Wiederherstellung von ökologisch funktionsfähigen Flusslandschaften einen Biotopverbund von nationaler Bedeutung aufzubauen.

Im Teilprojekt „Buhnenfelder Schlüsselburg“ sollten durch verschiedene Maßnahmen vorhandene Buhnen und der Uferbereich der Weser bei km 236,8 bis 238,0 ökologisch optimiert werden. Die Umsetzung der Maßnahmen erfolgte von September 2018 bis Januar 2019.

Für die Bewertung der durchgeführten Maßnahmen sind insbesondere die biologischen Komponenten Fische und Makrozoobenthos als geeignet anzusehen, da diese sensibel auf hydromorphologische Veränderungen reagieren. Daher wurde zur Beurteilung des Maßnahmenerfolgs im Jahr 2021 eine erste Erfolgskontrolle für die Artengruppen Fische und Makrozoobenthos durchgeführt, deren Ergebnisse wir in diesem Poster vorstellen.

Die Untersuchungen der Fischfauna und des Makrozoobenthos zeigen, dass die Artengemeinschaften stark durch Neozoen beeinflusst werden. Dabei weist vor allem das Makrozoobenthos eine artenarme Faunenzusammensetzung auf, die sich überwiegend aus euryöken und weniger anspruchsvollen Arten zusammensetzt.

Positive Entwicklungen gegenüber dem IST-Zustand konnten nur vereinzelt beobachtet werden. Bezüglich der Fischfauna deuten die Zunahme der Individuendichten rheophiler Arten, der Anstieg der Jungfische, der Rückgang invasiver Arten sowie die etwas besseren Diversitätsmaße auf eine leichte Verbesserung der Artenstruktur und der Diversitäts- und Dominanzverhältnisse gegenüber dem IST-Zustand hin.

Beim Makrozoobenthos gaben, trotz der etwas schlechteren ökologischen Bewertung der Buhnenfelder des Maßnahmengebietes im Vergleich zum IST-Zustand, der Rückgang invasiver Arten und die geringfügig besseren Indexwerte einiger Diversitätsindizes gegenüber der Referenzstrecke Hinweise auf eine leichte Verbesserung der Diversitäts- und Dominanzverhältnisse.

Es ist wahrscheinlich, dass diese Entwicklungen in Zusammenhang mit den durchgeführten Maßnahmen stehen.

S03: Responses of aquatic ecosystems to anthropogenic stressors

The impacts of climate change and agriculture on freshwater ecosystems: Investigating multiple stressor effects on macroinvertebrate communities in a streamside mesocosm experiment via DNA metabarcoding in a New Zealand stream

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Climate change and the growing world population put freshwater ecosystems under unprecedented pressure: the increased likelihood of extreme weather events in combination with increased atmospheric CO_2 levels and impacts of agricultural land use expose stream ecosystems to multiple stressors. In contrast to single stressor effects, multiple stressors often interact resulting in synergistic or antagonistic effects on stream communities. In order to better understand these interactions and to make adequate stream management decisions, there is an urgent need to investigate multiple stressor effects further.

In this study we tested four common stressors that occur due to climate change and agricultural land use in a streamside mesocosm experiment using the "ExStream system" at a fifth-order stream in New Zealand. The effects of heat waves, fine sediment deposition, increased levels of dissolved CO_2 and high variability of flow velocity were tested in all possible combinations with 8 replicate mesocosms each in a full-factorial design for a period of 34 days. After the stressor period, macrozoobenthos was sampled to compare the communities inhabiting the mesocosms via DNA metabarcoding. In a prior morphological analysis the determination of samples to species level was not possible in many cases. DNA metabarcoding allowed for the analysis of stressor effects on macroinvertebrates with a high taxonomic resolution (i.e., species level), even for species that are difficult to identify based on morphological criteria (e.g., Chironomidae), and helped to further disentangle taxon-specific response patterns.

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