ANNUAL RESEARCH REPORT 2023

One year of freshwater research

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Out of breath
Oxygen depletion in water has far-reaching consequences – not just for lakes

Small waters, big opportunities
Ponds and pools deserve special protection

Tiny but powerful
Microorganisms and their importance to our freshwater ecosystems

IGB
Leibniz Institute of Freshwater Ecology and Inland Fisheries

Research for the future of our freshwaters

IGB is Germany's largest and one of the leading international centres for freshwater research. It is also one of the oldest institutions in this field. The roots of the predecessor institutions can be traced back to the end of the 19th century. Today, science at IGB covers a wide range of disciplines. Together, we seek to improve the mechanistic and quantitative understanding of the fundamental processes that shape our freshwater ecosystems and of how they are embedded in a terrestrial and societal context. We investigate the ecological and evolutionary dynamics that aquatic organisms undergo, and the drivers and implications of changes in biodiversity. We develop holistic insights in ecosystem services provided by freshwaters, ranging from water security and natural flood protection to fisheries and implications for human health.

On the following pages we present selected research findings and activities from 2023. They are allocated to our three programme areas, each containing all kinds of interesting information that we have compiled for you. For each programme area, you will find further information, materials, experts, background information and the latest news on our website.

We wish you an informative dive into the fascinating world of freshwaters!

PHOTO: DR JULIAN TAFFNER (TERRA ALIENS)

Aquatic Biodiversity in the Anthropocene

Aquatic Ecosystem Services and Sustainability

Dimensions of Complexity of Aquatic Systems

Dear Reader

We live in a challenging world. We are confronted with crises of all kinds, sizes and intensities. We are shocked by devastating wars, terrorism and acts of retaliation that challenge our view that we are moving towards a better world. At the same time, we face global crises such as climate warming, biodiversity loss and ecosystem degradation. These global crises are increasingly manifesting themselves in extreme weather events and reduced resilience of our ecosystems. This is also true for our freshwaters, which are heavily impacted by human activities and the climate crisis, and whose ecological integrity and biotic diversity determine their ability to provide ecosystem services to our society.

It is tempting to become pessimistic upon witnessing all these crises and their consequences. But, it is more effective to be a "stubborn optimist", as the former Executive Secretary of the UN Framework Convention on Climate Change, Christiana Figueres, aptly put it. We should be very aware of the challenges and invest in solutions, rather than be depressed by their sheer scale.

To achieve a transition to a more sustainable trajectory for our ecosystems, we need the right mindset in society and among policy-makers. But we also need the knowledge and data to understand how our systems will respond to global change and to changes in management. Making such predictions is challenging, not least because of the complexity resulting from having multiple interacting species that all react in their own way to environmental change. That is why we are establishing a new programme area on "Predictive Ecology". Building on our existing assets of diverse and highly relevant research on aquatic systems and the use of unique infrastructure, we will strengthen our capacity in predictive modelling and data-driven research through the establishment of new research groups.

The research results presented on the following pages reveal not only the beauty of our aquatic systems, but also the underlying mechanisms and processes that determine their fate and functioning. This knowledge is vital for the future of our freshwaters in all their diversity.

None of this would have been possible without the trusting collaboration with many partners and stakeholders who have supported and inspired our research, teaching and transfer activities. Thank you for contributing to this development and for supporting our work!

Yours

Luc De Meester
Director

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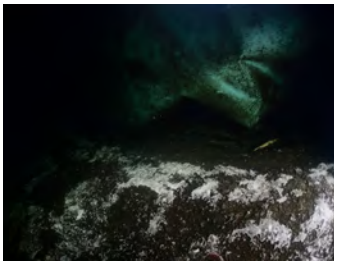

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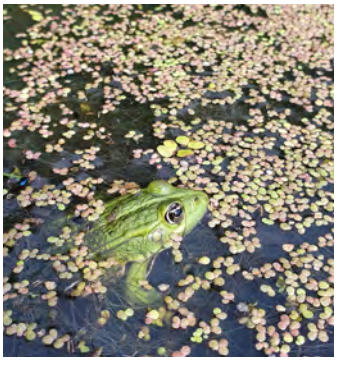

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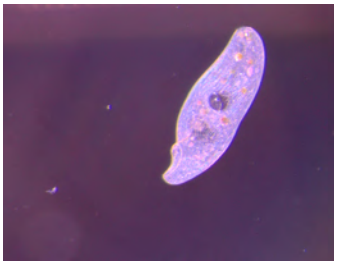

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News

Successful in competition

It has become a tradition at IGB to select project proposals for the Leibniz Competition through an internal selection process. The most promising research teams present their ideas and approaches to the entire institute and answer questions from their colleagues. An evaluation committee then decides which proposal will be submitted to the Leibniz Competition. *POUNDER* (Pollution in urban ponds, eco-evolutionary dynamics, and ecosystem resilience), a project by two junior research group leaders, Lynn Govaert and Stephanie Spahr, was nominated for this competition and was successful. In autumn 2023, they received a positive evaluation from the Senate Competition Committee of the Leibniz Association and will be funded under the Collaborative Excellence Programme.

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Urban ponds: Can adaptation to pollution improve the resilience of aquatic ecosystems?

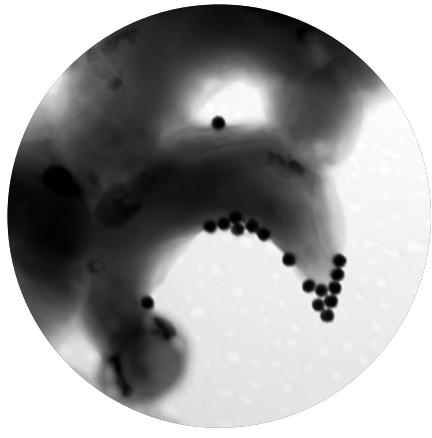

PHOTO: FAZEL A MONIKH

Assessing the toxicity of microplastics and nanoplastics

Standard protocols exist for assessing the risk of most pollutants to natural ecosystems, but not for microplastics and nanoplastics. Previous protocols were developed for chemicals that dissolve or form stable dispersions. However, plastic particles do not dissolve, and exhibit a dynamic behaviour in the liquid in which they are suspended. With the participation of IGB, researchers have therefore developed a new protocol that can be used to assess the toxicity of these substances to soil and aquatic ecosystems in a standardised way. The new protocol also takes into account the differences between microplastics and nanoplastics. The researchers also presented a method for producing realistic microparticles and nanoparticles for experiments.

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Assessing the toxicity of micro- and nanoplastics to ecosystems

Monikh et al. (2023) Exposure protocol for ecotoxicity testing of microplastics and nanoplastics. Nature Protocols. https://doi.org/10.1038/s41596-023-00886-9

Restoring Rügen's pike population

The Bodden landscape around Rügen, Germany, is both a popular holiday destination and a valuable natural area. What many people do not know is that it is also home to one of the largest and fastest growing stocks of pike, attracting many anglers from Germany and abroad, as well as being used by professional fishermen and women, and natural predators such as cormorants and grey seals. However, pike catches and sizes of pike have been declining for a number of years, as has angling interest since 2017, on the coast. This is a cause for concern from both an ecological and a tourism perspective. Researchers at IGB have therefore been investigating the causes in the four-and-a-half-year *BODDENHECHT* project. The results are available in an 800-page book, together with clear recommendations for policymakers, authorities and user groups.

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Rebuilding Rügen's pike population

PHOTO: FALK WEISS

PHOTO: SHUTTERSTOCK_279357398

Water purification with biotechnology

Nitrogen, especially in the form of inorganic nitrite and nitrate, is one of the major pollutants in freshwater systems and human wastewater. Researchers from the Chinese Ministry of Natural Resources in Xiamen and from IGB have identified a natural fungus-bacteria consortium from mariculture that is particularly efficient and consistent in metabolising nitrate: In the presence of oxygen, nitrate removal was up to 100 per cent and denitrification efficiency was 44 per cent. This could be crucial for the further development of biotechnological approaches to wastewater treatment and provides further evidence of the important role of fungi in aquatic ecosystems.

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Water purification with biotechnology

Zuo et al. (2023) Aerobic denitrifying bacterial-fungal consortium mediating nitrate removal: dynamics, network patterns and interactions. iScience. http://dx.doi.org/10.1016/j.isci.2023.106824

PHOTO: DR JULIAN TAFFNER (TERRA ALIENS)

New database shows where semi-aquatic insects occur

We know many flying insects only as adults, because they spend their first life stages in the water. The larvae of mayflies, for example, remain almost a year in the shallow shore zones of standing waters before coming ashore for a few days as adult flies. These so-called semi-aquatic insects, which also include stoneflies, caddisflies and dragonflies, are an important food source for both aquatic and terrestrial animals. They are also used as bioindicators to assess water quality and the state of freshwater ecosystems. Thanks to the commitment of nearly 100 researchers, the EPTO database is a new source of geo-referenced and freely available datasets on the occurrence of semi-aquatic insects worldwide. The work was coordinated by IGB.

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Mayflies, dragonflies & Co live as larvae in water

Grigoropoulou et al. (2023) The global EPTO database: worldwide occurrences of aquatic insects. Global Ecology and Biogeography. http://dx.doi.org/10.1111/geb.13648

Migration corridors for sturgeon

PHOTO: SOLVIN ZANKL

Sturgeons are true survivors; they have been around for more than 200 million years. Today, however, all 26 remaining species of sturgeon are threatened with extinction. The reasons are all man-made: weirs and other transverse structures in rivers impede migratory fish on their way to spawning grounds, and many perish in the turbines of hydroelectric power plants. Traditional fish ladders are often not designed for sturgeon, and few individuals use them. Researchers led by China's Yunnan University, the Chinese Academy of Sciences and IGB have published a recommendation on how to facilitate effective passage and even promote sturgeon with bypass channels at dams that can serve as additional habitat.

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Designated migration corridors for sturgeon

Zhang et al. (2023) To save sturgeons, we need river channels around hydropower dams. PNAS. https://doi.org/10.1073/pnas.2217386120

Large-scale experiments at the LakeLab

The IGB LakeLab has once again demonstrated its importance as a central hub for international scientific collaboration: More than 80 scientists from ten different countries conducted two large-scale experiments here in the spring and summer of 2023 to investigate the influence of experimentally altered fish densities on the relationships between zooplankton behaviour, phytoplankton development and carbon cycling in lake ecosystems. This collaborative effort, supported by the *AQUACOSM-plus Transnational Access Programme*, also demonstrated that cross-border research promotes scientific progress, facilitates new approaches, especially for young scientists, opens up a network and even paves the way for lasting friendships. The first results were presented at the *AQUACOSM-plus* Symposium in Antalya, Turkey, in October 2023. In total, 89 per cent of the LakeLab's capacity was open to external researchers in 2023.

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LakeLab

PHOTO: JENS NEJSTGAARD

Shallow water zone and introduced coarse woody habitats in Lake Linner See

PHOTO: THOMAS KLEFOTH, AVN

Ecological improvement of freshwater ecosystems benefits fish and people

The loss of biodiversity in inland waters is alarming. A research team led by IGB and Humboldt-Universität zu Berlin, with the participation of Hochschule Bremen and in cooperation with angling associations, has ecologically improved 20 lakes in large-scale experiments. In some lakes, additional shallow water zones were created. In others, coarse wood bundles were added to enhance structural diversity. Other experimental lakes were stocked with five species of fish popular with anglers, while unmodified control lakes were used for comparison. In total, more than 150,000 fish were involved in the study. The result: The only way to sustainably increase fish stocks was to create shallow water zones. These zones are ecologically essential for many fish species, especially as spawning grounds and refuge areas. The introduction of coarse wood only had a positive effect in a few water bodies, while fish stocking failed completely.

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Ecological improvement of freshwater ecosystems benefits fish and people

Radinger et al. (2023) Ecosystem-based management outperforms species-focused stocking for enhancing fish populations. Science. http://dx.doi.org/10.1126/science.adf0895

On a drip

The Spree River – between urban sprawl, mining and biosphere reserve

Questions to 8 experts

At around 380 kilometres, the Spree is not one of Germany's longest rivers, but it is one of its most famous. As the capital's river, it is representative of water bodies in Germany and around the world that are under increasing pressure. While private and commercial interests in its water resources continue to grow, it is also clear that there will be significantly less water available in the future. What needs to be done to counteract this is the subject of controversial debate. IGB is located directly on Berlin's Lake Müggelsee, through which the Spree flows. This is not the only reason why scientists here have been conducting research in and on the Spree for decades. They are helping to better understand the interrelationships and to develop sustainable solutions.

PHOTO: RIVER SPREE AT HANGELSBERG BY PAUL SCHULZE, HUMBOLDT-UNIVERSITÄT ZU BERLIN (CC-BY 4.0)

PROFESSOR DR DÖRTHE TETZLAFF

The Berlin-Brandenburg region is rich in water bodies, but poor in rainfall. Ms Tetzlaff, you are a hydrologist: How much water actually reaches the Spree and what water levels can we expect in the future?

