IGB
Leibniz Institute of Freshwater Ecology and Inland Fisheries

The big kill
A chronicle of an environmental disaster on the River Oder

Contagious behaviour
Social conformity in animals and humans

Vegetation in water
Mass developments of algae and aquatic plants

ANNUAL RESEARCH REPORT 2022

One year of freshwater research

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Research for the future of our freshwaters

Research for the future of our freshwaters

Through innovative research on the structure and functioning of freshwaters, their biodiversity, ecosystem services and responses to global change, we make a relevant contribution to a better understanding of these ecosystems and to sustainable freshwater management.

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 2022. They are allocated to our three new programme areas, each containing a variety 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!

Aquatic Biodiversity in the Anthropocene

Aquatic Ecosystem Services and Sustainability

Dimensions of Complexity of Aquatic Systems

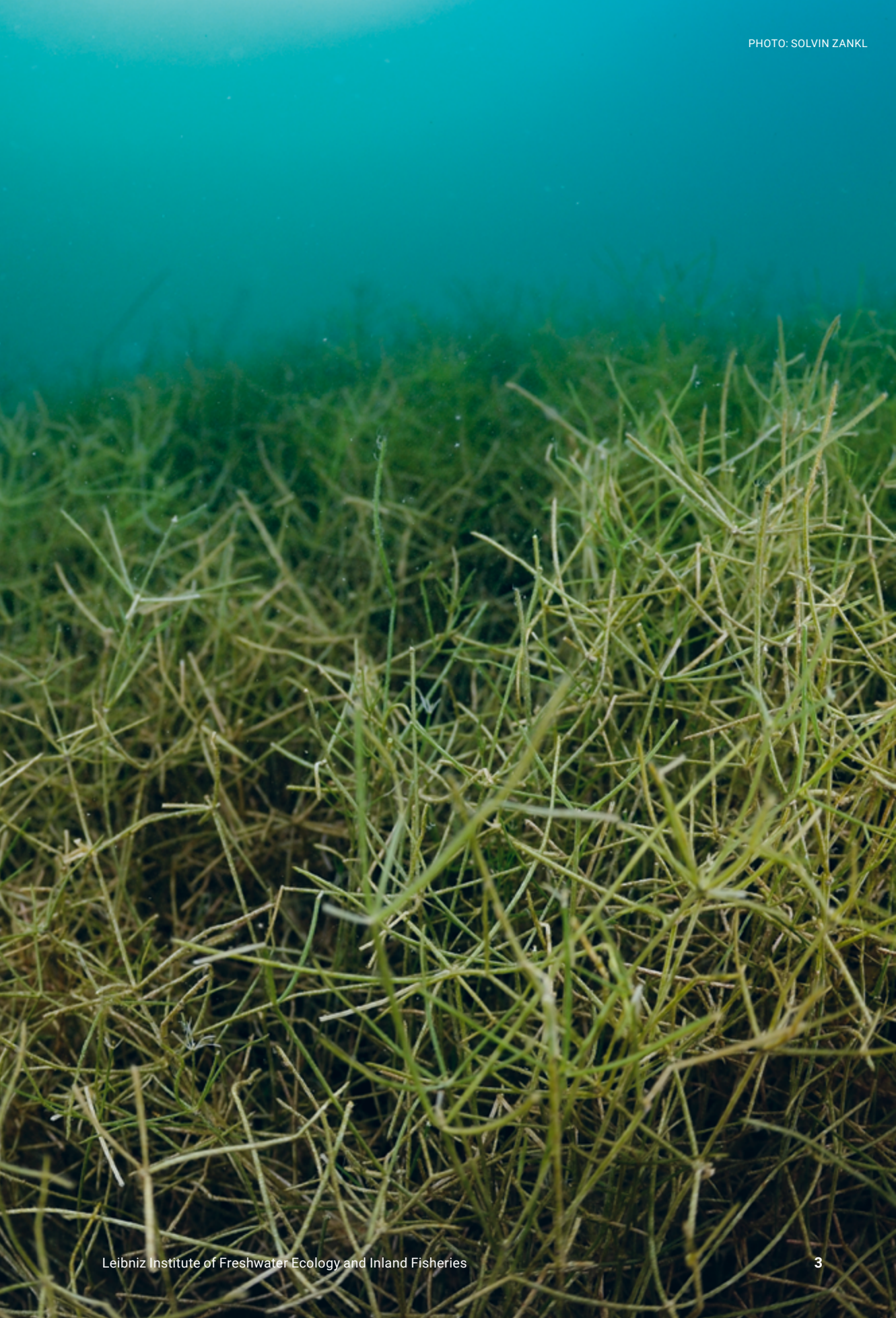

PHOTO: SOLVIN ZANKL

Dear Reader


PHOTO: DAVID AUSSERHOFER/IGB

It is impossible to reflect on 2022 without thinking about the war in Ukraine. A human drama. And an environmental one as well, not only because of direct damage to the environment and water resources, but also because the world lost momentum in the fight against climate change. Military action and energy crises have interfered with our goal to slow down global warming. And yet the world was hit badly by climate change in 2022, by heat waves and prolonged drought, on a scale that Europe – as yet little affected by environmental disasters – has rarely witnessed. Freshwater systems, be it rivers, lakes, ponds or marshlands, suffered considerably, even up to the point of drying out. The massive fish kill in the River Oder was also linked to the high temperatures and low water levels experienced in August, which, in combination with pollution from salt discharges, led to a bloom of a toxin-producing alga. IGB was actively engaged in identifying the causes and communicating the findings. The consequences of this disaster and extreme drought will affect biodiversity for many years to come.

Indeed, biodiversity is rapidly declining, and although the biodiversity and nature crisis is having a major impact, it receives less attention than the climate crisis. In this context, the outcome of the UN Biodiversity Conference (COP15) offers a glimmer of hope, given its ambition to protect at least 30 per cent of the world's lands, inland waters, coastal areas and oceans, and especially areas of importance for biodiversity.

Inspired by our mission to combine scientific excellence and societal relevance, IGB launched its new programme areas this year, focusing on biodiversity research, sustainability and an understanding of the mechanisms that determine the structure and functioning of freshwater ecosystems. We are also driving the development of a truly predictive ecology in the context of global change. It is intrinsically complex to predict how ecosystems and their biota will respond to human-induced disturbances. My vision for IGB is to develop an integrated approach that can grasp this complexity. It is very much needed.

On the following pages, we outline some of our results from 2022. Besides enhancing our understanding of responses to global change, our efforts contribute to the goals of sustainability. Our achievements would not have been possible without the close cooperation of many partners and stakeholders who supported and inspired our research, teaching and transfer activities. Thank you for your continued support!

Yours

Luc De Meester
Director

Contents

Social conformity in animals and humans
Page 14

Mass developments of algae and aquatic plants
Page 26

A chronicle of an environmental disaster on the River Oder
Page 42

News

Inside news

In November, IGB established new programme areas in which we pool our entire research. As incubators for creative ideas and approaches, these programme areas foster interdisciplinary research within IGB and with national and international partners. Societal challenges of growing relevance to which we as an institute feel strongly committed played a major role in the selection of topics: issues on how to better protect aquatic biodiversity, what consequences can be expected from the progressive loss of biodiversity, or how water-based ecosystems and resources can be used and managed more sustainably in the Anthropocene.

www.igb-berlin.de/en/our-programme-areas

An ultrafine network for rivers

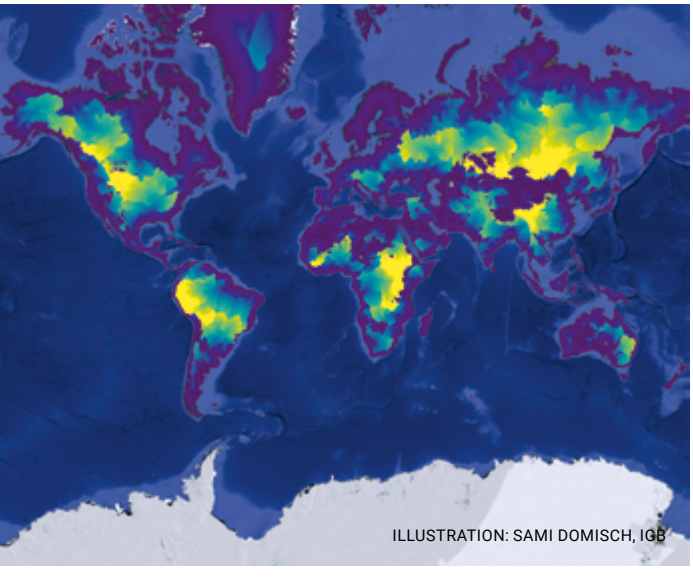

ILLUSTRATION: SAMI DOMISCH, IGB

How are freshwater biodiversity and the characteristics of running waters related on our planet? This question is being addressed by a team at IGB. The researchers have developed the highest-resolution map of the world's river systems ever produced. The "Hydrography90m" data set, which the researchers created on the supercomputer at the renowned Yale University, comprises a total of 726 million potential river sections. The team is currently modelling discharges to identify which of those rivers actually carry water – either throughout the year or intermittently. To do this, they use data from around 30,000 gauging stations worldwide.

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https://hydrography.org

Unusual reproduction

Native to Asia, the Prussian carp or Gibel carp (*Carassius gibelio*) is a close relative of the goldfish. It competes with endangered native species in Europe and is considered one of the most successful invasive fish species. In particular, its ability to reproduce asexually gives it an advantage over competing fish such as Crucian carp. Prussian carps occur only as females and engage in sperm parasitism: foreign sperm trigger only the development of its clonal eggs. An international research team involving IGB has succeeded in completely decoding the genome of the Prussian carp. This should help us better understand this mechanism of unisexual reproduction.