Berlin-Brandenburg is one of the driest regions of Germany. What little rainfall there is is quickly lost due to very high evaporation rates. Compared to other well-known rivers, the Spree carries very little water on average, less than 10 per cent of the annual precipitation. A large part of the discharge – up to 40 per cent in the summer months – currently comes from the so-called sump water of the lignite mining area. However, the mining area is increasingly turning from a water source into a water sink, with the creation of large post-mining lakes that evaporate additional water over their large surface area. As a result, we expect the water resources of the Spree River, which is also an important part of Berlin and Brandenburg's water supply, to become even more vulnerable in the future. This will require careful planning and management of resources as the effects of climate change and continued population growth are already being felt in Berlin.

Are there ways to adapt land management and land use in the Spree region to improve water retention?

Different types of land use, such as forest, grassland, agroforestry and arable farming, can indeed influence the hydrology of landscapes – for example, how precipitation is distributed and partitioned, and how much of it evaporates. Tracer-based ecohydrological modelling allows us to map the differences between these various land uses, as well as the temporal dynamics of soil moisture, water levels and groundwater recharge. Compared to other forms of vegetation, large-scale pine monocultures lead to high evaporation losses through transpiration and interception, which is reflected in reduced infiltration rates and groundwater recharge. On arable and pasture land, especially in spring when the vegetation cover is not yet very dense, a lot of water can be extracted from the soil by evaporation, which is then also not available for groundwater recharge. We therefore recommend a so-called land use mosaic, i.e. away from monotonous large areas and towards a varied land use such as agroforestry or mixed forests with different tree species and ages and the best possible distribution in terms of soil cover, increased infiltration and groundwater recharge, while at the same time minimising evaporation losses.

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DR STEPHANIE SPAHR

If the Spree River is supplying less and less water to the capital, can Berlin's stormwater be part of the solution, Ms Spahr?

Stormwater is a valuable but underutilised resource for urban water supplies. However, stormwater also washes away pollutants from roads and buildings, for example, which can end up in freshwaters or groundwater. During heavy rainfall events, there is also a large influx into wastewater treatment plants, which can then overflow. Discharging untreated wastewater into freshwaters can have serious impacts on ecosystems, including fish kills, as we see time and again in Berlin after rainfall. To avoid such events and to use stormwater as a resource, Berlin is aiming for decentralised stormwater management. Multifunctional blue-green infrastructure such as ponds and vegetated swales play a central role. They provide valuable habitats, improve the quality of urban life, and keep rainwater in the city. One challenge remains: persistent, mobile and potentially toxic organic substances are difficult to remove from stormwater. To safely use stormwater for urban water supplies or discharge it into the Spree, these pollutants need to be systematically monitored, their emissions prevented, and purification processes improved.

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DR TOBIAS GOLDHAMMER

It is not just rain that leads to the discharge of contaminants; the Spree is also polluted with sulphate, iron, heavy metals, nutrients and agricultural and industrial run-off. Mr Goldhammer, what is the current state of the river's chemical water quality?

Unfortunately, water quality has not improved over the last ten years in terms of the main pollutants. The Spree is mainly characterised by the effects of open-cast lignite mining in the Lusatian mining region, which discharges large amounts of iron and sulphate. While iron no longer plays a major role downstream of the Spreewald, sulphate is distributed throughout the river system up to the urban Spree in Berlin. Concentrations are increasingly reaching levels where some waterworks have to add groundwater with a lower sulphate content when extracting drinking water from the Spree bank filtrate. Mining also emits heavy metals. However, the main sources are of urban-industrial origin and therefore mainly affect the urban Spree. It remains to be seen how the pollution situation will develop in the coming years as a result of the establishment of large industrial enterprises in the catchment area. Concentrations of nutrients, especially nitrogen from agriculture and phosphorus from domestic sewage, have decreased compared to previous decades, but the guidance values for good ecological status are not yet met everywhere. The overall picture is still problematic and will worsen with the challenges of climate change unless action is taken.

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DR JÖRG LEWANDOWSKI

A river that is running out of water can hardly dilute nutrient and pollutant inputs. Is that right, Mr Lewandowski?

Exactly, water quality depends very much on water quantity. Take, for example, the purified wastewater from sewage treatment plants that Tobias Goldhammer mentioned, the so-called clear water that is discharged into the Spree and its tributaries. Purified does not mean that the water is really completely clean. Many problematic water constituents are not removed by sewage treatment plants, such as organic micropollutants like pharmaceuticals or industrial chemicals. The lower the flow of water in the Spree, the less this clear water is diluted. However, the quality of the clear water could be significantly improved by retrofitting a fourth purification stage in wastewater treatment plants. In addition, the natural purification capacity of the hyporheic zone, i.e. the river bed, can be increased by restoration measures in the tributaries of the Spree. In times of climate change and increasing water consumption, well-purified clear water is becoming an increasingly important resource for aquatic ecosystems. Even today, the proportion of treated wastewater in the Spree increases massively in some places during dry summers, and can amount to over 50 per cent in Berlin-Köpenick, for example. At the same time, the water flow in the Spree is sometimes no longer sufficient to compensate for the water losses from Lake Müggelsee through evaporation and bank filtration, so that the flow direction downstream of Lake Müggelsee can even be reversed in some places.

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DR MARTIN PUSCH

The clear water from the Münchehofe sewage treatment plant then flows in the opposite direction via the Erpe and the Spree into the Müggelsee, from which drinking water is drawn. Mr Pusch, what would you recommend to politicians and authorities to deal with this situation?

Because water is extracted from the river in many places, it was already flowing backwards in some stretches in 2003. Today, the Spree is only kept flowing in summer by sump water and would otherwise regularly dry up. In order to preserve the Spree's waters with their rich flora and fauna and their diverse ecosystem services, efforts are needed on several levels: technical water retention will not be sufficient and must be supplemented by other measures, in particular water saving, further wastewater treatment, water recycling, but also nature-based solutions such as water retention in the catchment area, supplemented by active groundwater recharge in times of water surpluses. There is also an urgent need to adapt the river bed to the reduced water flow so that the Spree can continue to flow and thus remain a river ecosystem. Of course, such a range of measures can only be implemented if all relevant stakeholders are involved and if water management alternatives and their respective advantages and disadvantages are transparently weighed up.

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PROFESSOR DR MICHAEL HUPFER

DR SABINE HILT

Iron inputs lead to the brown colouring of the water in the Spree. Is this just a very local problem and what is known about the effects, Mr Hupfer?

Sediment analyses along the Spree River showed typical patterns and signatures indicating that mining activities in Lusatia are still clearly detectable at a distance of more than 90 km. After that, urban influences increasingly dominate the geochemical composition of sediments up to the mouth of the Havel. Up to the Spremberg reservoir, iron deposition and redistribution create hostile conditions for many organisms. Along the Spree, iron and sulphur compounds from pyrite weathering are subject to different transport mechanisms, which we were able to demonstrate using remote sensing techniques. While the high sulphate concentrations in Berlin are still strongly influenced by mining, the additional iron input after the Spremberg reservoir no longer plays a significant role in the matter balance of the Spree. The expectation that the increased iron discharge from mining would bind so much phosphorus that it would have a positive effect on the eutrophication of the lakes through which the river flows could not be confirmed on the basis of laboratory experiments and model calculations.

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Ms Hilt, you have observed the return of some rare aquatic plants in the Spree, which should be a sign of improved water quality. At the same time, however, reeds are dying and massive algal blooms are occurring. How do you think these observations fit together?

The nutrient inputs of nitrogen and phosphorus into the upper part of Lake Müggelsee have decreased overall over the last four decades – so the amount of algae turbidifying the water in this area has also decreased. As a result, sunlight is more available and this has led to a positive feedback loop: More plants in the summer act like a sieve, holding back more particles and increasing the clarity of the water. They also naturally slow down the flow and retain the water in the river system, and increase the structural diversity of the river bed. Aquatic plants also provide additional habitat for many animals and micro-organisms. Mechanical removal of these plants, e.g. for flood protection, should therefore be done as infrequently and as sparingly as possible. However, large quantities of nutrients, especially phosphorus, still accumulate in the sediments of the lakes through which the Spree flows, such as Lake Müggelsee. In summer, this can lead to mass blooms of cyanobacteria – commonly known as blue-green algae – as water temperatures rise. The decline of the reeds is partly due to predation by herbivores such as muskrats and nutria, but other factors also play a role.

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PROFESSOR DR SONJA JÄHNIG

In the face of water scarcity, the concept of environmental flow requirements is also being discussed. Ms Jähnig, what exactly does this term mean?

This is the amount of freshwater that aquatic habitats and water-bound terrestrial ecosystems need to maintain their ecological functions. For the Spree, the scientifically recommended minimum water flow is 5-8 cubic metres per second – in spring and summer, the Spree often carries less water. However, it is important to consider not only the surface waters themselves but also their catchment areas, i.e. not only the watercourses but also their floodplains and other groundwater-dependent terrestrial ecosystems. The quantity, quality and timing of water supply, sediment transport and connectivity of water bodies all play a role. The underlying idea is that only if aquatic ecosystems have sufficient water for their basic functions can humans sustainably use them as a basis for life.

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PHOTOS: DAVID AUSSERHOFER/IGB

Find out more at www.igb-berlin.de/en:

- Lakes in Berlin: Sulphate influences reed development
- The River Panke in Berlin: Climate change can jeopardise restoration successes
- IGB gives feedback on the National Biodiversity Strategy 2030

Roesel et al. (2023) Unravelling the role of sulphate in reed development in urban freshwater lakes. Water Research. http://dx.doi.org/10.1016/j.watres.2023.119785

Chen et al. (2023) Synoptic water isotope surveys to understand the hydrology of large intensively managed catchments. Journal of Hydrology. https://doi.org/10.1016/j.jhydrol.2023.129817

Ying et al. (2023) Developing a conceptual model of groundwater – surface water interactions in a drought sensitive lowland catchment using multi-proxy data. Journal of Hydrology. https://doi.org/10.1016/j.jhydrol.2023.130550

Mutzner et al. (2023) Urban stormwater capture for water supply: look out for persistent, mobile and toxic substances. Environmental Science: Water Research & Technology. https://doi.org/10.1039/D3EW00160A

Kommana et al. (2023) Iron from Lignite Mining Increases Phosphorus Fixation in Sediments, but Does Not Affect Trophic States of Lakes Along River Spree (Germany). Water, Air and Soil Pollution. http://dx.doi.org/10.1007/s11270-023-06441-2

Ulrich et al. (2023) Mapping Specific Constituents of an Ochre-Coloured Watercourse Based on In Situ and Airborne Hyperspectral Remote Sensing Data. Water. http://dx.doi.org/10.3390/w15081532

Nature in the city ticks differently

How do animals and plants survive and thrive in cities? Urban ecology is a rapidly growing field of research. To help scientists navigate the information jungle of urban ecology, a team led by IGB and Freie Universität Berlin has created a map of 62 key research hypotheses. These include assumptions such as the ideal city dweller, the bold urban dweller, living on credit and the biological monotony of cities. Research has yet to show how reliable the hypotheses are and to which cities they apply. But the overview provides an important basis for doing so. It is available as an open Wikidata file. The scientists hope it will make research in this fast-growing field more efficient by making it easier to find existing evidence, identify opportunities for collaboration and improve the way research projects are linked.

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➔ Nature in the city ticks differently

Lokatis et al. (2023) Hypotheses in urban ecology: building a common knowledge base. Biological Reviews. https://doi.org/10.1111/brv.12964

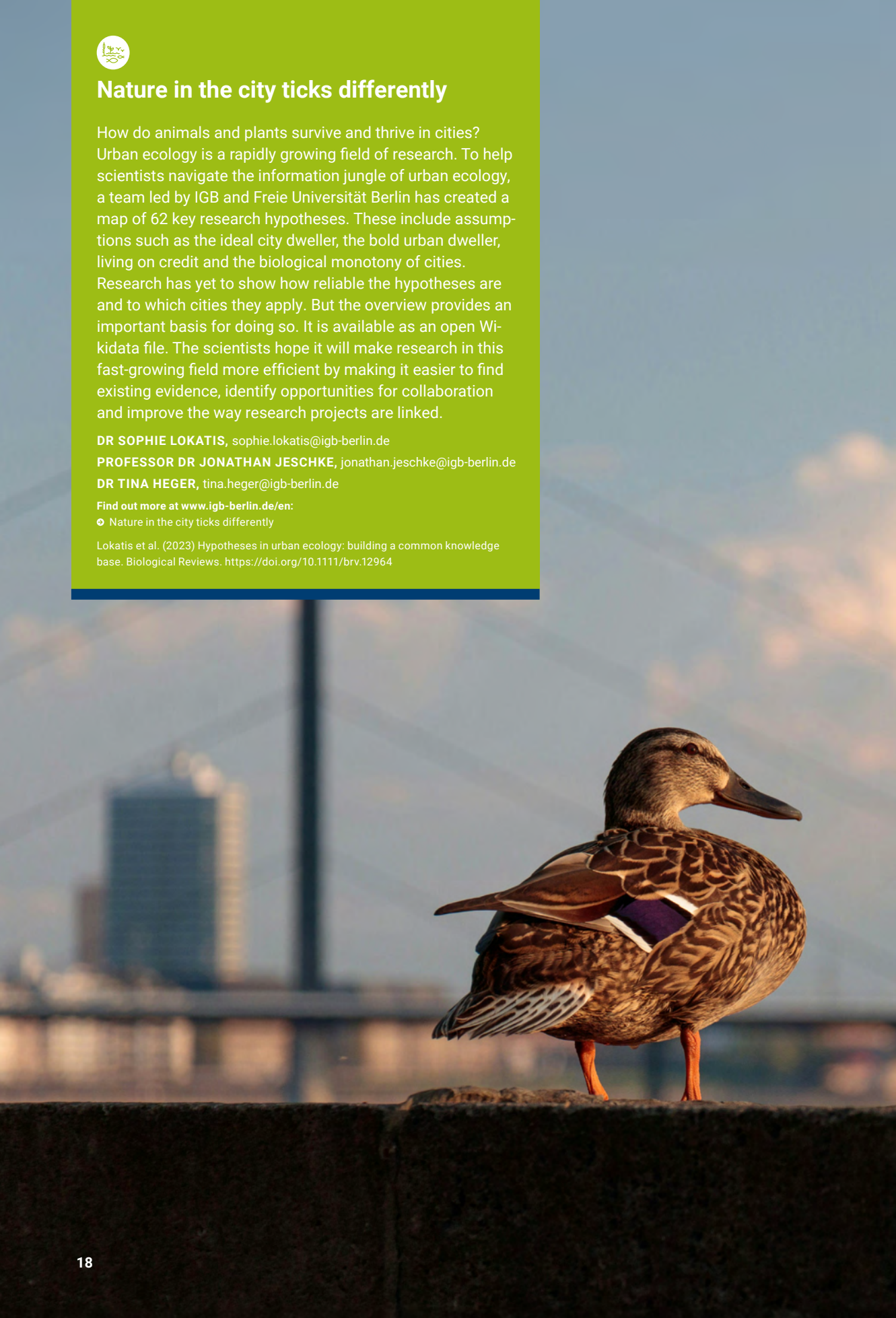

PHOTO: PATRICK ROBERT DOYLE/UNSPLASH

PHOTO: SOLVIN ZANKL

Out of breath

Oxygen depletion in water has far-reaching consequences – not just for lakes

Oxygen is becoming increasingly scarce in the depths of lakes around the world. This has far-reaching effects, including on various metabolic processes at the bottom of the lake.

Oxygen is essential for most aquatic organisms. Chemical and biological processes, such as the ability to self-purify, are also dependent on oxygen. However, environmental changes and rising water temperatures are altering the oxygen content of lakes, ponds and pools. Oxygen concentrations in the deep layers of lakes are decreasing worldwide. In addition, oxygen depletion can lead to an increased release of greenhouse gases. IGB researchers are investigating the extent and consequences of this. In the process, they are also questioning some theories about the laws of lake ecology.

Lonely landscapes, sunshine at midnight, rationed drinking water, a gravel road as a motorway: Robert Schwefel still has vivid memories of his research trip to Alaska a few years ago. As part of a joint project with the University of Santa Barbara in California, the physicist, who explores oxygen depletion under ice, studied four lakes in northern Alaska that are covered by ice in winter. “We wanted to know how the oxygen content of the lakes changes under ice. Our results show that ice-covered lakes are also dynamic systems,” stated the researcher. The explanation: The sunlight that penetrates the ice and the heat stored in the sediment keep the water circulating. And these physical processes play a crucial role in determining the oxygen balance.

The second major finding of the study was surprising: oxygen depletion decreases significantly during the winter. “Oxygen depletion is very pronounced in the first 30 days, after which it declines significantly,” explained Robert Schwefel. This is also due to the heat stored in the sediment: it is transferred to the water and drives exchange processes in the deep water, where bacteria consume oxygen. Over time, these exchanges level out.

NO EVIDENCE OF LOWER GREENHOUSE GAS PRODUCTION WITH LESS ICE

The results suggest that most of the oxygen depletion takes place at the beginning of the ice cover. A shorter duration of the ice cover is therefore largely irrelevant because the consumption processes have already taken place. “We had assumed that the oxygen concentration at the end of the winter would increase significantly with shorter ice cover, but we found no evidence for this effect,” remarked Robert Schwefel. Since greenhouse gases such as carbon dioxide and methane accumulate in anoxic conditions, Arctic lakes may contribute more to greenhouse gas emissions and global warming than previously thought.

Even in our latitudes, lakes are subject to changes that affect their oxygen balance. “In Lake Stechlin, the stratification period has lengthened dramatically in recent years, which means that the oxygen-rich upper layer and the rather oxygen-poor lower layer of the lake mix less frequently and for shorter periods,” stated Hans-Peter Grossart. The mixing periods in autumn and spring are now at least one month shorter. If there is no mixing in autumn, com-

plete mixing does not take place until spring, shortly before the new stratification. The lake then remains stratified for even much longer. As a result, the concentration of dissolved oxygen (DO) in the deep water greatly decreases and oxygen depletion increases. Levels below 3 milligrams of oxygen per litre (mg/l) are referred to as hypoxia, which is critical for fish. Anoxia is the absence of oxygen.

NUTRIENTS ARE A KEY ELEMENT

Deep-water anoxia in one summer can lead to severe anoxia in subsequent summers. A team with the participation of Hans-Peter Grossart analysed data from 656 lakes to identify the mechanisms that need be present simultaneously for this to happen. Nutrient inputs are a key element. They stimulate the growth of algae and bacteria: Dead material sinks and is broken down by bacteria. This microbial activity leads to respiration and oxygen levels drop. "The causes of the global increase in eutrophication are manifold. In addition to agriculture, nitrogen from the atmosphere, which enters the lakes through the air, plays an important role," explained the biologist. In addition, global air temperatures are rising, which favours more stable and longer stratification phases and further reduces oxygen concentrations.

Another factor is that anoxic zones alter biogeochemical processes in complex ways and intensify internal cycling. This can also reduce the retention capacity for phosphate in the sediment, making more nutrients available for algal growth in the water body. These feedback mechanisms accelerate lake eutrophication. "The sediment in Lake Stechlin also contains relatively high levels of phosphate, and there is a risk that this will be released again due to changes in environmental conditions," commented Hans-Peter Grossart. The researcher is also concerned about the fact that in lakes with prolonged anoxic periods, hydrogen sulphide can accumulate as a result of sulphate reduction. "It stinks and is toxic, the whole chemistry of the lake changes. This is also a problem for drinking water," he stated. The competition between phosphate and hydrogen sulphide also explains why the sediments in Lake Stechlin can bind less phosphorus to iron than before.

Similar findings are reported in a study in which also Stella Berger was involved. The study analysed and compared data on dissolved oxygen in the deep water of 12 stratified lakes in the northern hemisphere in winter and summer. "Hypoxia, i.e. dissolved oxygen concentrations below 3 mg/l, occurred in more than half of the lakes and lasted on average 83 per cent longer in summer than in winter," the researcher reported. How quickly dissolved oxygen decreased depended mainly on the morphology of the lake in winter and on the trophic state in summer. "As long as dimictic lakes mix completely twice a year, the entire water body – right down to the bottom – is supplied with oxygen in autumn and spring. In the wake of climate change, with warmer and longer summers, these patterns are changing and the period of stable stratification is lengthening. This can result in full circulation starting later in the autumn, being incomplete or failing altogether, leaving deep water oxygen levels low. We are seeing the first signs of this in Lake Stechlin," stated Stella Berger.

OXYGEN CONCENTRATION AND METHANE PRODUCTION CLOSELY LINKED

Mina Bizic wants to know how oxygen in lake water is linked to the production of the greenhouse gas methane: Around 25 per cent of global methane emissions come from lakes, reservoirs and rivers. "Recent measurements show that methane emissions from lakes have already increased," stated the researcher. For a long time, methane was thought to be produced only under anoxic conditions by a specialised group of microorganisms belonging to the archaea (single-celled organisms with similarities to both bacteria and higher organisms). These microorganisms break down organic material near and in the sediment, producing methane

Long-term IGB data from Lake Stechlin show that the lake becomes increasingly oxygen-depleted towards the end of the summer stratification period – i.e. in November/December – and that this development is related to the increasing phosphorus levels (shown here as annual mean values for the entire water body) and the resulting eutrophication.

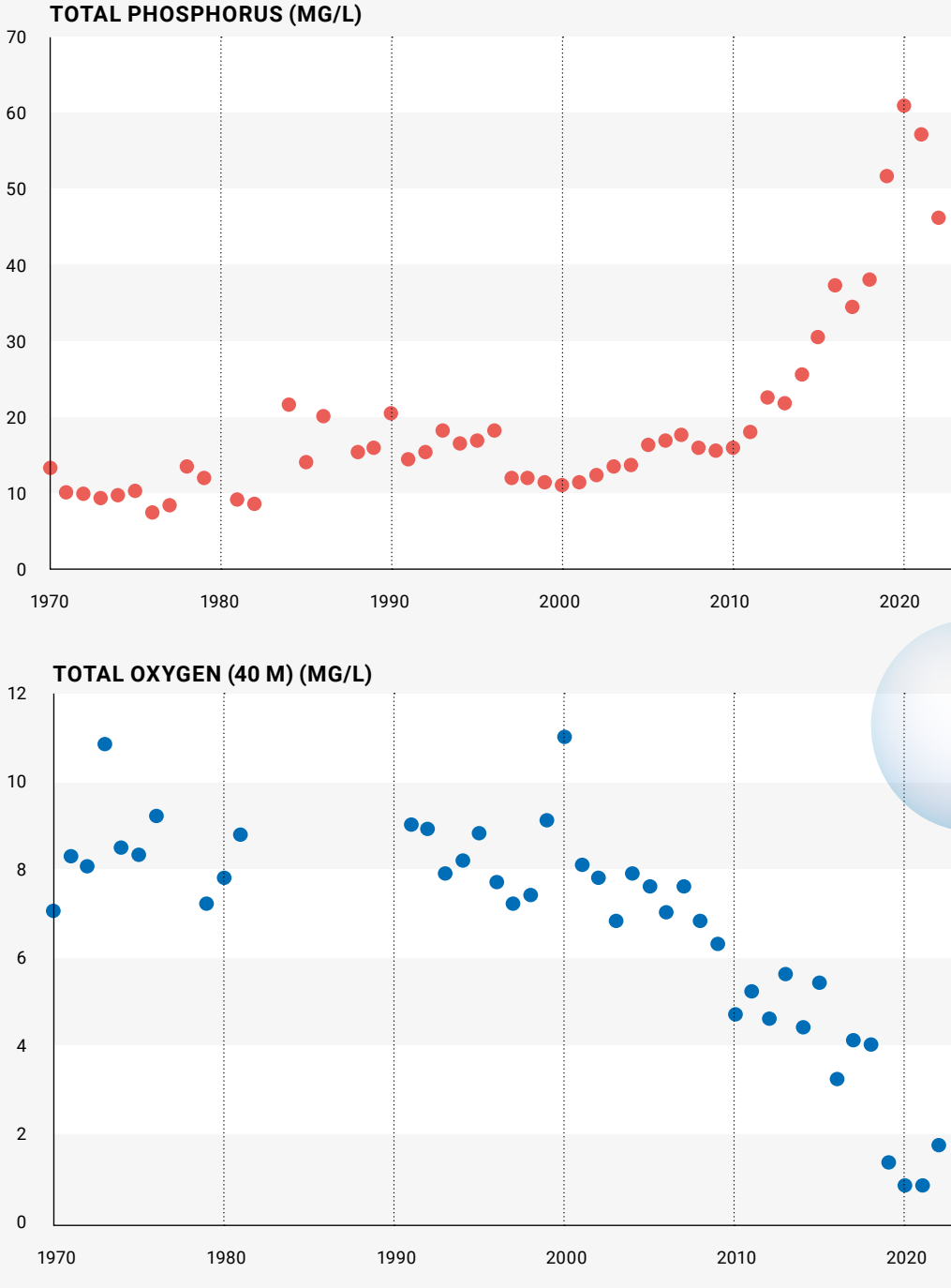

FIGURE: THOMAS GONSIORCZYK/IGB

> "As long as dimictic lakes mix completely twice a year, the entire water body – right down to the bottom – is supplied with oxygen in autumn and spring. In the wake of climate change, with warmer and longer summers, these patterns are changing and the period of stable stratification is lengthening. This can result in full circulation starting later in the autumn, being incomplete or failing altogether."
>
> **Dr Stella Berger**

in the process. "However, as we have been able to show, it is also produced – continuously – in other parts of the water, under oxic conditions," emphasised Mina Bizic. Oxic methane production can account for up to 85 per cent of a lake's total emissions, but it can also be much lower.