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Kuhl et al. (2022). Equilibrated evolution of the mixed auto-/allopolyploid haplotype-resolved genome of the invasive hexaploid Prussian carp. Nature Communications, 13, 4092. http://dx.doi.org/10.1038/s41467-022-31515-w

ILLUSTRATION: FABIAN OSWALD

PHOTO: SLAWEK CERBIN

Warm lakes

Caullerya mesnili is a common gut parasite that frequently infects water fleas. It was only two years ago that researchers succeeded in placing it within a class of protists through genomic analyses. Now, a research team comprising scientists from IGB and Adam Mickiewicz University (AMU, in Poznań, PL) set out to find out how rising temperatures affect the incidence of infection. To simulate global warming, they used a number of lakes in Poland that have experienced discharges of cooling water from coal-fired power plants for 60 years, causing an average increase in water temperature of 3 to 4 °C compared to other lakes in the area. The tentative good news: the experiments did not prove that warming generally leads to a faster spread of such an epidemic. Instead, the host and parasite thermal ecology determines how this interaction will change in a warming world.

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Lu et al. (2022). Revisiting the phylogenetic position of Caullerya mesnili (Ichthyosporea), a common Daphnia parasite, based on 22 protein-coding genes. Molecular Phylogenetics and Evolution, 151, 106891. https://doi.org/10.1016/j.ympev.2020.106891

A game to explore career paths in ecology

It is not easy to find a career path that matches your own interests, preferences and skills. Researchers from IGB, Freie Universität Berlin and Humboldt-Universität zu Berlin know this feeling, and set out to find solutions. The result is an applied card game for ecology and related disciplines. The "Ecologist's Career Compass" helps students and professionals to discover the diversity of career paths in the environmental job market. The game is available as an appendix to a peer-reviewed open access publication, and can be downloaded for free.

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Itescu et al. (2022). The Ecologist's Career Compass: a game to explore career paths. Ecology and Evolution. 12(9), Article e9259. https://doi.org/10.1002/ece3.9259

PHOTO: ANGELINA TITTMANN/IGB

Phosphorus recycling

PHOTO: LENA HEINRICH, IGB

Phosphorus is an important raw material, especially as a fertiliser for agriculture. But in water bodies, it deteriorates the water quality. Since the 1980s, phosphorus is therefore bound with salts in the sewage sludge of wastewater treatment plants. However, since this raw material is becoming increasingly scarce worldwide, there are plans for it to be better recovered. This can be achieved, for example, if it is present in bound form as vivianite. IGB researchers have investigated which factors promote the formation of vivianite and thus increase the amount of recoverable phosphorus: they found that high iron content promotes vivianite formation, whereas high sulphur content reduces its formation. The issue is important to aquatic ecologists because ferrous precipitants are also candidates for restoring eutrophic lakes, i.e. lakes contaminated with nutrients such as phosphorus.

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Heinrich et al. (2022). Formation of vivianite in digested sludge and its controlling factors in municipal wastewater treatment. Science of the Total Environment, 854, Article 158663. http://dx.doi.org/10.1016/j.scitotenv.2022.158663

Nitrogen retention in wetlands and floodplains

Wetlands and floodplains can serve as buffer zones to reduce the nitrate load of water bodies, as an IGB study in cooperation with the Helmholtz Centre for Environmental Research (UFZ) has recently shown. The study investigates how nitrates – a nutrient that pollutes soils, groundwater and surface waters – are distributed spatially and temporally in the environment. To do this, the scientists combined a mathematical model with field data from a typical catchment area in the northeastern German lowlands. They were also able to determine that nitrate pollution from agriculture is likely to remain a problem as a result of climate change, because nitrate degrades less during drought. Measures to reduce nitrogen sources in the upper catchment areas of water bodies had a particularly large-scale effect.

Intact or restored floodplains are important for nitrogen retention, too, as another international research team involving IGB showed using the Danube as an example. For the first time, modelling carried out at this scale proves that large-scale restoration of river floodplains has a positive effect on water quality.

PHOTO: JGGRZ/3471 ON PIXABAY

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Yang et al. (2022). Functional multi-scale integration of agricultural nitrogen-budgets into catchment water quality modeling. Geophysical Research Letters, 49(4), Article e2021GL096833. http://dx.doi.org/10.1029/2021GL096833

Wu et al. (2022). Disentangling the influence of landscape characteristics, hydroclimatic variability and land management on surface water NO3-N dynamics: spatially distributed modeling over 30 yr in a lowland mixed land use catchment. Water Resources Research, 58(2), Article. e2021WR030566. http://dx.doi.org/10.1029/2021WR030566

Tschikof et al. (2022). The potential of large floodplains to remove nitrate in river basins: the Danube case. Science of the Total Environment, 843, Article 156879. http://dx.doi.org/10.1016/j.scitotenv.2022.156879

Microbes with a special taste

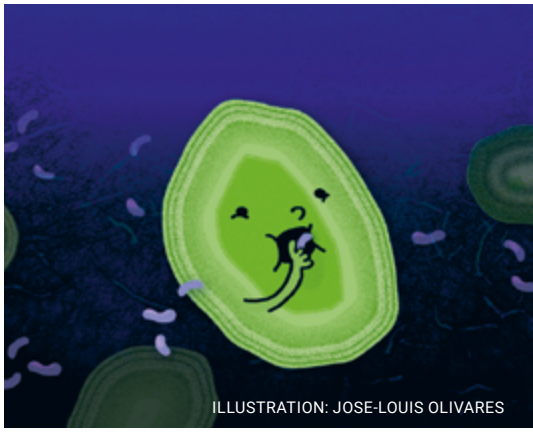

ILLUSTRATION: JOSE-LOUIS OLIVARES

One of the smallest and mightiest organisms on the planet is a plant-like bacterium known to marine biologists as *Prochlorococcus*. This green microbe measures less than a micron across. It grows through photosynthesis, using sunlight to convert the atmosphere's carbon dioxide into organic carbon molecules. It was long thought that this microbe relies solely on photosynthesis, but it may after all get as much as one-third of its carbon through a second strategy: an international research team led by the Massachusetts Institute of Technology (MIT) has shown that *Prochlorococcus* consumes the remains of other dead microbes. This allows the bacterium to survive in the deeper, dark zones of the ocean where there is no sunlight. This new estimate may have implications for climate models, given that the microbe is a significant force in capturing and "fixing" carbon in the Earth's atmosphere and oceans.

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Muñoz-Marín et al. (2022). Mixotrophy in depth. Nat Microbiol, 7, 1949–1950. https://doi.org/10.1038/s41564-022-01251-4

The blue planet

How new methods of remote sensing provide information on the state of water bodies

6 questions put to 6 experts

The view from above changes our perspective – also on water bodies. The greater the distance, the more visible some climate-related or water ecology problems become. With this in mind, IGB researchers are increasingly making use of remote sensing techniques. Satellite images hold enormous potential. After all, the colour of the water allows us to draw conclusions about the degree to which rivers or lakes are contaminated with nutrients, or the speed at which algal blooms are spreading. We asked IGB researchers about the methods they use, the findings they have generated, and the opportunities and limitations of remote sensing in inland waters.

PHOTO: NASA/UNSPLASH

PROFESSOR RITA ADRIAN (EMERITUS)

Ms Adrian, in one of your studies you used satellite images of 344 lakes from across the world, some of which appeared more blue, and others more green. What is the significance of these colour differences?

Green usually means that a lot of chlorophyll is being produced. Chlorophyll is a natural pigment produced by organisms that perform photosynthesis. In water, for example, such organisms are algae and cyanobacteria. We use satellite data to estimate parameters such as the water temperature and chlorophyll-*a* concentration of the lakes we study. This data allows us to analyse the relationship between the lake surface temperature and the chlorophyll-*a* concentration, and how algae concentrations in these waters have changed over the years. In one of our studies, for example, we found that a lake's nutrient concentration has a major impact on how rising temperatures affect the chlorophyll-*a* concentration. Lakes low in nutrients and algae, which often appear blue in satellite images, are likely to become less productive as global warming progresses. The reason is the warming-induced prolongation of stable thermal stratification. The phytoplankton lack nutrients, the algal biomass decreases, and the lake becomes even "bluer". In nutrient-rich, "green" lakes it is different: due to stratification, they are likely to become more productive – and even greener. Here, too, higher temperatures lead to longer thermal stratification. This in turn results in a loss of oxygen in the deep water, which favours internal fertilisation from the sediment. This further increases eutrophication, and therefore algal biomass.

DR IGOR OGASHAWARA

Mr Ogashawara, you focus on sensors on satellites so that images can be better used for water monitoring in the future. What are the biggest technical hurdles, and what developments can we expect to see?

For example, there is a lack of an efficient way to reduce atmospheric effects in the image data. Atmospheric correction is particularly challenging for inland waters because the optical signal in the water column and also in the surrounding areas of the aquatic system is complex. We tackle this issue within the GEO AquaWatch network. Just recently, we were able to define a product family specification that specifies the requirements for the atmospheric correction processors to retrieve aquatic reflectance from satellite imagery. Another challenge is the lack of match-up data, which is essential for earth-observation calibration and validation activities. This is why collaboration between limnology and remote sensing communities is so promising for the development of new products. We are also hopeful that remote sensing technology will constantly evolve: New hyperspectral satellite sensors such as in the Environmental Mapping and Analysis Program (EnMAP) – a German mission launched in April 2022 – will enable us to monitor even more water quality variables from space. In addition, a global coordination point was launched in 2022: the GEO AquaWatch Node on Calibration and Validation, hosted by IGB. We can therefore expect to have new, harmonised and better validated remote sensing-based products for monitoring water systems in the near future.