Too many nutrients in the lake also play a role. They often lead to cyanobacteria and algae blooms. When this biomass dies, it is decomposed by microorganisms that need oxygen to do so. This depletes the lake of oxygen and creates more oxygen-free zones in the lake where the archaea can continue their work. In addition, some of this biomass sinks in the form of floc-like aggregates. If these are large enough, they can contain oxygen-free zones, as Mina Bizic stated. "We call these anoxic microniches," she explained. Archaea can also produce methane in these zones, which is released to the surface and into the air much faster than from the bottom of the lake. The morphology of the lake also plays a role in determining the relationship between the main source of methane and the atmosphere – classic or oxic methane production.

MANY TRACE ORGANIC COMPOUNDS IN RIVERS ARE HARDER OR IMPOSSIBLE TO BREAK DOWN WITHOUT OXYGEN

Oxygen is also important for the self-purification of water bodies, as Jörg Lewandowski's work shows. His research group studies the degradation and transformation of organic micropollutants, such as industrial and pharmaceutical residues, in the hyporheic zone. Put simply, this zone is the stream bed. It is where many degradation and transformation processes take place that contribute significantly to the self-purification capacity of flowing waters. Ripple structures, a kind of small dune on the stream sediment, cause some of the river water to flow through the sediment. "Many trace substances are well degraded along this flow path, albeit rarely completely," stated Jörg Lewandowski. Transformation products are formed. In the ab-

sence of oxygen, little degradation takes place. Organic micropollutants are undesirable in river water because they pollute ecosystems, can accumulate in the food chain and limit the usability of water, e.g. for drinking water production.

OXYGEN DEPLETION AND ITS CONSEQUENCES CAN BE PREDICTED

In order to better monitor the effects of climate and environmental changes on lakes, Michael Hupfer's research group, in which Robert Schwefel is a postdoctoral researcher, has co-developed two models. The first can be used to predict the development of oxygen levels in lakes in summer: "It is a highly simplified model that predicts the oxygen constellation as a function of temperature under nutrient-poor, moderately nutrient-rich or nutrient-rich conditions and the duration of stratification," explained Robert Schwefel. The model is based on extensive oxygen depletion data from a literature review and has been validated using IGB measurements from several lakes.

Together with the TU Bergakademie Freiberg, the team has also developed an easy-to-use calculation method that can be used to estimate the effects of oxygen depletion on the deep water of lakes. The researchers used high-resolution temporal and spatial information on the duration of anoxia. They also showed that this information can be calculated relatively easily from a few measurements and the topography of the lake bed. "Such models can also be used to develop adaptation strategies for the management of lakes and reservoirs," concluded Michael Hupfer, adding that research can not only contribute to a better understanding of the severity of the situation, but also help to initiate possible improvements.

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Find out more at www.igb-berlin.de/en:

- New model predicts consequences of anoxia in lakes
- Global warming: lakes lose too much oxygen

Abigail et al. (2023) Anoxia begets anoxia: A positive feedback to the deoxygenation of temperate lakes. Global Change Biology. https://doi.org/10.1111/gcb.17046

Pilla et al. (2024) Deepwater dissolved oxygen shows little ecological memory between lake phenological seasons. Inland Waters. https://doi.org/10.1080/20442041.2023.2265802

LaBrie et al. (2023) Anaerobic duration predicts biogeochemical consequences of oxygen depletion in lakes. Limnology and Oceanography Letters. https://doi.org/10.1002/lol2.10324

Schwefel et al. (2023) Oxygen depletion and sediment respiration in ice-covered arctic lakes. Limnology and Oceanography. https://doi.org/10.1002/lno.12357

Nkwalale et al. (2023) A simple model for predicting oxygen depletion of lakes under climate change. Inland Waters. https://doi.org/10.1080/20442041.2024.2306113

Schroll et al. (2023) Methane accumulation and its potential precursor compounds in the oxic surface water layer of two contrasting stratified lakes. Science of The Total Environment. https://doi.org/10.1016/j.scitotenv.2023.166205

PHOTO: DAVID AUSSERHOFER/IGB

How does water flow in the city?

How is the natural and artificial water balance distributed across a city? How and where is groundwater recharged and runoff generated? And how do these hydrological processes affect the ecohydrology of cities? Using hydrological models and water isotope data, researchers led by IGB analysed the flow paths, areas of origin and age of the water in the 217 square-kilometre catchment area of the city of Berlin. They found that the deeper groundwater in the upper reaches of the less urbanised areas accounts for a very high proportion of the runoff. Downstream, the urban influence increases, with high contributions from wastewater effluents. In the highly urbanised lower reaches, direct storm runoff and subsurface inflows add to the complexity. The analysis of water age showed that in less urbanised areas, the water is on average older, i.e. it is retained in the area for longer. Downstream, the age decreases, making urban areas more sensitive to heavy rainfall events and less resilient to long periods of drought. The results are a first step towards integrated tracer-based hydrological modelling tools for urban catchments. Thus, this research contributes to more sustainable urban planning in an era of change.

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Smith et al. (2023) Enhancing urban runoff modelling using water stable isotopes and ages in complex catchments. Hydrological Processes. https://doi.org/10.1002/hyp.14814

Burst banks

Why intact floodplains are better at protecting us from floods

Questions to 3 experts

At the turn of the year 2023/2024, prolonged rainfall in parts of Germany caused rivers to burst their banks, causing extensive flooding of both agricultural fields and human settlements. Rivers and streams were slow to return to their original course. But how much space does a river actually need? Under what conditions do floods become dangerous for us – and is it also dangerous for nature? How can we better prepare for such extreme events, and what measures benefit both people and nature? We take a look at the state of the country's rivers and floodplains and explain why it is worth rethinking flood protection.

PHOTO: 2319474775/SHUTTERSTOCK

PROFESSOR DR SONJA JÄHNIG

Professor Jähnig, intense and prolonged rainfall is likely to become more frequent due to climate change. Are we going to have to get used to flooding?

Unfortunately, yes, at least if we continue to do things as we have in the past. Floods are actually natural events in intact riverine landscapes, which over thousands of years have created unique biodiversity and resilient ecosystems. They are even a prerequisite for vital ecosystem functions – such as groundwater recharge. By straightening rivers and building dikes too close to them, humans have created rivers in which floodwaters swell faster and higher. Rather than allowing the water to expand in the floodplain and partially seep away, large volumes of water flow faster towards the sea. While this certainly had advantages, for example for navigation and agriculture, it also poses considerable risks – as we can see today. Conventional technical flood control does not offer absolute protection. It interferes heavily with the structure of rivers, it is expensive to maintain and difficult to adapt to the increasing number of flood events. As a society, we therefore need to take a different approach to our rivers and floodplains. Dykes and artificial reservoirs should increasingly be replaced or at least complemented by nature-based solutions. These new approaches are usually multifunctional, i.e. they serve several regulatory, social or economic objectives simultaneously. In the case of floodplains, for example, they benefit climate adaptation, recreation, nature conservation and biomass production. It is important to find a good mix and to redesign the landscape, including our forests and cities, to better absorb rainfall and retain water for the hot season when water is scarce.

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DR MARTIN PUSCH

After the severe floods of 2013, the German Federal Government and the German Federal States adopted a National Flood Protection Programme. Dr Pusch, how do you rate what has been achieved from a research perspective?

The aim of the programme is to reduce river flood levels by 10 or even 50 centimetres over long stretches. This would certainly be a major success for flood protection, but it is uncertain whether this capping of flood waves will be sufficient in the face of climate change. It is disappointing that two-thirds of this flood retention is to be achieved through new polders, and only one-third through near-natural flood protection measures such as dyke relocation. Ten years later, in 2023, of the 168 spatially significant partial and individual measures planned, 66 were still in the design phase, 46 in the preliminary planning phase, 18 in the approval or contract award phase and only 26 in the construction phase. There are countries that are much better positioned in terms of flood protection, such as the Netherlands. For almost 30 years, the Netherlands has been moving back large sections of dykes and creating floodplains as part of the "Room for the River" programme. In Germany, on the other hand, the active floodplain area increased by only 0.1 per cent per year between 2009 and 2020. It must be said that most of the money spent on flood protection in Germany is still being invested in raising and reinforcing dykes. From a scientific point of view, however, it would be advisable to limit the use of dykes specifically to the protection of settlements, and not agricultural land, as this increases the risk of flooding for settlements and important infrastructure.

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DR CHRISTIAN WOLTER

Mr Wolter, being a fish ecologist, do you think that more intact floodplains automatically result in more species and more stable populations?

Natural or restored floodplains are undoubtedly some of the most species-rich habitats in Germany. Oxbow lakes and shallow floodplains, for example, create zones with less turbulence, where fish larvae can develop undisturbed and poor swimmers can thrive. The Red List of endangered freshwater fish and lampreys in Germany, which we updated together with partners in 2023, also shows how important these habitats are. More than half of our native species are now considered endangered or already extinct. This means that the threat to native freshwater fish and lampreys has worsened significantly over the past fourteen years. Even the trout (*Salmo trutta*) has been reclassified as an endangered species. It too could benefit from natural flood protection – provided it starts in the upper reaches. The trout – and many other species of flora and fauna – would also gain habitat if these stretches were more richly structured, with many more obstacles such as dead wood or large stones, providing habitat diversity through deep pools, wide and narrow stretches or small riffles. Not only have the main waterways been straightened, but also many of the upper reaches of rivers in order to drain off rainfall as quickly as possible. In terms of flooding, this means that the straighter these small tributaries are, the faster a flood wave will reach the downstream areas – giving local residents little chance to react.

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PHOTOS: DAVID AUSSERHOFER/IGB

Find out more at www.igb-berlin.de/en:
- Better flood protection
- Every second species threatened or extinct

Freyhof et al. (2023) Rote Liste und Gesamtartenliste der sich im Süßwasser reproduzierenden Fische und Neunaugen (Pisces et Cyclostomata) Deutschlands – Naturschutz und Biologische Vielfalt 170 (6): 63 S.

Lu et al. (2024) The impacts of reduced connectivity on multiple facets of aquatic insect diversity in floodplain wetlands, Northeast China. Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2023.169207

New Red List for freshwater fish and lampreys in Germany

The Red List of Freshwater Fish and Lampreys for Germany has been updated for 90 established native species based on current population status, long-term and short-term population trends, and existing threats. It was published as Issue 170/6 of the "Naturschutz und Biologische Vielfalt" series of the Federal Agency for Nature Conservation (BfN) in cooperation with the Red List Centre.

PHOTO: SHUTTERSTOCK 1507315184, DOTTED YETI

Microplastics: Some lakes are worse impacted than oceans

A team led by the University of Milan-Bicocca, Italy, with the participation of IGB, has analysed 38 lakes and reservoirs in different regions of the world with different environmental conditions to identify the drivers of microplastic pollution. The researchers found microplastics in all the lakes and reservoirs studied, even in remote areas. Two types of lakes were expected to be particularly vulnerable to microplastic pollution: lakes and reservoirs in densely populated and urbanised areas, and lakes and reservoirs with large surface areas, long water retention times and high levels of anthropogenic influence. The extent of pollution was surprising in some supposedly nutrient-poor lakes located in sparsely populated areas, such as Lake Tahoe and Lake Stechlin. However, both lakes have long water retention times, which can lead to an accumulation of microplastic particles. Some of the lakes with the highest levels of microplastic pollution are also used as drinking water sources.

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Microplastic pollution: some lakes are worse impacted than oceans

Nava et al. (2023) Plastic debris in lakes and reservoirs. Nature. https://doi.org/10.1038/s41586-023-06168-4

PHOTO: MAREIKE BENEDIX, IGB

Small waters, big opportunities

Ponds and pools deserve special protection

While we have watched with concern as the water levels of major rivers and lakes have fallen in recent years, another type of inland water is disappearing almost unnoticed: small standing waters such as ponds, pools and park waters. Often overlooked because of their small size, they are also experiencing historic lows, drying up and disappearing altogether. For decades, they were dismissed as insignificant, filled in or built over – with serious consequences: It is estimated that more than 50 per cent of Europe's small standing water bodies have disappeared in the last century.

PHOTO: LUC DE MEESTER, IGB

Ponds are home not only to amphibians and other animals, but also to specialised aquatic plants such as the rare and protected water soldier (Stratiotes aloides).

We now know that these inconspicuous water bodies play an important role: They account for 30 per cent of the world's inland standing waters, are home to 70 per cent of Europe's regional freshwater species, and are both ecologically and socially important. Because of their modest size and important contribution to biodiversity, small water bodies are ideally suited as nature-based solutions to help us adapt to climate change or mitigate its effects.

Whether for livestock watering, irrigation, water storage, fire-fighting or local recreation, small water bodies provide many benefits to society, known as ecosystem services. But ponds and pools are more than just areas of water in the landscape; they are diverse habitats. In fact, they are home to a higher proportion of rare, endemic and threatened freshwater species than lakes or rivers. This is because they provide very different habitats. They can be found in a wide variety of environments – from forests to agricultural landscapes to cities. Small water bodies can be permanent or temporary, containing water all year round or only for a few weeks or months. They can be of natural origin (in Germany, especially the numerous kettle holes) or man-made (such as fish ponds). What they have in common is that they are particularly vulnerable to low rainfall and falling groundwater levels, and are increasingly drying out. This process is accelerated by surface sealing and drainage. Very little water reaches the small water bodies and groundwater recharge is inadequate.

PHOTO: THOMAS MEHNER

Small natural or semi-natural water bodies are often hotspots of biodiversity. However, water scarcity, increasing use pressure and climate change with its extreme weather events are putting these ecosystems and all the plant and animal species that depend on them under severe pressure.

LESS WATER – FEWER SMALL WATER BODIES

In addition to climatic changes such as drought and heat, changes in land use are a major factor in the disappearance of small water bodies, for example when ponds and pools are filled in, built over or converted to farmland. The remaining small water bodies are exposed to pollution from inorganic and organic substances such as fertilisers, pesticides, road salt, tyre wear, flame retardants, and other industrial chemicals, and are unable to buffer such pollution because of their small size.

All these pressures reinforce each other: Prolonged droughts can lead to increased concentrations of nutrients and pollutants because there is less water available for dilution. When water is scarce, the high concentrations of pollutants can have a greater negative impact on the ecosystem. Increased nutrient concentrations combined with faster warming of the reduced water volume also lead to algal blooms.

The opposite weather extreme, which is becoming more frequent with climate change, is heavy rainfall events: They generate high surface run-off and lead to massive inputs of pollutants from urban, industrial and agricultural areas into small water bodies.

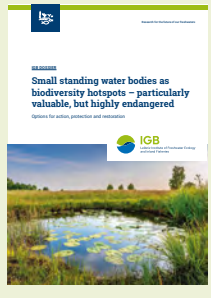
As a result, the number of small water bodies is decreasing and their ecological quality is deteriorating. The fewer small water bodies there are and the greater the distance between them, the less likely it is that species will reach them. Small standing water bodies then no longer serve as stepping stones for the (re)colonisation of habitats and the exchange of genetic material. This is a particular problem for species that spread passively, such as plankton organisms and aquatic plants.

Amphibians such as frogs, toads, newts and salamanders are also severely affected: Many of them depend on temporary water bodies, because they are free of typical predators such as fish. But when ponds dry up for too long or disappear altogether, amphibians are unable to complete their life cycles. For many amphibian species, landscapes with a sufficient number of small and shallow standing waters are therefore essential for survival.

POND LANDSCAPES: DIVERSE, NUMEROUS AND INTERCONNECTED

Conservation measures should therefore focus not only on the individual water body, but also on its potential as a networked ecosystem. A network of water bodies – a true pond landscape – can sustainably promote regional biodiversity and enhance ecosystem services such as water retention. The density and diversity of the water network determines the extent to which the landscape can support rare and specialised species. It is also important whether small water bodies are permanent or temporary – a good mix of permanent and temporary systems, as well as those with relatively short or relatively long wet periods, is ideal for supporting regional biodiversity. However, perennial drying will soon lead to the complete and irreversible disappearance of these small water bodies.

The small size of ponds and pools, and the fact that their chemical and ecological status is determined by the land use in their immediate vicinity, make them particularly suitable for so-called nature-based solutions – that is, for or as measures that protect, restore or manage natural or modified ecosystems in a way that simultaneously benefits biodiversity and human well-being. This is particularly important in the context of climate change. As these solutions can be implemented very locally for small water bodies, they are often comparatively simple and inexpensive.



IGB Dossier

Small standing waters are overlooked and undervalued because of their small size – yet they account for more than 30 per cent of the world's inland water bodies and are of great ecological and social importance. To raise awareness of this problem and to identify options for action for policymakers, authorities and the civil society, IGB has published an IGB Dossier on this important type of water body.

IGB_Dossier_Small_standing_water_bodies_2023.pdf

A RETHINK OF POLICY AND PRACTICE IS NEEDED:

1. A consistent interpretation of the regulatory framework is essential. Small water bodies should be given greater consideration in water policy and management. Policymakers and authorities should use the existing Water Resources Act, the Federal Nature Conservation Act and regulations at state and municipal level to ensure the sustainable management of small water bodies.

2. Clear competencies and responsibilities are essential for the sustainable management of small water bodies and pond landscapes. If necessary, civil society actors can also be involved in this responsibility, as they need appropriate resources and technical support. Different types of small water bodies require tailor-made management guidelines and maintenance measures.

3. In the face of increasing water scarcity, it is extremely important to ensure the ecological minimum water requirements for small water bodies. Water supply concepts in rural and urban areas should take into account the ecohydrological functionality of catchments.

4. The restoration and creation of small water bodies increases regional diversity

Ecosystem services provided by small water bodies to people and nature

- Biodiversity hotspots with higher proportions of rare, endemic and threatened freshwater species than larger lakes or rivers
- Stepping stone biotopes through which water-related species can spread and colonise or re-establish themselves in landscapes
- Important source of water and food for terrestrial animals
- Positive influence on microclimate and local temperature, especially in urban areas
- Opportunities for recreation and places to experience nature, especially in urban areas
- Particularly species-rich refuges in monoculture agricultural landscapes, e.g. for pollinators
- Regulation of the water cycle through purification and enrichment of water in the landscape, interaction with groundwater and mitigation of floods and heavy rainfall events
- Small water bodies as “pond landscapes” provide the above ecosystem services to an even greater extent

Main causes of loss of small water bodies and their biodiversity

- Increasing climate change and longer periods of droughts
- Urban development and soil sealing
- Overexploitation and overpopulation, especially in urban areas
- Intensive agriculture and forestry
- Pollution from organic and inorganic contaminants
- Invasive plant and animal species introduced by humans
- Lack of consistent interpretation of the regulatory framework
- Lack of continuous, technically sound maintenance of water bodies

and promotes rare species. The development of small water bodies should be given a higher priority in public programmes and should be taken into account in compensation and replacement measures for interventions in the ecosystem.

5. Small water bodies should be given greater consideration in urban and settlement planning. The "sponge city" concept can help to make more efficient use of rainfall, preserving small water bodies. Urban planning should encourage the removal of sealed surfaces, prioritise local infiltration and, where appropriate, develop access and visitor management concepts for small water bodies.

6. Improved protection of small water bodies is also important in rural areas. Designing and managing soils so that they can absorb and store water well would benefit both agriculture and small water bodies.

7. In order to maintain or improve the water quality in small water bodies, substance inputs should be better regulated. Structurally rich buffer zones and riparian strips are effective measures to further reduce pollutant inputs. They also provide valuable habitats.

8. Finally, all small water bodies should be included in environmental databases in order to involve experts from civil society or research in their protection. Long-term monitoring is essential to assess the status and benefits of small water bodies and pond landscapes.

In general, we should be more aware that diverse habitats and species communities are a kind of "insurance" against external stresses, natural and anthropogenic environmental changes and fluctuations. Biodiversity increases the likelihood of survival of species and communities and the functioning of the ecosystems on which we humans depend – in small water bodies as well as in larger lakes, rivers and wetlands.

PHOTO: LUC DE MEESTER, IGB

The disappearance of small water bodies has clearly contributed to the collapse of amphibian populations such as frogs, toads, newts and salamanders in Germany and Europe.

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www.oekom.de/zeitschrift/politische-oekologie-6

Cuenca-Cambronero et al. (2023) Challenges and opportunities in the use of ponds and pondscapes as Nature-based Solutions. Hydrobiologia. https://doi.org/10.1007/s10750-023-05149-y

Ionescu et al. (2022) From microbes to mammals: Pond biodiversity homogenization across different land-use types in an agricultural landscape. Ecological Monographs. https://doi.org/10.1002/ecm.1523

Video on the importance of ponds:
https://youtu.be/s16LCC_wLvE

PHOTO: NICK PRICE FOR COSTA SUNGLASSES

How group-hunting works in the open ocean

Behavioural ecologists from IGB and Humboldt-Universität zu Berlin have studied the hunting behaviour of animals in groups and found that animals in water hunt differently than their terrestrial counterparts. One reason for this could be the different predator-to-prey size ratio: If the prey is much smaller than the predator, as is the case in shoals of fish, individual animals are divided among the predators before being killed. In this case, group hunting is particularly advantageous to overcome the collective defence of the prey and to increase manoeuvrability. Using the striped marlin (*Kajikia audax*), a member of the billfish family, as an example, the researchers were able to show that motivation plays a greater role than rank in the division of prey. The large fish also tolerated hunting together with sea lions. The studies were made possible by advances in tracking technology: Using high-resolution video recordings, the researchers analysed the animals in the wild in Baja California Sur, in the Mexican Pacific Ocean, and were able to identify individual animals based on their physical characteristics, allowing them to study their hunting behaviour and their role in the group in detail.

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- How group-hunting works in the open ocean

Hansen et al. (2023) Mechanisms of group-hunting in vertebrates. Biological Reviews. http://dx.doi.org/10.1111/brv.12973

Tiny but powerful

Microorganisms and their importance to our freshwater ecosystems

With around 8,000 different species, ciliates are the largest and most complex group of protozoans. They can be tiny, measuring just 10 micrometres, or impressive, measuring up to 4 millimetres. Ciliates have numerous hair-like organelles called cilia that cover their cell membrane, giving them their name. They use these cilia to move through the water, feed and explore their microscopic world, hunting bacteria and other unicellular organisms.

PHOTO: KESHINEE APAJEE / IGB

Without microorganisms, our ecosystems would not function properly: fungi "predigest" food, parasites keep blue-green algae in check, and water fleas play an important role in aquatic food web dynamics and structure. At IGB, many researchers are working on different microorganisms, studying both the ecology of these organisms and the extent to which they are threatened by climate change and other human-induced changes. While the findings are fascinating, they are also a strong reminder that the diversity of life in our waters is under threat – even that of microbes.

When you meet Hans-Peter Grossart for a video call, you find yourself in an icy environment. "The landscape behind me is Antarctica," explained the limnologist. But he is not wearing a hat or scarf, because the ice landscape is a digitised photograph. Hans-Peter Grossart is all too familiar with the real-world extremes of our planet's cold poles – it's where he and his team study the interaction between parasitic fungi and benthic diatoms. "We want to understand how climate change is affecting food webs and biodiversity in Antarctica and the Arctic," the researcher said. He observes changes in various environmental parameters, such as rising temperatures and the increased input of "fresh" glacial meltwater: Does this increase or decrease parasitism, and how does this affect the food chain and biodiversity in general? His team has taken numerous samples, which are still being analysed.

Grossart and his team know from numerous recent research projects that fungi play a special ecological role. For example, they are much more widespread than previously thought – occurring even in the deep sea, another extreme habitat. In the deep ocean, a number of cycles are driven by fungi, some of which also break down plastic. There are only rough estimates of fungi as a percentage of microorganisms in the different types of water. In freshwaters, they are thought to account for up to half of all single-celled microorganisms. Interactions between parasitic fungi and algae in lakes are important: parasitic fungi break down particular types of algae and bacteria, e.g. filamentous and toxic cyanobacteria, which then become food for zooplankton. "This means that the parasitic infestation makes part of the algal biomass available in the first place, which is a very important effect in the food web, as demonstrated by the team of my colleague at IGB, Justyna Wolinska," reported Hans-Peter Grossart.

FUNGI ARE IMPORTANT FOR A VARIETY OF NUTRIENT CYCLES

Certain types of fungi can apply mechanical pressure to larger organic matter, such as leaves, to gain access to the cells. Cells that have been opened by the fungus can then be invaded by bacteria, causing the leaf to decompose more rapidly. "This is a fundamental mechanism that also occurs in soils," remarked Hans-Peter Grossart. In the carbon cycle of freshwaters, microorganisms such as filamentous fungi contribute to the accumulation of organic matter. Larger aggregates sink faster to the bottom. But there are also fungi that work in the opposite direction, preventing aggregation and rapid sinking. Hans-Peter Grossart and his team are investigating parameters such as temperature, industrial pollution and nutrient availability to see how they affect these matter flows.

Many fungi have special enzymes that allow them to interact with other organisms to transform persistent materials such as microplastics. "We have already tested a large number of fungal isolates and found some that break down plastics," reported Hans-Peter Grossart. However, these results are obtained in a bioreactor, i.e. under laboratory conditions. How much plastic can be indeed transformed by fungi in a natural system depends on many factors, including temperature, nutrient conditions, microbial community composition and whether the fungus is able to grow on the plastic.

However, fungi are at risk. Fungicides and many other pollutants such as pharmaceuticals, metals, toxins from microplastics and nutrients may be affecting fungi and their delicate networks. How this happens is the subject of an ongoing research project led by Justyna Wolinska. Moreover, fungi are probably affected by the same factors as other aquatic organisms, which include habitat degradation, invasive species and climate change. Such threats can lead not only to species extinctions in aquatic fungal communities, but also to population declines and even to a total loss of their key functions in the ecosystem, which can ultimately produce cascading effects in aquatic food webs. For this reason, Hans-Peter Grossart and an international research team are calling for the protection of aquatic fungi to be recognised as a priority for the management of water bodies.