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DR JENS C. NEJSTGAARD

Mr Jens Nejstgaard, what other methods are useful or perhaps even necessary to match data from satellites or drones with the actual state of the water bodies?

The possibilities of artificial intelligence and imaging technologies in particular have developed rapidly over the last two decades. It used to take experts hours or even days to analyse a single preserved sample of organisms in the laboratory. Now, new automatic video techniques allow us to observe living organisms directly in their complex ecosystems in a matter of minutes. To exploit this opportunity to even greater effect, research groups at IGB and around the world are developing such automated systems. These systems will fundamentally change the way we observe what is going on in all kinds of water bodies. In both freshwater and marine research, the combination of *in-situ* probe measurements and image-based technologies is becoming a key tool that enables precise real-time data to be linked with remote sensing data, facilitating prediction. First results support our hypothesis: Combining these techniques has great potential to extend our abilities to observe and understand our environment in time and space – especially when carefully calibrated, as is the case in our mesocosm experiments, for example using the IGB LakeLab.

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DR ANDREAS JECHOW

Mr Jechow, not only daytime images are relevant. You are more interested in the night side of the globe, where you encounter a completely different ecological problem. What is it about?

We are indeed interested in the night, and above all artificial light. Human traces on earth are particularly visible at night. Generally speaking, where there are people, there is light. Since humans often settle close to water bodies, aquatic ecosystems are more affected by light pollution than terrestrial ones. Earth observation satellites and measurements by aircraft or drones help us quantify the extent of light pollution. Unfortunately, satellite systems that operate at night are not nearly as sophisticated as earth observation systems that operate during the day. There is basically only one satellite that provides daily information for the entire planet, but only monochromatically in the visible spectral range and with a coarse spatial resolution of 750 metres. With this data set, IGB researchers together with an international team were able to show that light pollution is increasing by more than 2 per cent per year, i.e. exponentially. High-resolution multispectral data is only available sporadically, for example from a number of cities taken by astronauts from the International Space Station (ISS) using digital cameras. This data requires considerable post-processing effort. What we need is a mature multispectral satellite system that reliably delivers high-resolution and freely available data of the whole earth, even at night.

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DR SABINE WOLLRAB

DR STELLA A. BERGER

Ms Wollrab, you are investigating how river-connected lakes react to nutrient inputs or extreme weather events – two phenomena that will become more important in the wake of climate change. What do satellite images tell you?

We are observing worldwide how water levels and runoff regimes of freshwater systems are impacted by changes in precipitation and land use patterns. For example, nutrients that originate from agriculture and are flushed into water bodies by heavy rainfall events accumulate along river systems. We are interested in the role played by lakes connected to such river systems. There are very few studies on this, most of which are based on data with low temporal and spatial resolution. We use images from Sentinel-2 satellites, which pass over our study area in the North German Plain every two to three days. Thanks to the high spatial and temporal resolution, we can observe how algal blooms develop and spread in a regional context. We can see, for example, that upstream nutrient inputs lead to an increased development of phytoplankton downstream. How intense this algal bloom is and how far and fast it spreads along river-connected lake chains depends on the flow regime and the lake characteristics, i.e. their volume and depth, which determine the residence time of the water.

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Ms Berger, how can you draw concrete conclusions on algal blooms and their development from remote sensing data?

To be able to use data from remote sensing to estimate chlorophyll content, satellite images of inland waters must be atmospherically corrected due to the influence of the surrounding environment, the bottom of the water body and nutrient levels. We match this remote sensing data with our data from coordinated sampling and laboratory analysis in combination with *in-situ* monitoring data from automated multiparameter probes in the water bodies under investigation. Together, these methods provide a solid framework for the early detection of potential algal blooms and their spread. However, algae in deeper water layers, which form a so-called deep chlorophyll maximum, cannot be detected by current remote sensing technology. Our research therefore also aims to obtain even more detailed information about the composition of phytoplankton. Besides chlorophyll, we would like to use other algae pigments as indicators of blue-green algal blooms. In combination with multiparameter networks, targeted sampling and image-based plankton analysis, remote sensing can make it easier for us to distinguish between different algal groups in the future, enabling us to detect potentially toxic phytoplankton blooms at an earlier stage.

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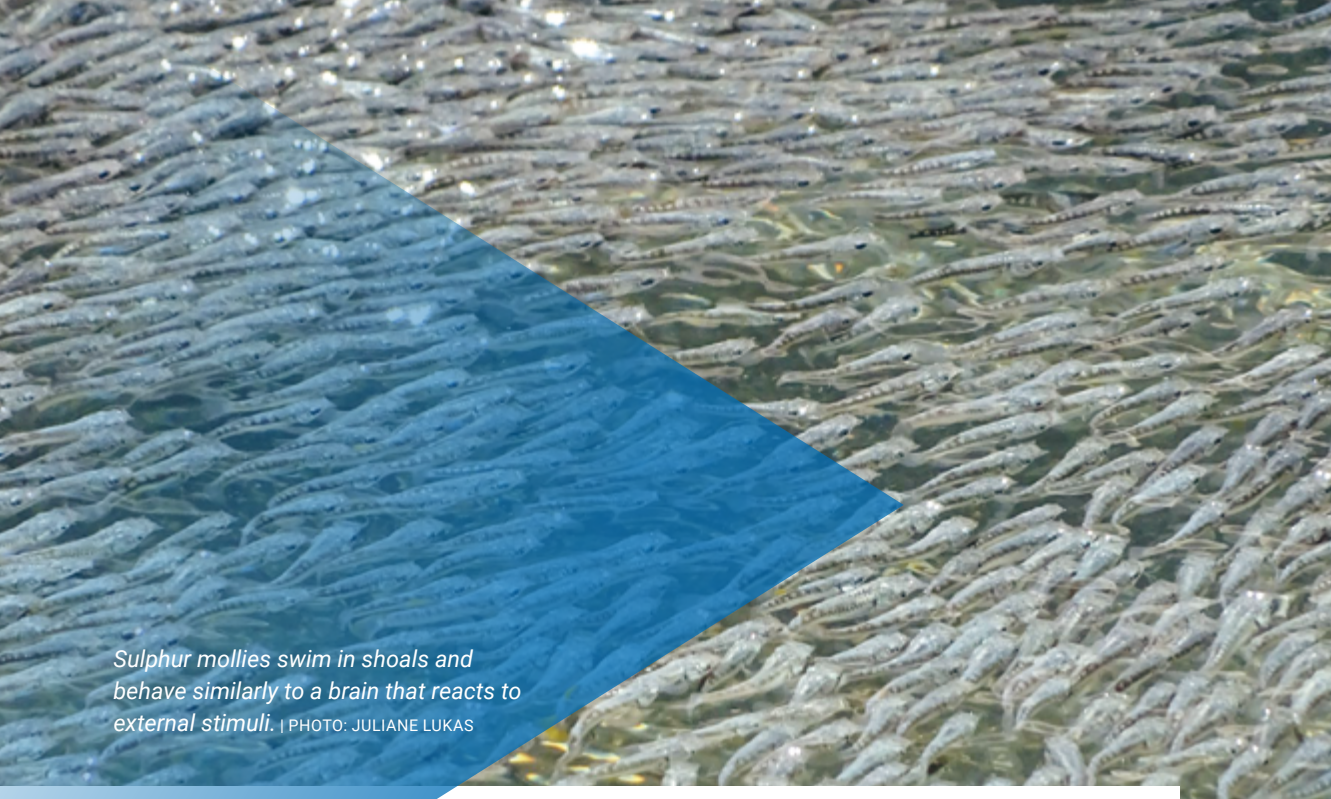
PHOTOS: DAVID AUSSERHOFER/IGB (4), PRIVATE (2)

Find out more at www.igb-berlin.de:
- Lakes worldwide are becoming greener, but large lakes bluer
- Calibrating and validating satellite data for aquatic research

- www.aquacosm.eu
- https://waterforce.eu
- www.geoaquawatch.org

Kraemer et al. (2022). Worldwide moderate-resolution mapping of lake surface chl-a reveals variable responses to global change (1997–2020). PLOS Water 1(10): e0000051. https://doi.org/10.1371/journal.pwat.0000051

Siqueira et al. (2022). Product Family Specification Aquatic Reflectance (CARD4L-AR). v.1, Committee on Earth Observation Satellites (CEOS).