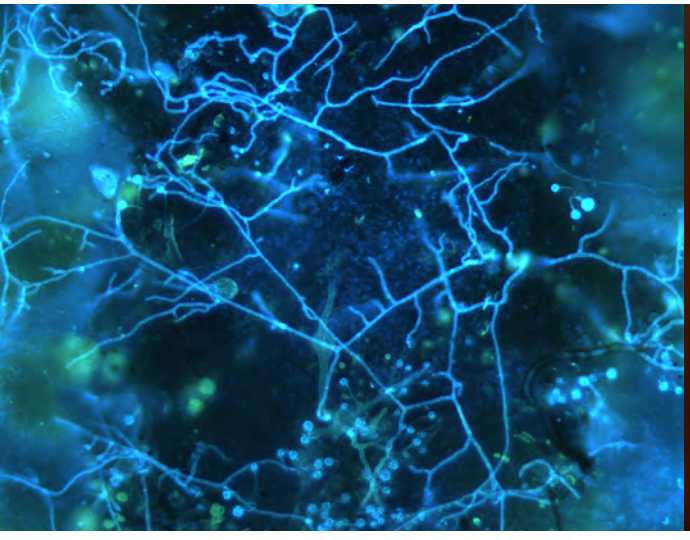
USING WATER FLEAS TO STUDY THE EFFECTS OF CLIMATE CHANGE

Dagmar Frisch from the "Evolutionary and Integrative Ecology" department also conducts research on microorganisms in the Arctic. She focuses on a special phenomenon in the animal kingdom: the dormant eggs of a *Daphnia* population in this extreme weather region. "*Daphnia*, or water fleas, are of great interest because they belong to the keystone species in freshwater ecosystems: they play a key role in food webs at an intermediate position, feeding on algae and serving as food to larger organisms including fishes," reported Dagmar Frisch.

She works with *Daphnia pulicaria*, a species found mainly in lakes. The Greenland population she is studying differs from many other populations of this species in that the animals reproduce completely asexually: there are males, but they have no known function – the females clone themselves. Water fleas hatch from the eggs they produce, even without fertilisation, each with a triple set of chromosomes completely identical to their mother's. Dagmar Frisch wants to know how climate change is affecting these populations and, in turn, the local ecosystem as a whole. To do this, she takes advantage of a special feature of this species: Daphnia eggs can survive in the sediment for several hundred years before being "awakened" to hatch. Daphnia eggs are contained in a chitinous shell that forms on the back of female daphnia and detaches when the animals shed their skin. The shell containing the eggs – the ephippium – slowly sinks to the bottom and rests in the sediment. Over the decades, layers of ephippia form in the sediment. Dagmar Frisch and her team take sediment cores and use radiocarbon dating to date the sediment layers from which the eggs were taken.

How well the eggs survive depends on the conditions in the sediment – they cannot always be resurrected, usually "only" to an age of just over 100 years. The purpose of the resting eggs: If a generation dies due to poor conditions, the population from the sediment can regenerate – usually the following year.

In the laboratory, Frisch and her team resurrect dormant eggs of different ages and analyse how the animals that develop from them differ from one another. An individual and its copies in different sediment layers provide the researchers with a kind of time series that can be used to track the effects of different temperatures: for example, on the number of eggs per generation or the time it takes for the *Daphnia* to reach sexual maturity. "Usually you collect individuals from populations in different places and then compare their genomes, for example: Where are the genes that have changed through selection, where are the differences? In this case, you're following the same population and its evolution, which



Chytrid fungi are particularly diverse and beneficial: they infect filamentous cyanobacteria, kill and "chop" them into pieces, turning them into food for the smallest invertebrates.

PHOTO: HANS-PETER GROSSART, IGB

Under unfavourable conditions some water fleas, such as Daphnia pulicaria*, produce a special type of eggs that can survive for decades in the sediment of a lake.*

PHOTO *DAPHNIA MAGNA*: DR JULIAN TAFFNER (TERRA ALIENS)

makes it so special," enthused Dagmar Frisch. The researchers have already discovered that their temperature tolerances vary. Present-day *Daphnia* from the habitat under study are more sensitive to heat, so their populations could be at risk from climate change.

LYNN GOVAERT SEEKS TO DISCOVER UNDERLYING MECHANISMS

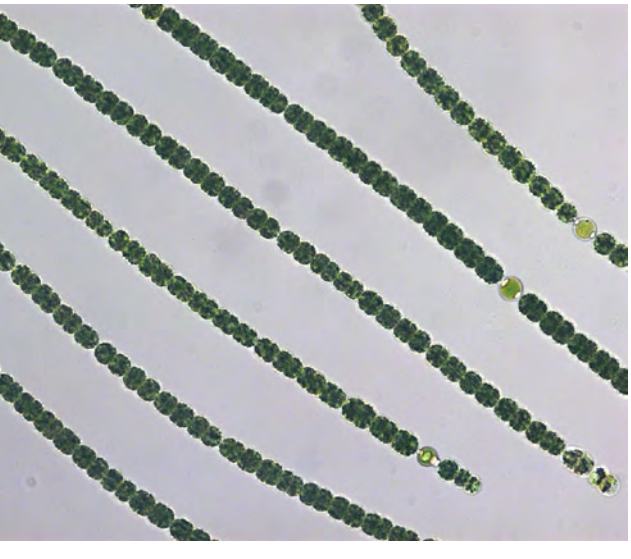
Changes over many generations also play a central role in Lynn Govaert's research: she is investigating the rules that govern community dynamics using tools from evolutionary ecology. Environmental conditions affect individuals and also influence their genetic makeup over time; animals that have undergone physical and behavioural changes which in turn affect their population dynamics but also their interaction with other species. "I am interested in the rules governing these complex dynamics and what we can learn from them for the future," remarked Lynn Govaert. Before the Belgian mathematician came to IGB in spring 2021, she had already studied how single-celled organisms known as ciliates evolve under changing conditions. Ciliates are interesting because they have very short generation times, ranging from approximately four hours to two days depending on the species. This means that evolutionary changes are already visible after a few weeks. They are also relatively easy to keep in the laboratory, respond quickly to a variety of stressors and have different responses to environmental change. In the coming years, Lynn Govaert wants to study how different ciliate species interact when environmental conditions such as the salinity of their water habitat or water temperature are changed. "Evolutionary ecology and especially eco-evolutionary dynamics is a young field of research with much to discover," noted the researcher. She is aided by modern technology. Lynn Govaert and her team use a software programme that allows them to tag a large number of single ciliate

individuals in a randomly sampled "sip" of the miniature ecosystems following them under the microscope. Lynn Govaert's goal is to understand evolutionary changes of ciliates to environmental change in their complexity to the point where it is possible to discover mechanisms and make predictions for natural systems.

HEAT AFFECTS *DAPHNIA* SIZE AND FECUNDITY

Justyna Wolinska also studies evolutionary processes and what they can teach us about the coexistence of the smallest organisms. To this end, she and her team use a number of lakes in Poland that have experienced discharge of cooling water from coal-fired power plants for 60 years. As a result, the temperature of these water bodies is on average 3 to 4 degrees Celsius higher than the surrounding lakes. The researchers use these cooler water bodies as control lakes. Sixty years represents hundreds or even thousands of generations during which the species studied – *Daphnia* and the tiny parasites that live with them – have been able to evolve together and adapt to the higher water temperatures. One of the results of Wolinska's research is that the *Daphnia* grow larger and lay more eggs in the warmer lakes – although these conditions are not actually suitable for the species: when *Daphnia* from cooler lakes are exposed to the same temperatures, they produce fewer eggs. The common microparasite infecting *Daphnia* was found less frequently in the warmer lakes. "This may sound like good news, but it is not. After all, these parasite species have many functions in the ecosystem. If these key actors disappear, other trophic levels will be affected," stated Justyna Wolinska. Microparasites and the epidemics they cause increase the evolutionary pressure on *Daphnia* to be genetically diverse and hence better able to adapt to stressful conditions. And given that *Daphnia* are at the centre of the food web, their potential decline might have consequences for other species.

More than 3.5 billion years ago, cyanobacteria colonised the planet and became the first organisms to produce oxygen. But if they proliferate massively – due to climate change or eutrophication – toxic algal blooms occur.
PHOTO: MAREN LENTZ/IGB



EVEN SMALL QUANTITIES OF MICROPLASTICS HAVE A MAJOR IMPACT ON MICROORGANISMS

Wolinska and her team are currently investigating how microplastic and nanoplastic particles affect the host–parasite relationship in water. "There are numerous studies on the toxicity of microplastics to individual species, but we still don't know how they affect interactions and contribute to the spread of diseases, for example," stated the evolutionary biologist. The researchers tested low levels of nanoparticles and microplastics in water, expecting that such low levels would have no effect. But contrary to expectations, infection rates in *Daphnia* increased dramatically. The mechanism behind this could be that the plastic particles damage their immune system, leaving them unable to defend themselves against the parasites. The researchers made similar observations when cyanobacteria interacted with chytrid fungi. In summer, these fungi help to prevent the spread of algal blooms. "We observed that when

the cyanobacteria were exposed to the smallest plastic particles, they were covered by them. As a result, the chytrid fungi were unable to attack the cyanobacteria," stated Justyna Wolinska, describing the connection. Increased amounts of plastic in our freshwaters could therefore contribute to more cyanobacteria blooms and also put pressure on *Daphnia* populations.

MICROBIAL LIFE ON MARS?

Meanwhile, Dirk Schulze-Makuch knows that microorganisms are also the key to extraterrestrial life: his work in the Atacama Desert has shown that certain species of bacteria can survive without that it ever rains; they only need sufficient moisture in the atmosphere. On Mars, such bacteria may already have been detected but inadvertently eradicated – with too much water. During Mars missions in the 1970s, for example, scientists treated the soil with water to "wake up" any life that might be present. As discussed by Schulze-Makuch in a report for the US-American online forum *Big Think*, this method may well have wiped out any bacteria that may have been on Mars. After all, microbes that could survive on Mars would be adapted to extremely arid conditions. The smallest organisms are not only essential to our survival, they are also adaptable. But if their basis for life is disrupted, it can have far-reaching consequences for the ecosystem around them.

IGB Fact Sheet

The enormous impact that microorganisms can have on aquatic ecosystems was demonstrated in the Oder River disaster in the summer of 2022, when toxic algae triggered a massive fish kill. In the *ODER~SO* project, IGB is investigating the conditions that allowed the algae to multiply so suddenly and exponentially. An IGB Fact Sheet summarises the current state of scientific knowledge.

DR JAN KÖHLER et al.
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➲ State of knowledge on the toxic alga *Prymnesium parvum* in the Oder River

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Govaert et al. (2023) Quantifying interspecific and intraspecific diversity effects on ecosystem functioning. Ecology. http://dx.doi.org/10.1002/ecy.4199

Klawonn et al. (2023) Fungal parasitism on diatoms alters formation and bio–physical properties of sinking aggregates. Communications Biology. http://dx.doi.org/10.1038/s42003-023-04453-6

Ilicic et al. (2023) Temperature-Related Short-Term Succession Events of Bacterial Phylotypes in Potter Cove, Antarctica. Genes. http://dx.doi.org/10.3390/genes14051051

Manzi et al. (2023) Polystyrene nanoplastics differentially influence the outcome of infection by two microparasites of the host *Daphnia magna*. Philosophical Transactions of the Royal Society of London. http://dx.doi.org/10.1098/rstb.2022.0013

Sager et al. (2023) Habitability of Polygonal Soils in the Hyper-Arid Atacama Desert After a Simulated Rain Experiment. Journal of Geophysical Research: Biogeosciences. http://dx.doi.org/10.1029/2022JG007328

Hardly further recovery: Biodiversity in European rivers stagnates

An international team of researchers has analysed the state and development of biodiversity in European rivers using invertebrates. The comprehensive study shows that between 1968 and 2010, biodiversity in river systems in 22 European countries initially recovered due to improved water quality. Since 2010, however, biodiversity has stagnated; many river systems have not fully recovered. Given the expected consequences of climate change, such as higher temperatures and lower water flows in rivers, wastewater networks and sewage treatment plants should be further expanded, the overflow of sewage systems during heavy rainfall events should be prevented, and inputs of micropollutants, nutrients, fertilisers and pesticides, salts and other pollutants should be further reduced. In addition, more emphasis should be placed on restoring water bodies in the future.

PROFESSOR DR SONJA JÄHNIG, sonja.jaehnig@igb-berlin.de

Find out more at www.igb-berlin.de/en:

➲ Hardly further recovery: Biodiversity in European rivers stagnates

Haase et al. (2023) The recovery of European freshwater biodiversity has come to a halt. Nature. http://dx.doi.org/10.1038/s41586-023-06400-1

Sinclair et al. (2024) Multi-decadal improvements in the ecological quality of European rivers are not consistently reflected in biodiversity metrics. Nat Ecol Evol. https://doi.org/10.1038/s41559-023-02305-4

PHOTO: DR JULIAN TAFFNER (TERRA ALIENS)

Lynn Govaert

"I have always been fascinated by traits and how they change and evolve. The realisation that trait evolution can indeed be rapid and interact with ecological dynamics sparked my research interest in eco-evolutionary dynamics."