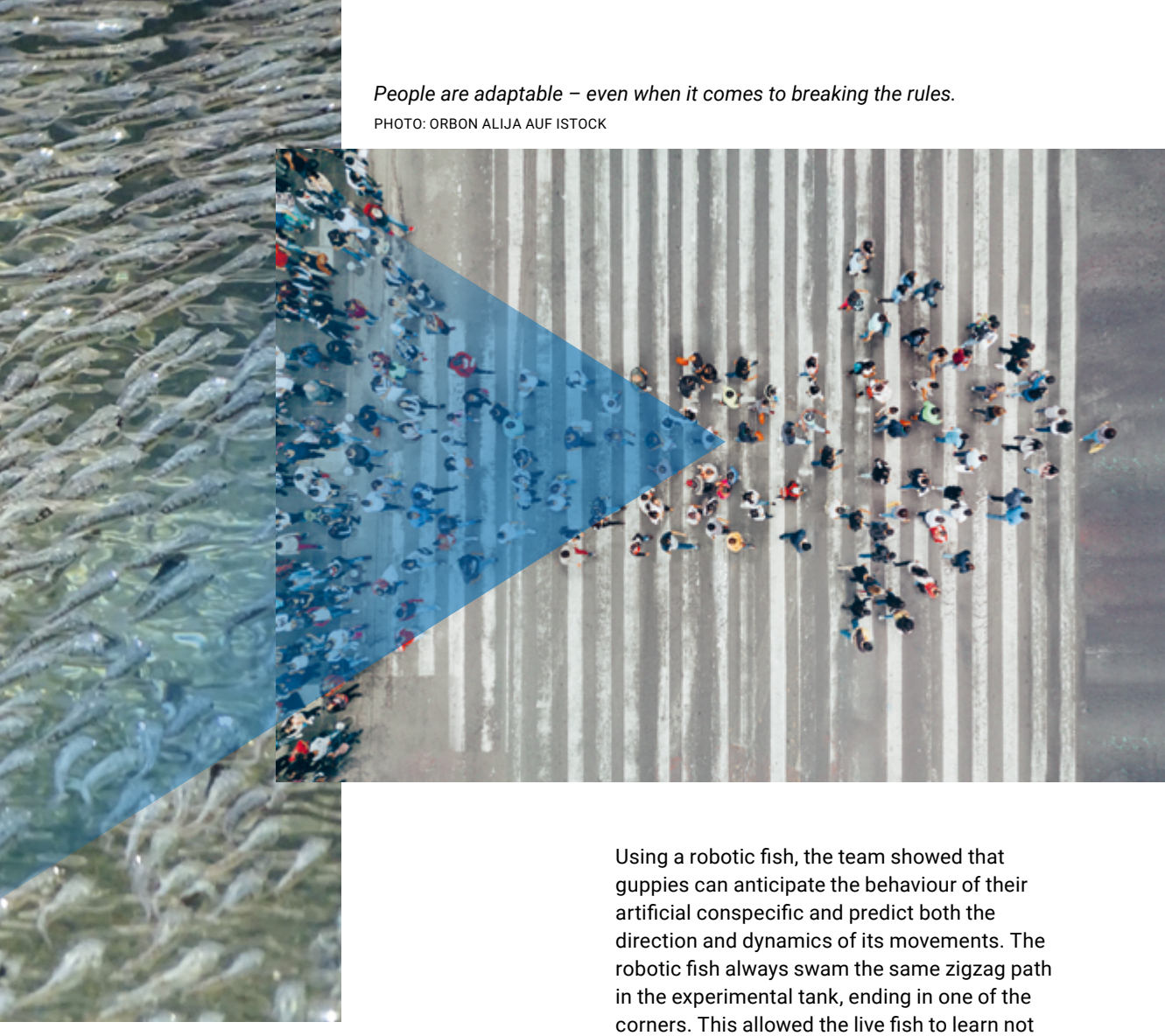


Sulphur mollies swim in shoals and behave similarly to a brain that reacts to external stimuli. | PHOTO: JULIANE LUKAS

Contagious behaviour

Social conformity in animals and humans can be useful, but also dangerous

Animal behavioural research is fascinating, not least because it reveals information about how we humans interact with each other as social beings. Behavioural biologists at IGB are deeply involved in exploring the ways in which communities, such as shoals of fish, make decisions and the factors that influence individuality. Current research shows that behaviour can be “contagious”. It also reveals the role that anticipation plays in collective decision-making – and that even genetically identical individuals raised under the same conditions can develop different character traits.

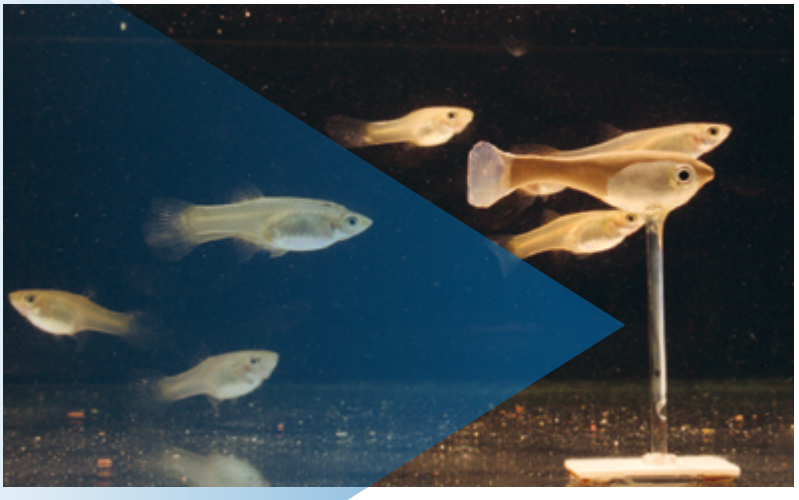


People are adaptable – even when it comes to breaking the rules.
PHOTO: ORBON ALIJA AUF ISTOCK

People are social beings, as are many animal species – fish, for example. Fish are the focus of several research projects at IGB. After all, schools of fish are ideal for studying certain properties of biological systems. Let us take the example of the rapid spread of information: How do fish manage to move synchronously in water, even when the direction of movement changes? This question was investigated by a team comprising IGB's research group Mechanisms and Functions of Group-Living and researchers from the "Science of Intelligence" Cluster of Excellence at Humboldt-Universität zu Berlin (HU). The researchers were able to prove that fish can anticipate the actions of their conspecifics.

Using a robotic fish, the team showed that guppies can anticipate the behaviour of their artificial conspecific and predict both the direction and dynamics of its movements. The robotic fish always swam the same zigzag path in the experimental tank, ending in one of the corners. This allowed the live fish to learn not only the location of the final target, but also the specific turns of the robot in three consecutive trials: in the third experimental run, they reached the target corner of the robotic fish significantly earlier than the robotic fish itself. "The results show that fish are able to anticipate the behaviour of social partners and even get better at it with training. So this is another explanation for why fish in a school – which know each other well – are capable of extremely fast collective movements," concluded David Bierbach.

By doing so, the researchers drew a parallel to humans: we know from studies that professionals in ball sports can predict the flight curve or impact location of the ball even before it is thrown or kicked by interpreting various signs such as their fellow players' postures or body movements. And, in fact, they are able to do this



Using a robotic fish, researchers showed that guppies can anticipate the behaviour of their artificial conspecific and predict both the direction and dynamics of its movements.
PHOTO: DAVID BIERBACH

much more effectively than amateurs. Although humans possess an inherent ability to anticipate, this skill can be improved with training and practice.

OPTIMAL INFORMATION PROPAGATION PROTECTS AGAINST PREDATORS

A similar issue was addressed by a team led by HU researcher Luis Gómez-Nava, which also included David Bierbach and Jens Krause. "The study was about whether biological systems reach the state of criticality under certain conditions. This state is characterised by factors such as the optimal spread of information," explained Jens Krause. To be able to explore this issue, the researchers need a large number of individuals in a small space. They found this condition in a pond in Mexico that is home to swarms of sulphur mollies (*Poecilia sulphuraria*). "We observed up to 4,000 individuals per square metre, equating to a population of around half a million fish in the entire pond," reported Jens Krause. In order to breathe, this fish species usually dwells at the water surface, where, however, they risk being attacked by birds. When a bird approaches or attacks, the fish react by diving down collectively, each fish touching the water surface with its tail. The researchers measured the size and propagation of these excitation waves and then fed the field data into a model. The model results confirmed that, in certain phases of high excitability, there is indeed optimal information propagation and, consequently, criticality of the biological system under investigation. The IGB researcher explained that the results cannot be transferred directly to humans, but: "In principle, I think it is conceivable that excitation waves can also spread quickly and widely in large crowds of people."

Next, the researchers hope to determine at what times such states of optimal information exchange exist. "Our assumption is that maximum excitability occurs in particular when the fish's predators are active," remarked Jens Krause. But this could also be influenced by other factors, such as temperature: in hot weather, the fish need greater energy to dive down into the water, meaning that they may then be less willing to do so.

COLLECTIVE RULE-BREAKING IN ANIMALS AND HUMANS

These findings also tie in with recent insights into collective rule-breaking, a topic that Jens Krause has published in a review study together

with Marcel Brass, Einstein Professor of Social Intelligence at HU Berlin. “For example, we stop at a red light because everyone else does so, and we might cross the road even if the light is red because others are doing the same,” stated Jens Krause, describing a situation in which collective rule-breaking follows collective compliance with rules – both being an expression of social conformity.

From the cognitive side, three processes are particularly important in this respect: distraction, imitation and change of evaluation. “By distraction we mean that individual attention is drawn from the rule to the reaction of others. The group influences perception and directs attention in a particular way. Such influence can inform the individual’s decision to act in accordance with the group,” explained Jens Krause. If we cross a red light because others are doing so, we may be distracted by the group to such an extent that we ignore the light.

> “As soon as a certain number, or a certain percentage, of individuals show a certain behaviour, it is quickly adopted by others.”
>
> **Professor Jens Krause**

Imitation effects describe the phenomenon that people do certain things because others are also doing them. It is a motor-cognitive mechanism that happens unconsciously and automatically, whereby the “contagiousness” of rule-breaking increases with group size. “Then there is change of evaluation: we reinterpret the situation based on the behaviour of the group,“ stated Marcel Brass. Two effects are involved here: people perceive a conflict with the group as negative and, on the other hand, experience it as positive when they act together with the group. “As far as negative affect is concerned, research has shown that a different opinion from that of the group triggers a conflict signal in the brain, the dimension of which predicts the extent to which people subsequently change their minds,” the psychologist explained.

Amazon mollies are natural clones of their mother, and therefore genetically identical. A perfect model for twin studies.
PHOTO: DAVID BIERBACH

VIOLENCE AS A RESULT OF GROUP DYNAMICS

Such behavioural changes reflected real changes in evaluation, according to current research findings. We are not just pretending to make a different decision, we are actually adjusting our decision-making basis for our actions. This can be problematic: “Current scientific consensus

is that situational group dynamics are at least necessary and sometimes even sufficient for the outbreak of violence," reported Jens Krause.

These mechanisms are similar in animals. As in humans, the decision-making dynamics of groups of animals often run non-linearly via quorums: "As soon as a certain number, or a certain percentage, of individuals show a certain behaviour, it is quickly adopted by others," explained Jens Krause. Even with animals, group behaviour occurs that actually signifies a disadvantage or even a danger to the individual. The study with the robotic fish, for example, shows that a school of fish can indeed be led into the vicinity of a predator by the leader and the group behaviour induced by him – a dangerous situation that an individual fish would not normally enter. So fish in a pond and people at traffic lights are not all that dissimilar at times, the IGB researcher concluded.

INDIVIDUALITY IS MORE THAN JUST A MATTER OF GENES AND LIVING CONDITIONS

Whether collectivity or conformity, the importance of individuality continues unaffected, and is even reinforced. As such, a team involving David Bierbach and led by IGB researcher Max Wolf was able to show for the first time that genetically identical individuals already differ in their character traits on the first day of life and that these early character differences significantly shape the animals' behaviour into adulthood.

The researchers studied the behaviour of the Amazon molly (*Poecilia formosa*). These fish naturally reproduce clonally. The offspring are therefore copies of the mother, meaning that they are genetically identical. Moreover, these fish are live-bearing, and no brood care is involved. This meant that the team around Max Wolf was able to keep newly born Amazon mollies under identical conditions from day one and record their behaviour using a high-resolution tracking system. It was found that strong behavioural individualities are already present on the first day after birth. For example, the fish differ systematically in their activity patterns. These differences in individual behavioural patterns persisted throughout the ten weeks of the experiment and even gradually increased. "This is the first experimental evidence that individuality in later life can be strongly shaped by prenatal factors, such as nourishment in the womb, epigenetics and pre-birth developmental stochasticity," concluded David Bierbach. Higher organisms can therefore act in a way that is very much in conformity with the group – while remaining highly individual.

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

- Why Mexican fish swim the Mexican wave
- Fish schools work a bit like the brain
- Experimental twin research: Personality differences from day one after birth despite identical genes and identical environment
- Collective rule-breaking
- Here's why the swarm is so fast: its individuals anticipate what the others will do

Bierbach et al. (2022). Live fish learn to anticipate the movement of a fish-like robot. Bioinspiration & Biomimetics, 17(6), Article 065007. https://dx.doi.org/10.1088/1748-3190/ac8e3e

Laskowski et al. (2022). The emergence and development of behavioral individuality in clonal fish. Nature Communications. 13, Article 6419. http://dx.doi.org/10.1038/s41467-022-34113-y

Doran et al. (2022). Fish waves as emergent collective antipredator behaviour. Current Biology, 32(3), 708-714.e4. http://dx.doi.org/10.1016/j.cub.2021.11.068

Krause et al. (2021). Collective rule-breaking. Trends in Cognitive Sciences, 25(12). https://doi.org/10.1016/j.tics.2021.08.003

PHOTO: IGB

Protecting fungi

Millions of species of fungi occur in all types of water bodies – in small puddles, large inland lakes, and even in ice and snow. Although most of them cannot be seen with the naked eye, they make up a large part of biodiversity in all ecosystems. They form the basis of every food web and make a major contribution to the functions of an ecosystem, such as by remineralising organic matter, keeping nutrients and other compounds in the production cycle. Especially in larger bodies of water, fungi play an important role in the so-called “carbon pump”. By ensuring that organic matter sinks to the depths of the water body, aquatic fungi make sure that other organisms get the food they need. They also help to break down pollutants. Nevertheless, the great kingdom of fungi leads a shadowy existence. Besides being threatened by pollutants such as fungicides that are washed into the water, fungi are probably also affected by habitat degradation, e.g. missing macrophytes, invasive species and climate change. All of this can have a negative impact on fungal biomass and diversity, disrupting essential functions, which can cause further cascading effects. To help protect fungi, researchers therefore recommend bioassays and improved monitoring. There is also an urgent need to add key fungal species to the list of organisms to be protected. However, this will not be easy, given that fungi are still one of the least investigated groups of organisms in water bodies.

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- Protecting fungi
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Water bodies with no water

What happens when rivers, lakes and groundwater decline?

7 questions put to 7 experts

Dry banks in place of water, trickles instead of torrents. In the wake of climate change, water bodies are declining. The resulting increase in water shortages and longer periods of drought are causing historic low levels in water bodies. Some have even dried up completely. Researchers at IGB are investigating what exactly this means for humans and ecosystems, and what adaptation measures should be undertaken.

PHOTO: 1902396049/SHUTTERSTOCK

PROFESSOR SONJA JÄHNIG

Ms Jähnig, you keep an eye on river networks, and their status and biodiversity. What dramatic developments have occurred in terms of water loss in recent years?

Sixty per cent of the world's flowing waters dry up temporarily, and the figure is growing. This is not fundamentally a problem. After all, it is natural for sections of many rivers to dry up from time to time. Resilience in river ecosystems requires that organisms survive in the face of highly dynamic hydrological and geomorphological changes. We know that disturbance events such as floods and droughts shape life-history traits in species that enhance resilience. We conducted a study to investigate the factors that promote resilience in river ecosystems. The answer is the 3 Rs – resources, recruitment and refuges. By recruitment we mean that communities are able to re-establish after a disturbance. In addition to the local species pool and the dispersal abilities of the species, this also depends to a large extent on connectivity in the river network. Species can indeed adapt to disturbances. However, they must have the possibility to disperse and recolonise. This cannot be achieved if rivers are fragmented by instream barriers, if sections dry up more frequently, and if habitats become increasingly homogeneous.

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DR MATTHIAS STÖCK

Amphibians are among the most threatened species. Mr Stöck, to what extent is this phenomenon also related to water bodies and drought?

Amphibians face complex threats and are affected by ongoing population declines worldwide. Anthropogenic causes such as industrial agriculture, habitat destruction, invasive species, pesticides, land use changes, infectious diseases and climate change are among the greatest threats. In Central Europe, increasing drought is also causing them problems. First of all, most European amphibian species, i.e. frogs and Caudata, often only visit water bodies to reproduce, spending the rest of the year in more or less moist terrestrial habitats. Some amphibian species have adapted to such temporary spawning ponds in the course of evolution; today, they usually only reproduce in man-made habitats, such as gravel or clay pits. Ephemeral waters have the advantage that when they dry up, predators of tadpoles and newt larvae, such as fish and dragonfly larvae, do not settle there at all, or simply disappear. Amphibian Red List updates in Germany clearly show that amphibian species that prefer temporary water bodies have suffered severe population declines. The loss of dynamic riverine landscapes is one reason for their decline; heat and drought are another. It is not just smaller water bodies that are drying up longer and more severely. The lowering of groundwater levels and the sharp decline in soil moisture in the upper layers also have a major impact on all amphibians.

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DR THOMAS MEHNER

Sure, fish need water, too. But at what point are water levels insufficient, Mr Mehner?

Well, there are species that may actually benefit from changes in water bodies, such as warmer temperatures. Many cyprinid (carp-like) species, for example. They originally evolved in warmer parts of Europe and Asia. Other species need cold and oxygen-rich water as their habitat. Examples include vendace and many salmonid species, which often occur in deep lakes. The global warming of lakes is a threat to these species. In small water bodies, however, the situation is particularly worrying. Of course, no fish can survive in ponds and ditches that have dried up completely. But even if there is any water left at the bottom of these small water bodies, this remaining water heats up very quickly, oxygen levels fall, and nutrient and pollutant concentrations increase, severely reducing the chances of survival of all aquatic animals, including fish.

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> "Besides drought, there is also the other extreme – heavy rainfall events. Rain can wash pollutants from roads, houses or fields into water bodies. Preventing this is a challenge."
>
> **Dr Stephanie Spahr**

PROFESSOR HANS-PETER GROSSART

Mr Grossart, you recently quantified how much methane is released by sections of water bodies that are drying out. What was the outcome?

Greenhouse gases such as methane and carbon dioxide are produced when microorganisms break down organic substances from dead plants or dead animal tissue. If this happens under oxygen deficiency, mainly methane is produced, otherwise primarily carbon dioxide is formed following respiration processes. Most methane is released directly from the sediment when the water body starts to dry up and when the areas are rewetted by heavy rainfall – referred to as first flush events. According to our projections, dry inland waters emit 2.7 million tonnes of methane per year, and emissions will continue to increase with the expected rise in temperature. The type of water body and the climate zone have less impact on the amount of greenhouse gases released, especially methane. The decisive influencing factors are the content of organic matter at the bottom of the water body in interaction with the local temperature and humidity. Global warming in combination with the ongoing eutrophication of water bodies will therefore certainly fuel emissions, which in turn will accelerate global warming. This cycle can only be broken by taking targeted policy measures.

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DR STEPHANIE SPAHR

In dry summer months, rivers in urban areas are largely fed by treated wastewater. Examples in Berlin are the Panke and the Erpe. What does this shift mean for tomorrow's wastewater and stormwater treatment, Ms Spahr?