IGB researcher Lynn Govaert is funded by the Emmy Noether Programme of the Deutsche Forschungsgemeinschaft (German Research Foundation, DFG). This programme enables outstanding young researchers to acquire the prerequisites for a professorship over a period of six years. The qualification is achieved by leading a junior research group in combination with teaching responsibilities. Lynn Govaert's group is investigating whether the responses of species and communities to environmental change can be predicted if the important evolutionary and ecological interactions are known.

DR LYNN GOVAERT
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Lynn Govaert leads new Emmy Noether research group
Page 43

Dörthe Tetzlaff

"Water is of great importance worldwide, also for the city of Berlin and the Federal State of Brandenburg – one of the driest regions in Germany. I would therefore like to use the platform and network of the BBAW to bring the issue of protecting and using our water resources much more to the fore."

The Berlin-Brandenburg Academy of Sciences and Humanities (BBAW) has appointed IGB Department Head Dörthe Tetzlaff as a full member of the Academy. As one of the world's leading landscape hydrologists, her work on streamflow generation and water storage capacity of landscapes using stable isotopes, and on the role of plants in the water cycle in catchments, has become a benchmark against which other studies are measured and implemented.

PROFESSOR DR DÖRTHE TETZLAFF
doerthe.tetzlaff@igb-berlin.de

Dörthe Tetzlaff elected to the Berlin-Brandenburg Academy of Sciences and Humanities
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PHOTOS:
DAVID AUSSERHOFER/IGB

Igor Ogashawara

"We are helping to record the water cycle – precipitation, soil moisture, extent and quantity of water – as well as the water quality of lakes, rivers and wetlands in a completely new spatial and temporal dimension. This is a milestone for drinking water production, food production and ecology."

At the GEO Ministerial Summit in Cape Town, South Africa, IGB scientist Igor Ogashawara received the GEO Emerging Leader Award. He is investigating how remote sensing data, such as satellite imagery, can be used to improve environmental monitoring of water bodies – for example, to quickly detect and contain algal blooms. He is also a mentor to young scientists.

DR IGOR OGASHAWARA
igor.ogashawara@igb-berlin.de

➔ Exploring water with satellites helps us with drinking water, food and ecology

PHOTO: PRIVATE

Further honours:

Professor Dr Jonathan Jeschke was appointed by the Berlin Senate to the Advisory Council for Nature Conservation and Landscape Management.

Professor Dr Mark Gessner was appointed as Adjunct Professor at the Australian Rivers Institute of Griffith University in Brisbane, Australia.

Professor Dr Dörthe Tetzlaff was appointed to the Board of Reviewing Editors of the SCIENCE journal.

Dr Dominik Zak was appointed Professor of Catchment, Science and Environmental Management by Aarhus University, Denmark.

Dr Andreas Jechow was appointed Professor of Ophthalmic Optics and Optical Instrument Technology at the Brandenburg University of Applied Sciences.

Professor Dr Justyna Wolinska and **Professor Dr Jonathan Jeschke** were selected for the "Good Teaching Award" by students of biochemistry, biology, chemistry and pharmacy at Freie Universität Berlin.

Malwina Schafft received the third prize of the German Limnological Society (DGL) for her publication "Ecological impacts of water-based recreational activities on freshwater ecosystems: a global meta-analysis".

Dr Anja Höhne received the Nick Rock Memorial Prize from the University of Western Australia, Australia, for her doctoral thesis "Measurement and modelling of transport and reactivity of trace organic compounds in hyporheic zones".

Olga Lukyanova received the Thaer Master's Degree Award from Humboldt–Universität zu Berlin for her Master's thesis on the behaviour of the pike.

Katja Mehrwald received the Master's Prize of the German Zoological Society (DZG) for her Master's thesis on the diet of grey seals in the Baltic Sea.

PHOTO: VINCENT MUNDY

Wars threaten freshwater resources and water infrastructure

In armed conflicts, freshwater and water infrastructure are among the most vulnerable resources. Access to water resources can be a trigger for conflict, a means of exerting military pressure, or the water sector itself can be directly affected by acts of war. The ongoing war in Ukraine is having a dramatic impact on the country's water sector. An international team of researchers from Ukraine, Germany, Belgium and the USA collected and analysed information on the number, location, type and impact of military operations during the first three months of the conflict. The results show a wide range of damage, including flooding of large areas due to dam breaches, pollution from untreated sewage spills, dumped munitions, an increase in mine water levels, and a significant reduction in the quantity and quality of water for drinking and agricultural purposes. The consequences are likely to be felt for decades to come, with massive negative impacts on the environment – including coastal areas of the Black Sea – and on the supply of clean drinking water for millions of people, as well as water for agriculture and fisheries.

DR OLEKSANDRA SHUMILOVA, oleksandra.shumilova@igb-berlin.de

Find out more at www.igb-berlin.de/en:

War in Ukraine threatens freshwater resources and water infrastructure

Shumilova et al. (2023) Impact of the Russia–Ukraine armed conflict on water resources and water infrastructure. Nature Sustainability. http://dx.doi.org/10.1038/s41893-023-01068-x

Review of the year 2023

INTERNAL MATTERS

JANUARY-DECEMBER The newly established Competence and Technology Platforms (CTP) organised three CTP Days to present current and planned work and explore opportunities for internal networking.

DR STELLA A. BERGER
DR SABINE HILT
DR JENS C. NEJSTGAARD

All CTP on our website
www.igb-berlin.de/en/competence-and-technology-platforms

OCTOBER With the aim of standardising the management of research data and promoting open science, IGB set up a competence and technology platform for this focus and adopted a new research data policy.

DR CHRISTINA HABERMEHL

OCTOBER IGB received the TOTAL E-QUALITY award for its equal opportunities strategy. IGB's gender- and diversity-sensitive recruitment processes and the reconciliation of work and family responsibilities were among the areas recognised.

DR KIRSTEN POHLMANN

www.igb-berlin.de/en/news/igb-receives-total-e-quality-award

PHOTO: DAVID AUSSENHOFER, IGB

PROJECT LAUNCH

JANUARY The *NYMPHE* project, funded by the Horizon Europe programme, focuses on the bioremediation of contaminated habitats. The aim is to develop effective biological remediation strategies for different environments.

DR JÖRG LEWANDOWSKI
DR STEPHANIE SPAHR

JANUARY The EU project *DANUBE4all* aims to further develop digital tools, citizen science and revitalisation measures to support the restoration of freshwater and transitional waters.

DR MARTIN PUSCH
PROFESSOR DR SONJA JÄHNIG

www.danube4allproject.eu

FEBRUARY A special investigation programme on the environmental disaster in the Oder River (*ODER~SO*), funded by the BMUV, documents the damage and regeneration of the ecosystem.

DR MARTIN PUSCH
DR CHRISTIAN WOLTER
PROFESSOR DR SONJA JÄHNIG

www.oder-so.info
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Page 55

FEBRUARY In the DFG-funded project *Dynamic hyporheic zone*, a German-Israeli research team is investigating the effects of non-stationary flow and a moving riverbed on organic trace substances.

DR JÖRG LEWANDOWSKI
DR STEPHANIE SPAHR

MARCH *ISO-SCALE*, funded by the Leibniz Competition, aims at an integrated, cross-compartmental and cross-scale understanding of rainfall distribution in agricultural systems.

PROFESSOR DR DÖRTHE TETZLAFF

MARCH In collaboration with the Alfred Wegener Institute, IGB researchers are developing and validating an evaluation assessment system to improve animal welfare and animal health in shrimp farming within the *CrustaWohl* project.

DR SVEN WÜRTZ
DR DAVID BIERBACH

www.igb-berlin.de/en/news/we-need-evaluation-criteria-animal-welfare-crustacean-farming

APRIL The *FUNACTION* project brings together European and US research and nature conservation partners. They aim to increase our knowledge of the taxonomic, phylogenetic and functional diversity of aquatic fungi in order to develop conservation strategies.

PROFESSOR DR HANS-PETER GROSSART

https://funaction.eu

APRIL The aim of the *LILA* project, funded by the Volkswagen Foundation, is to establish a Kyrgyz-German environmental research and education laboratory at Issyk-Kul, one of the largest alpine clear-water lakes.

DR ASIYA MURAKAEVA

PHOTO: HANS-PETER GROSSART

MAY In the DFG-funded *EECODYN* project, researchers are developing experiments and theoretical models to test whether explicitly considering interactions between key evolutionary and community processes leads to a better understanding of species and community responses to environmental change.
DR LYNN GOVAERT

MAY The DFG-funded *Breaking the rules* project investigates the link between sex determination systems and the initiation and maintenance of hybrid asexuality through a comparative analysis of gametogenesis and early embryogenesis.
DR MATTHIAS STÖCK

JULY In a DFG-funded research network called *Comparative Urban Ecology*, an international and interdisciplinary team is investigating social-ecological networks in urban areas over a period of three years.
PROFESSOR DR JONATHAN JESCHKE
https://curt4future.com

AUGUST In the BMBF-funded *DIVATOX* project, researchers are investigating how the diversity of aquatic plants influences the associated cyanobacteria, their toxin production and thus also human health.
DR SABINE HILT
DR SVEN MEISSNER

SEPTEMBER The *BLIC* project, funded by the DFG's French-German funding programme, investigates the relative influence of diversity and biotic interactions on the early development of phytoplankton blooms.
DR SABINE WOLLRAB

SEPTEMBER The *PLATON* project focuses on the causes and consequences of the occurrence of plant-associated toxic cyanobacteria in freshwater ecosystems.
DR SABINE HILT
DR NIKOLA STANKOVIC

NOVEMBER The internally funded pilot project *ET-CHANGE* aims to gain a better understanding of the changes in regional evaporation over the last 40 years and their causes, and to improve the modelling of these processes in hydrological models.
DR DORIS DÜTHMANN
DR LAURENT STROHMENGER

ADVICE

JANUARY | FEBRUARY How can the Oder River ecosystem be better protected after the man-made environmental disaster, and what are the dangers of river regulation? IGB researchers advised SPD members of the German Bundestag and the state parliaments of Brandenburg and Mecklenburg-Western Pomerania on these questions.

DR JÖRN GESSNER
DR CHRISTIAN WOLTER

MAY As part of Leibniz in the Bundestag, IGB researcher Markus Venohr discussed the issue of "Nutrient pollution of groundwater caused by leaking sewer systems" with SPD Member of the German Bundestag Dunja Kreiser.

DR MARKUS VENOHR

(German only)

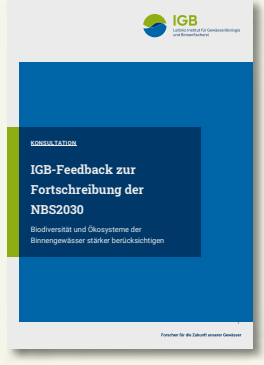
JUNE An IGB Fact Sheet summarises the key interim findings on the state of the Oder River after the environmental disaster. It was presented to Federal Environment Minister Steffi Lemke at a joint press conference.

DR CHRISTIAN WOLTER
DR SVEN WÜRTZ

IGB Fact Sheet Oder-Zwischenergebnisse

JULY IGB researchers provided feedback on the Federal Ministry of Agriculture's planned centre of excellence for aquaculture, highlighting the opportunities and challenges involved.

DR JÖRN GESSNER
PROFESSOR DR WERNER KLOAS
DR THOMAS MEINELT
DR FABIAN SCHÄFER

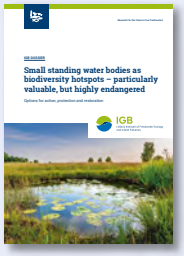


(German only)

JULY IGB provided feedback on the German federal government's draft of the National Biodiversity Strategy 2030. The researchers recommend that the ecosystems and biodiversity of inland waters should be given greater consideration.