Trace organic contaminants such as pharmaceuticals, cleaning agents and pesticides are continuously discharged into rivers in wastewater treatment plant effluent. During drought, the concentrations of certain chemicals in surface waters may increase because there is little dilution by groundwater or rainwater. This shows that we need improved wastewater treatment in the future, e.g. using activated carbon or oxidation processes. Besides drought, there is also the other extreme – heavy rainfall events. Rain can wash pollutants from roads, houses or fields into water bodies. Preventing this is a challenge. But we have visions of a sponge city, where stormwater is not directly discharged, but retained in the landscape – even in an urban context – and, ideally, purified. Stormwater needs to be perceived much more widely as a valuable resource. To remove substances such as biocides, flame retardants and tyre wear from stormwater runoff, I study treatment processes using biochar, for example. This has proven to be an inexpensive and effective method. For Berlin and many other cities, I would like to see climate-adapted wastewater and stormwater management that always considers water quality so as to feed and protect groundwater and our many surface waters.

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DR MARKUS VENOHR

When water bodies run out of water, what does this mean for water use and contaminants, Mr Venohr?

Many human-induced changes of land use and landscape cause discharges to our freshwaters, polluting them in different ways. Nutrients such as nitrogen and phosphorus, but also many trace organic compounds, which Stephanie Spahr mentioned, are the main inputs. The altered water balance due to climate change plays a major role here. During dry periods, inputs from agricultural land generally decrease, but discharges from wastewater treatment plants often remain unchanged. When runoff is low, less water is available in the water bodies to dilute the inputs, resulting in increased concentrations. The growing number of heavy precipitation events causes additional problems, especially after prolonged dry periods. In this case, dry soils cannot absorb the precipitation effectively, and more water runs off at the surface. This can cause increased nutrient loads in surface waters near agricultural land and in urban areas. Even the same nutrient concentrations can have much stronger eutrophication effects with lower discharges and the associated longer residence times and higher water temperatures. Under today's low water conditions, the maximum effluent concentrations from wastewater treatment may have to be reviewed and adjusted, and substance discharges may need be more strictly regulated.

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PROFESSOR DÖRTHE TETZLAFF

Ms Tetzlaff, groundwater is an invisible water resource for surface waters. How can be ensured that more water reaches deep layers and is available there?

Declining water levels are not only related directly to rising temperatures and higher evaporation. Secondary effects, such as the increased extraction of groundwater for irrigation or drinking water production, also play a role. Many water bodies – in particular in the region of Brandenburg – are fed by groundwater. The problem with groundwater is that it gets replenished by precipitation with a considerable time lag. In the Demnitz Mill Creek, a sub-catchment of the River Spree in Brandenburg, for example, we were able to show that it takes up to four years of average precipitation until groundwater levels reach their normal level again and reserves are replenished. 2022 was also an extremely dry year: many small rivers dried up completely between June and December, which is also a visible sign of excessively low groundwater levels. However, measures can be taken to improve water flows to groundwater: the targeted selection of vegetation and land management that avoids water-consuming monocultures, for example, facilitate transpiration and evaporation control. In addition, soil improvement measures help to increase the absorption and retention capacity of the landscape. Peatland restoration is also important, and even beavers can help us – by ensuring that water is retained in the landscape for longer periods, greater quantities of water reach the groundwater, taking longer to do so in the process.

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> “Declining water levels are not only related directly to rising temperatures and higher evaporation. Secondary effects, such as the increased extraction of groundwater for irrigation or drinking water production, also play a role.”
>
> **Professor Doerthe Tetzlaff**

PHOTOS: DAVID AUSSERHOFER/IGB (5), PRIVATE (1), ANDY KÜCHENMEISTER/IGB (1)

Find out more at www.igb-berlin.de:
- Freshwaters release methane – even when they dry out
- Diminishing habitats
- No water without freshwaters

Smith et al. (2022). Modelling temporal variability of in-situ soil water and vegetation isotopes reveals ecohydrological couplings in a willow plot. Biogeosciences. https://bg.copernicus.org/articles/19/2465/2022

Smith et al. (2022). Critical zone response times and water age relationships under variable catchment wetness states: insights using a tracer-aided ecohydrological model. Water Resources Research. https://doi.org/10.1029/2021WR030584

Wu et al. (2022). Tracer-aided identification of hydrological and biogeochemical controls on in-stream water quality in a riparian wetland. Water Research. https://doi.org/10.1016/j.watres.2022.118860

Kuhlemann et al. (2022). The imprint of hydroclimate, urbanization and catchment connectivity on the stable isotope dynamics of a large river in Berlin, Germany. Journal of Hydrology. https://doi.org/10.1016/j.jhydrol.2022.128335

Duethmann et al. (2022). Evaluating satellite-derived soil moisture data for improving the internal consistency of process-based ecohydrological modelling. Journal of Hydrology. https://doi.org/10.1016/j.jhydrol.2022.128462

In one of the experiments at the River Lab, IGB researchers visualised the turbulent wake downstream from a model patch of riparian vegetation with macro-plastic deposits at the front edge.

PHOTO: ALEXANDER SUKHODOLOV/IGB

The perfect mixture

IGB operates a River Lab at the Tagliamento, a river system in the Italian Alps. This area enables scientists to study how natural processes and mechanisms occur in a largely free-flowing river. This is important for developing effective river protection and management programmes. The River Lab serves as a platform for combining traditional fieldwork and laboratory research: using theoretical models, the researchers integrate physical laws that affect the fluvial system. The River Lab is then used to verify whether those theories fit. After all, the flow behaviour is sometimes different in nature to what might be expected from simple laboratory experiments. This is because rivers sometimes mix over very short distances, whereas at other confluences, the water masses remain unmixed for long stretches, for example where the Danube meets the Sava in Belgrade, Serbia. According to the findings of the IGB team, the length of time for which this interface remains stable depends to a great extent on the depth of the river in the area downstream of the confluence and to what extent flow velocity differs. Riverbed roughness also plays a key role: it can inhibit the lateral turbulence, preventing merging flows from mixing for many kilometres downstream.

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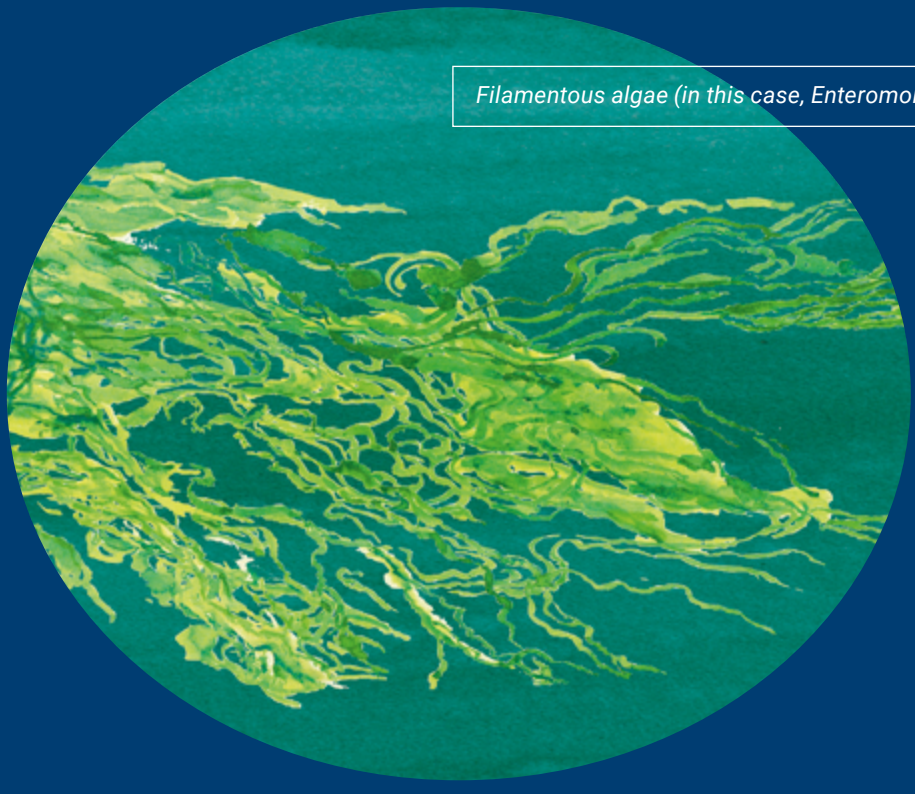
➔ "To researchers, this river is like a textbook"

Sukhodolov et al. (2023). Mixing dynamics at river confluences governed by intermodal behaviour. Nature Geoscience, 16(89–93). http://dx.doi.org/10.1038/s41561-022-01091-1



Filamentous algae (in this case, Enteromorpha)

Vegetation in water

Aquatic plants are essential to the ecosystem, but need good management

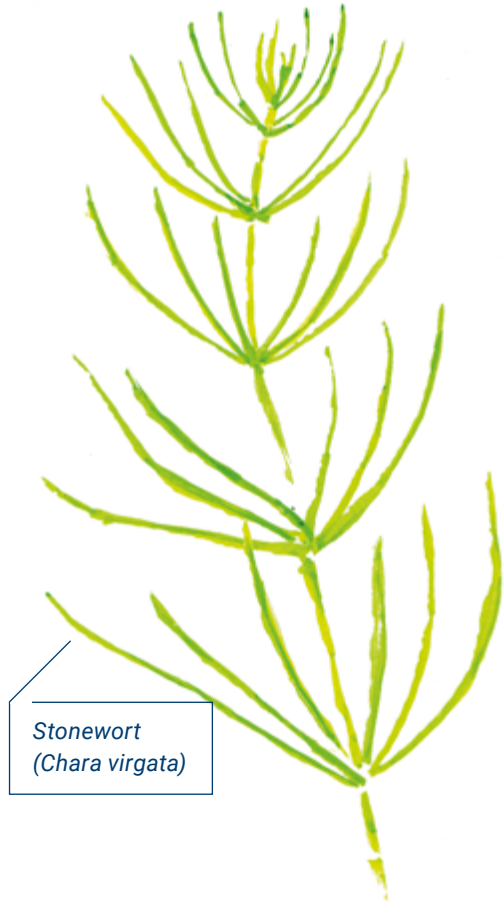
ILLUSTRATIONS: CHRISTIANE JOHN

Submerged macrophytes are declining in many shallow lakes around the world, with more algae and free-floating plants taking their place. But an opposite trend is also emerging: water bodies with improved water quality are increasingly experiencing a mass growth of aquatic plants. Given that these plants perform many important ecosystem functions, careful management is required.

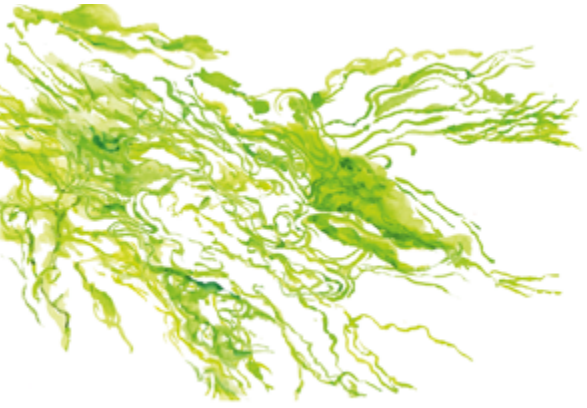
Macrophytes – large aquatic plants visible to the naked eye – are important habitats for a wide range of organisms and contribute to the self-purification of water bodies. If this type of vegetation disappears, leaving algae and floating plants to proliferate in water bodies, more greenhouse gases will be released. Sabine Hilt investigates why fewer submerged aquatic plants have grown in many water bodies in recent years. “It is known that both the growth of algae and the turbidity of the water play an important role in this process. After all, the plants, with roots in the sediment of the lake, need sunlight at those depths for photosynthesis. But other stressors also play a role,” explained the IGB researcher.

In agricultural landscapes, these stressors are, above all, various pesticides combined with nutrients. As part of a large team of scientists from France, UFZ Leipzig and LMU Munich, she investigated the effect of a cocktail comprising a herbicide, an insecticide, a fungicide and nitrate, as well as additional stress due to 3 to 4 °C warming, on aquatic plants and animals in the laboratory and in 600-litre mesocosms. Typical communities from shallow lakes of temperate zones were established in these mesocosms, including three typical submerged macrophyte species.

Hilt also explored a similar combination of typical stressors together with a team led by the Chinese Academy of Sciences in Wuhan. They investigated the individual and combined effect of warming, nutrients and the pesticide glyphosate on the growth of algae and two aquatic plant species. As examples, the researchers chose species that are typically found in Chinese waters such as water thyme (*Hydrilla verticillata*), which forms a canopy at the water surface, and vallisneria (*Vallisneria denseserrulata*), which grows at the bottom of water bodies. To simulate shallow lakes, they used 48 mesocosms, each with a water volume of 2,500 litres.



Stonewort (Chara virgata)



Filamentous algae (in this case, Enteromorpha)

Waterweed (Elodea)

The results of these two projects clearly show that the growth of aquatic plants is negatively affected, especially when several of the investigated stress factors come together. Continuous warming often enhanced the effect of the cocktail of pesticides and nutrients. Frequent heat waves have an even more damaging effect than continuous warming. There is therefore an increased risk of aquatic plants disappearing from shallow waters, especially in agricultural landscapes.

MASS ACCUMULATIONS OF FILAMENTOUS ALGAE IN CLEAR LAKES

Nutrients also constitute a stress factor that poses a threat to remote lakes that were previously clear, as another study involving IGB shows. Recently, an increased occurrence of filamentous algae blooms has been observed in such water bodies. This is an unusual phenomenon for nutrient-poor lakes – and a cause for concern: mass developments of filamentous algae can change the ecosystem profoundly and cause problems for water recreation. Filamentous algae, a collective term for various species of algae with a threadlike, filamentous shape, have higher nutrient requirements, especially for nitrate and ammonium. And indeed, nutrient inputs to several formerly clear, nutrient-poor lakes have increased in recent years. One example is Lake Baikal in Siberia – renowned for its unparalleled richness of animal and plant species. This biodiversity is threatened because the biomass of filamentous algae has increased fivefold in the last ten years. One reason could be nitrogen and phosphorus inputs from untreated human sewage discharged into the lake. Forest fires have also caused additional nutrient loading to the lake.

SHIFT IN PLANT TYPES IN WATER BODIES RESULTS IN HIGHER METHANE EMISSIONS

Less aquatic plant growth and more algae growth can also lead to the release of more greenhouse gases. This is demonstrated by another mesocosm experiment in the Netherlands, involving Sabine Hilt. The researchers studied the effect of 4 °C warming on the release of greenhouse gases from mesocosms used to simulate waters dominated by submerged plants, free-floating plants or algae for three consecutive years. The effect of warming on methane release was significantly higher in the mesocosms dominated by free-floating plants and algae than in those where submerged plants predominantly grew.

Perfoliate Pondweed (Potamogeton perfoliatus)

Cyanobacteria (in this case, Anabaena)

The expected shift in aquatic plant type toward a dominance of algae or free-floating plants under climate change will definitely increase the total amount of greenhouse gas emissions from shallow waters – a previously overlooked feedback that further fuels climate change. "Management strategies that focus on promoting the occurrence of submerged aquatic plants can therefore help to reduce greenhouse gas emissions from water bodies," remarked Sabine Hilt.

MASS DEVELOPMENTS OF AQUATIC PLANTS IN SUMMER

However, masses of aquatic plants can also be observed, especially in summer. This is when mass developments of aquatic plants occur in standing and flowing waters throughout Europe. The reason for this: "Macrophytes had disappeared for decades due to excessive nutrient inputs, and are now growing as water quality improves and nutrient inputs decline," explained Sabine Hilt.

Generally speaking, this is a positive development. "Aquatic plants are an important element of our water bodies. They influence nutrient cycles and interact with other aquatic organisms. As they grow, they bind carbon dioxide, which can then be stored in the sediment for longer periods. Macrophytes absorb excess nutrients such as phosphorus and nitrogen from the water body and release oxygen through metabolism, which improves water and sediment aeration," stated Jan Köhler, who conducts research on macrophytes and algae at IGB. Moreover, aquatic plants reduce turbidity and prevent sediment from being stirred up.

> "Weeding therefore poses risks to biodiversity, and can sometimes even cause a water body to change into a turbid, phytoplankton-dominated state that supports significantly fewer ecosystem functions and is less attractive for many forms of use."
>
> **Dr Sabine Hilt**

IGB Fact Sheet on the mass development of aquatic plants

Are these plants beneficial or harmful? And is there such a thing as "too much" of aquatic plants? To answer questions such as these, IGB scientists offer interested readers a brief, 7-page research-based overview. They explain how mass developments can occur – and also why their management requires a rethink by the public, authorities and water management.

Macrophyte stands also promote biodiversity due to their diverse structure: a species-rich growth of algae and bacteria can develop on their surface, which in turn provides habitat and food for small animals (zoobenthos). As well as providing shelter for small animals from predators, macrophytes are also food for various waterfowl. In addition, aquatic plant stocks are valuable spawning and hunting grounds for fish, offering areas of refuge for their larvae and juveniles.

From an aquatic ecological perspective, the benefits for nature often outweigh the disadvantages in most mass developments of macrophytes. The main disadvantages are related to human use: a dense growth of aquatic plants could, for example, interfere with boating and other water sports, hinder anglers or put off swimmers. Indirect usage or safety interests also play a role, especially in the case of flowing waters. Impoundment caused by macrophytes can reduce the outflow, raising the groundwater level on adjacent areas.

WATER-WEED REMOVAL POSES A RISK TO BIODIVERSITY

For authorities and other stakeholders involved in water management, it can be very challenging to address the trade-offs between protecting or achieving good ecological status on the one hand and various human use interests on the other, and to develop approaches that take into account and balance all objectives. If these stakeholders decide to take action against macrophytes, weeding, i.e. the mowing or removal of aquatic plants, is the most commonly chosen method.

Although weeding creates space for recreational use or increases the flow of ditches and natural flowing waters in the short term, the process is very expensive. In addition, after weeding, plant fragments may drift into previously unaffected areas and become established there, causing macrophyte stocks to spread. With some species, water-weed removal can even cause enhanced growth rates. Since weeding is not very selective, the process also quickly reduces rare plant species, destroys diverse habitats, and kills many creatures that live in aquatic plant stocks. These

measures can also lead to the stirring up of settled particles and increased oxygen depletion. "Weeding therefore poses risks to biodiversity, and can sometimes even cause a water body to change into a turbid, phytoplankton-dominated state that supports significantly fewer ecosystem functions and is less attractive for many forms of use," explained Sabine Hilt.

The ecological value of aquatic plants is often overlooked in the current public debate. With this in mind, economic, ecological and social aspects should be equally included in the analysis and planning of measures in the future. If it appears necessary to reduce aquatic plant stands, it would be preferable to take sustainable measures such as further reducing nutrient inputs or planting riparian trees.