DR SAMI DOMISCH
DR JÖRN GESSNER
DR SABINE HILT
PROFESSOR DR SONJA JÄHNIG
DR SIBYLLE SCHROER
DR MATTHIAS STÖCK
DR MARKUS VENOHR
DR CHRISTIAN WOLTER

IGB gives feedback on the National Biodiversity Strategy 2030



AUGUST Small standing water bodies such as ponds and kettle holes are of great ecological and societal importance, but they are particularly vulnerable to water scarcity. In an IGB Dossier, IGB researchers present options for action for policymakers, authorities and civil society.
PROFESSOR DR HANS-PETER GROSSART
DR SABINE HILT
PROFESSOR DR LUC DE MEESTER
DR THOMAS MEHNER
PROFESSOR DR MICHAEL MONAGHAN
DR CAMILLE MUSSEAU
DR STEPHANIE SPAHR
DR MATTHIAS STÖCK
DR SABINE WOLLRAB
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AUGUST Muhanad Al-Halak, Member of the German Bundestag and spokesman on water policy for the FDP parliamentary group, visited IGB for a background discussion and to learn about the man-made Oder River disaster, river regulation plans, and the need for action.
DR CHRISTIAN WOLTER
PROFESSOR DR SONJA JÄHNIG

NOVEMBER Members of the German Bundestag's Committee on the Environment visited the Oder River to learn about its current state. IGB researchers demonstrated the dangers posed by further waterway development of the river.
DR CHRISTIAN WOLTER
DR JÖRN GESSNER

EVENTS

APRIL At this year's Girls' and Boys' Day, boys were also invited to learn about the work of water researchers, including the use of drones for science, water analysis and sturgeon conservation.
NADJA NEUMANN

PHOTO: KONSTANTIN BÖRNER

JUNE The *BODDENHECHT* project presented the main results of four and a half years of pike research in the Bodden at the OZEANEUM in Stralsund. It was preceded by several stakeholder workshops.
PROFESSOR DR ROBERT ARLINGHAUS
IGB Bericht 33: BODDENHECHT

(German only)

JUNE During two evening walks in Berlin's Spreepark, colleagues from our *AuBe* project showed which animals can be found in the night sky – and how light pollution puts them at risk.
DR GREGOR KALINKAT

JULY "Experience water research!" was the motto of the open day at IGB's Lake Stechlin site. A varied programme attracted more than 250 guests, who had the opportunity to visit the LakeLab by boat.
NADJA NEUMANN

PHOTO: LUC DE MEESTER, IGB

SEPTEMBER During the open day at our main Berlin site, more than 600 visitors enjoyed informative talks, exhibitions and experiments. Aquariums were also on display.
ANGELINA TITTMANN

OCTOBER At the SPIEL ESSEN trade fair, IGB researchers presented the prototype of a board game on invasive species management. The game, called "Raccoon Rampage", shows that solutions to invasive species are not always simple.
PROFESSOR DR JONATHAN JESCHKE
DR SOPHIA KIMMIG

https://paidia.fun

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PHOTO: ALEXANDER SUKHODOLOV, IGB

OCTOBER German and Ukrainian researchers met at IGB to discuss the issue of "Water as a weapon during armed conflicts: the lessons of Ukraine". They summarised their findings on the effects of the Kakhovka dam breach and chemical contamination on ecosystems.
DR OLEKSANDRA SHUMILOVA
DR ALEXANDER SUKHODOLOV

PHOTO: STEFAN GLOEDE

OCTOBER The *Stadt, Land, Klima*. exhibition of the Brandenburg State Centre for Political Education is on show until June 2024, providing information on climate and climate change in Brandenburg. IGB contributed data and content on rivers, lakes and groundwater in the federal state.
ANGELINA TITTMANN

www.politische-bildung-brandenburg.de/ausstellungen/stadt-land-klima

PHOTO: ANGELINA TITTMANN, IGB

NOVEMBER Together with artist Francisca Rocha Gonçalves, IGB created an aquatic microbial cabinet for Berlin Science Week. For ten days, 11,000 visitors were able to immerse themselves in the world and soundscape of a drop of water and marvel at the diversity of microorganisms.
ANGELINA TITTMANN
NADJA NEUMANN

NOVEMBER What is the state of water on our planet? The recreation centre FEZ Berlin explored this question over two magical weekends. At two stations on riverine landscapes and aquaculture, young and old alike were able to discover what research is being carried out at IGB.
DR JÖRG LEWANDOWSKI
DR FABIAN SCHÄFER

DECEMBER Leading experts in metasystem ecology and knowledge visualisation met at IGB for a workshop to expand the *Hi Knowledge Atlas* that is currently under development and metasystem ecology.
DR SABINE WOLLRAB
PROFESSOR DR JONATHAN JESCHKE
DR TINA HEGER
https://hi-knowledge.org/

GUESTS

PHOTO: JANICE PAHL

MAY Together with Brandenburg's Environment Minister Axel Vogel and Dr Christiane Rohleder, State Secretary at the Federal Environment Ministry, researchers from IGB and the Mecklenburg-Western Pomerania State Research Institute for Agriculture and Fisheries released around 2,000 juvenile Baltic sturgeon into the Oder River as part of a reintroduction programme.
During a second event, a fourth-grade class from Lebus actively helped to release hundreds of sturgeon into the river. The young fish, which ranged in size from 10 to 60 centimetres, hold great promise for the conservation of the species.
DR JÖRN GESSNER
www.igb-berlin.de/en/news/baltic-sturgeon-stocked-after-environmental-disaster

PHOTO: BMUV / CHRISTOPH WEHRER

JUNE The German Federal Minister for the Environment, Steffi Lemke, visited IGB to find out about the interim results of the BMUV-funded special investigation programme into the environmental disaster on the Oder River, which attracted considerable media interest.
ANGELINA TITTMANN
www.igb-berlin.de/en/news/salt-discharges-must-be-reduced-and-river-development-stopped-regenerate-oder-river

AUGUST Students from the Cosmopolitan School at Lake Müggelsee, inspired by their visit to IGB and discussions with researchers, worked with artist Claudia van Hasselt and the *Trickmisch* team to produce short films on the subject of inland waterways. These were shown in an exhibition at the Akademie der Künste.
DR SVEN WÜRTZ

SEPTEMBER Berlin's State Secretary for Science, Dr Henry Marx, visited IGB and exchanged ideas with IGB Director Luc De Meester on cooperation in university teaching and integration into clusters of excellence and networks.
PROFESSOR DR LUC DE MEESTER

SEPTEMBER Around 60 staff members from the Berlin Senate Department for Urban Development, Building and Housing visited IGB for a lively dialogue with researchers on water quality and the water balance in the metropolis.
DR JÖRG LEWANDOWSKI

OCTOBER The Brazilian Academy of Sciences (ABC) and the National Academy of Sciences Leopoldina visited IGB to participate in the workshop "Sustainable Aquaculture – Impact on the Environment and Food Security".
PROFESSOR DR WERNER KLOAS

The most cited articles from 2022/2023 were

Carolli et al. (2023) Impacts of existing and planned hydropower dams on river fragmentation in the Balkan Region. Science of the Total Environment.
https://doi.org/10.1016/j.scitotenv.2023.161940

Liu et al. (2023) Crop residue return sustains global soil ecological stoichiometry balance. Global Change Biology.
https://doi.org/10.1111/gcb.16584

Manzi et al. (2023) Polystyrene nanoplastics differentially influence the outcome of infection by two microparasites of the host *Daphnia magna*. Philosophical Transactions of the Royal Society B-Biological Sciences.
https://doi.org/10.1098/rstb.2022.0013

Radinger et al. (2023) Ecosystem-based management outperforms species-focused stocking for enhancing fish populations. Science.
https://doi.org/10.1126/science.adf0895

Shumilova et al. (2023) Impact of the Russia-Ukraine armed conflict on water resources and water infrastructure. Nature Sustainability.
https://doi.org/10.1038/s41893-023-01068-x

Source: Web of Science (as of 28 February 2024), with IGB corresponding authorship

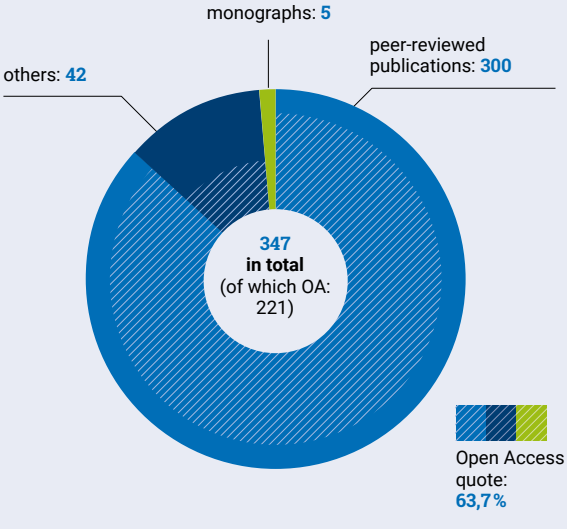
2023 in numbers

FINANCES

Overall budget	**€ 25,298,809**
Proportion of third-party funding*	**35 %**
Institutional funding from the federal government and the federal states	**€ 17,119,000**
of which core budget	€ 14,811,000
of which Leibniz Competition levy	€ 418,000
of which for major construction projects	€ 1,390,000
External grants**	**€ 7,826,909**
of which from the DFG	€ 2,261,848
of which from the EU/international	€ 2,537,494
of which from the federal government	€ 1,709,326
of which from the federal states	€ 236,696
of which from the Leibniz Competition	€ 301,948
of which from other public funding	€ 152,663
of which from foundations	€ 512,432
of which from non-public funding	€ 114,502
Other earnings (incl. DFG lump sums)	**€ 352,900**
Externally managed funds	**€ 529,909**

* related to the core budget
** on an earnings basis (status as of 31 December 2023)

PUBLICATIONS



INTERNATIONALITY

48.95 %
scientists

5.79 %
science supporting staff

Scientific highlights:
www.igb-berlin.de/en/selected-publications

JANA RUMLER
library@igb-berlin.de

INSTITUTE MEMBERS*

143
scientists including
37 leading scientists
54 postdoctoral scientists
30 doctoral candidates

121
science supporting staff
including
3 apprentices
26 student assistants

24
scholarship holders
including
6 postdoctoral scientists
16 doctoral candidates

118
guests
including
32 postdoctoral scientists
17 doctoral candidates

406
in total

BY SEX

Scientists:

41.96 %
women

57.35 %
men

0.70 %
diverse

Science supporting staff:

61.86 %
women

38.14 %
men

0 %
diverse

BY FUNDING

Scientists:

40.95 %
funded from core budget

59.05 %
externally funded

Science supporting staff:

87.20 %
funded from core budget

12.80 %
externally funded

To find more about working at IGB, take a look at our website
www.igb-berlin.de/en/career

DEGREES & CO.

8
Bachelor theses

13
Diplom and Master's theses

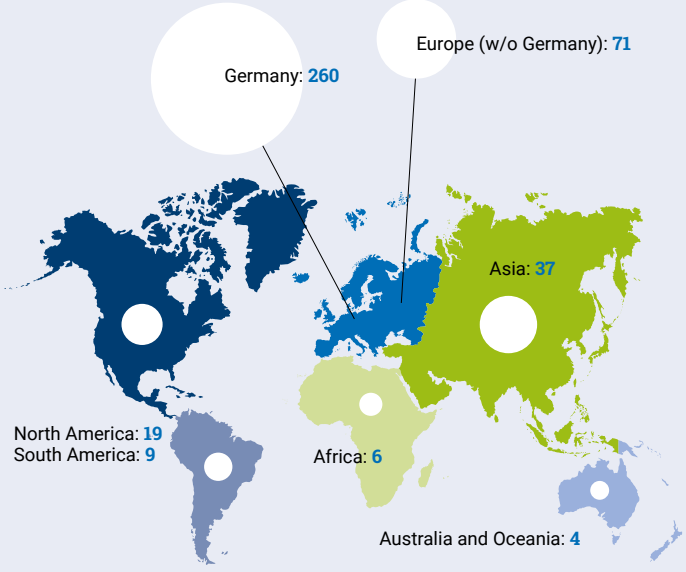
10
dissertations

PROFESSORSHIPS

10
joint professorships with
4 universities

2
honorary professorships with
2 universities

ORIGIN OF THE INSTITUTE MEMBERS*



* per capita

STATUS AS OF 31 DECEMBER 2023

Structure

Always up-to-date on our website:
www.igb-berlin.de/en/organisation

STATUS AS OF 31. DECEMBER 2023

Scientific Advisory Board

Chair
Bernhard Wehrli

Management

Director
Luc De Meester

Vice Director
Thomas Mehner

Managing Director in the Forschungsverbund Berlin e.V.
Nicole Münnich

Staff units

Science Officer
Ina Severin

Communications and Knowledge Transfer
Angelina Tittmann

Career Development
Kirsten Pohlmann

Administration

Head of Administration: Gwendolyn Billig

Procurement, Finance, Personnell
Gwendolyn Billig

Library
Jana Rumler

Information Technology
Christian Baal

Technical Services
Bernd Schubert

Research departments

1 Ecohydrology and Biogeochemistry
Dörthe Tetzlaff

2 Community and Ecosystem Ecology
Sonja Jähnig

3 Plankton and Microbial Ecology
Mark Gessner

4 Fish Biology, Fisheries and Aquaculture
Jens Krause
Werner Kloas

5 Evolutionary and Integrative Ecology
Jonathan Jeschke

Programme areas

PA 1 Aquatic Biodiversity in the Anthropocene	Justyna Wolinska | Franz Hölker
PA 2 Aquatic Ecosystem Services and Sustainability	Martin Pusch | Markus Venohr
PA 3 Dimensions of Complexity of Aquatic Systems	Stephanie Spahr | Tobias Goldhammer

Representatives

Ombudsperson
Sami Domisch and Sabine Wollrab (deputy)

Equal Opportunities Officer
Kirsten Pohlmann and Justyna Wolinska (deputy)

Diversity Officer
Hossein Masigol

Disability Representative
Georg Staaks

Works Council
Wibke Kleiner (chair)

Data Protection Coordinator
Christian Baal

Animal Welfare Officer
Nadja Neumann

All members of the works council, and the representatives of doctoral students and postdocs on our website:
www.igb-berlin.de/en/organisation

Imprint

The annual research report of IGB gives you an insight into the research work and structure of our institute. For more information, please visit our website or contact us directly at:

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LinkedIn: www.linkedin.com/company/leibniz-igb

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FRESHWATER NEWS

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Leibniz Forschungsverbund Berlin e.V.

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