A SUCCESS STORY: STONEWORTS RETURN TO LAKE MÜGGELSEE

Lake Müggelsee is a good example of recolonisation by aquatic plants. The stonewort has at last returned to this lake, following a long period of absence. As early as the end of the 19th century, nutrient inputs increased, and massive discharges from the 1970s onwards led to the virtual loss of submerged vegetation in the Müggelsee due to the resulting high levels of water turbidity. Aquatic plants only started to appear again slowly from the 1990s onwards, following a significant reduction in nutrient inputs. Since around 2011, turbidity in the Müggelsee has declined even further due to the influence of the quagga mussel, which has invaded the lake. Underwater flora is now present to a depth of 3-4 metres, forming very dense stocks in places, and there has also been a significant increase in species richness.

Stoneworts and other low-growing species were last sighted in the Müggelsee over a century ago. Now, after 20 years of intensive mapping and diving surveys, not just one but three of these desirable species of submerged vegetation have been detected: the fragile stonewort (Chara globularis), the starry stonewort (*Nitellopsis obtusa*) and another Nitella species (*Nitella spec.*). Stoneworts are not quite algae and not quite plants, but they are certainly a clear indicator of lower nutrient concentrations and cleaner waters. In addition to having all the aforementioned positive effects, they do not interfere with water recreation because they do not grow to the water surface. It remains to be seen whether they can establish larger populations over the next few years – we truly hope so.

> "Aquatic plants are an important element of our water bodies. They influence nutrient cycles and interact with other aquatic organisms."
>
> **Dr Sabine Hilt**

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- Back at last: stoneworts return to lake Müggelsee
- Climate change: More algae and fewer aquatic plants promote methane emissions
- Mass development of aquatic plants – natural phenomenon or serious problem?
- Blue waters – green beaches: benthic filamentous algae are an emerging threat to clear lakes worldwide
- MadMacs
- https://climshift.eu

Polst et al. (2022). Warming lowers critical thresholds for multiple stressor–induced shifts between aquatic primary producers. Science of the Total Environment, 838, 156511. http://dx.doi.org/10.1016/j.scitotenv.2022.156511

Zhang et al. (2022). Heat waves rather than continuous warming exacerbate impacts of nutrient loading and herbicides on aquatic ecosystems. Environment international, 168, Article 107478, http://dx.doi.org/10.1016/j.envint.2022.107478

Vijayaraj et al. (2022). Evaluating multiple stressor effects on benthic–pelagic freshwater communities in systems of different complexity: challenges in upscaling. Water, 14, 581. http://dx.doi.org/10.3390/w14040581

Harpenslager et al. (2022). Short-term effects of macrophyte removal on emission of CO2 and CH4 in shallow lakes. Aquatic Botany 182. http://dx.doi.org/10.1016/j.aquabot.2022.103555

Misteli et al. (2023). Short-term effects of macrophyte removal on aquatic biodiversity in rivers and lakes.- Journal of Environmental Management 325 (2023) 116442. https://doi.org/10.1016/j.jenvman.2022.116442

Thiemer et al. (2023). Drivers of perceived nuisance growth by aquatic plants.- Environmental Management. https://doi.org/10.1007/s00267-022-01781-x

White ice

Led by Sweden's Uppsala University, a research team involving IGB took samples of lake ice throughout the Northern Hemisphere in winter 2020/2021 – one of the warmest winters since 1880 – and examined its quality. They discovered that the lakes were predominantly covered by white ice during this period. White ice, which is less stable than black ice, forms when rain or melted snow freezes on the ice surface and melts again. This occurs especially when air temperatures fluctuate around freezing point. White ice could hence become even more common in the future. The researchers therefore suggest adapting the ice safety guidelines, because the differences in stability are enormous: black ice is about ten times more stable than white ice. The findings are also interesting from an ecological perspective. This is because white ice has a significantly higher reflectance than black ice, limiting the light conditions in the water. This threatens the growth and reproduction of all organisms that photosynthesise, which can disrupt or destroy the entire food web.

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➲ Watch out for white ice!

Weyhenmeyer et al. (2022). Towards critical white ice conditions in lakes under global warming. Nature Communications, 13 , Article 4974. http://dx.doi.org/10.1038/s41467-022-32633-1

PHOTO: ALEC FAVALE ON UNSPLASH

10 years of LakeLab

IGB's LakeLab in Lake Stechlin, containing "24 lakes within a lake", is globally unique. We use this large-scale research facility to investigate how lakes may change in the wake of global warming including extreme events, and also other aspects of global environmental change – such as light pollution, eutrophication, connectivity or browning. The facility celebrated its 10th anniversary in 2022. This year also marked the end of the first half of the permit to operate the LakeLab. Besides the aforementioned aspects, we intend to set a number of new priorities in the coming decade: more than before, we will rely on state-of-the-art approaches, such as remote sensing, high-resolution image analyses under field conditions, metagenome, metatranscriptome and other OMICS methods to characterise the many plankton organisms and their interactions and responses to environmental influences. We already use artificial intelligence for plankton image analysis, and will make increasing use of this method to assess large datasets of self-sustaining sensor systems. Furthermore, the LakeLab will serve as a test platform for instrument development, intercalibration and validation, for instance to compare sensor measurements with chemical analytical methods. Integrated into the newly established Competence and Technology Platforms (CTP) of IGB, the CTP LakeLab will enhance internal communication and expertise, promote international cooperation beyond the established European network of experimental facilities, and enable coordinated experiments.

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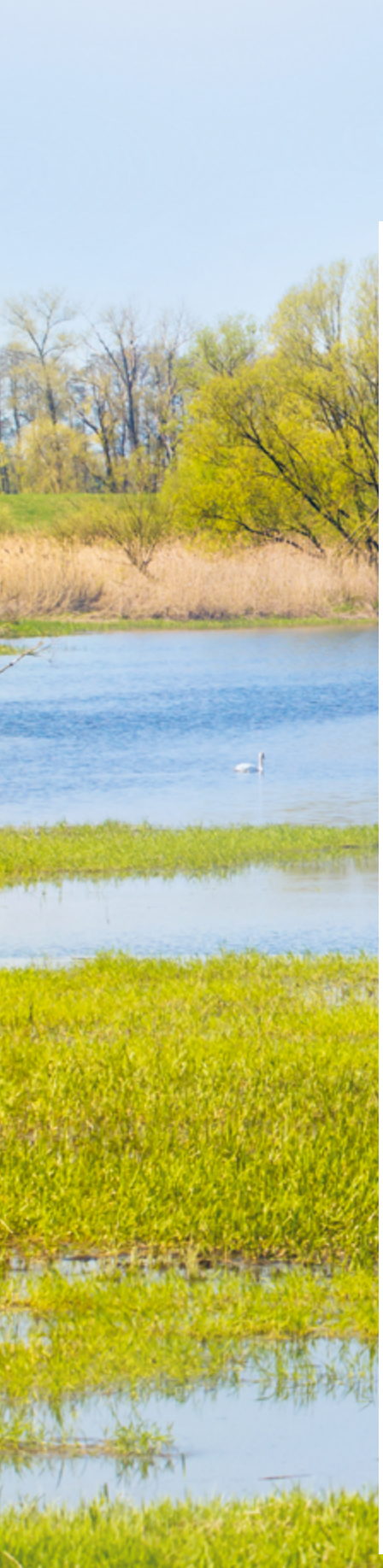
Find out more at www.igb-berlin.de:

- LakeLab
- "The LakeLab manages the balancing act between a high degree of realism and stringent experimental conditions"
- The IGB LakeLab: a decade of experimental aquatic research

PHOTO: CARMEN CILLERO/3EDATA



Back to nature?

Proper restoration of inland waters

8 questions put to 8 experts

Practically all water bodies have been impacted, if not clearly altered, by human use. And yet a near-natural water cycle, inland waters, diverse habitats and species communities are an indispensable basis of life for humans and nature alike. Many initiatives are currently being taken to restore peatlands, flowing waters and their floodplains, lakes and other stagnant waters. For example, the European Commission has initiated a Nature Restoration Law that aims, among other things, to restore more rivers in Europe to a free-flowing state. And the German Federal Environment Ministry's Climate Protection action programme is also designed to assist in the rewetting of peatlands and the establishment of a near-natural water balance. However, the restoration of aquatic ecosystems is a highly complex task. Researchers at IGB are exploring how best to go about this.

PHOTO: SHUTTERSTOCK 1073271503

DR TINA HEGER

Humans have greatly impacted the environment. Is it at all possible to reverse these changes, Ms Heger?

No, but that is not the point. In fact, there are virtually no places left in the world where truly untouched nature can be found. There are no primeval forests in Germany, unregulated flow conditions in Europe's rivers are almost non-existent, and anthropogenic climate change is affecting and altering all ecosystems throughout the world. Natural and man-made environments should therefore not be seen as polar opposites. All kinds of environmental states may exist between these two poles. An ecosystem in which humans intervene can be just as biologically diverse as a natural system, and in some cases it can even be more resilient – as successful restoration projects show. What we need, are new approaches to understand that everything we generally regard as "nature" has at some time been modified by humans, whether intentionally or not – and that this fact also implies a special responsibility. Contemporary restoration should therefore no longer have the stringent objective of restoring an environment to its "original state", because this is rarely possible. Restoration should rather be understood as a process that follows specific fixed principles, but is sufficiently flexible to take into account the prevailing conditions.

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PROFESSOR ROBERT ARLINGHAUS

One example of artificially created water bodies that are actually just a by-product of activities such as gravel or sand extraction are quarry ponds. How can these freshwaters be ecologically enhanced and their biodiversity promoted, Mr Arlinghaus?

As a matter of fact, this is a question we looked into in detail during our BAGGERSEE project. In our country, many quarry ponds are managed by angling clubs. These water bodies are usually nutrient-poor, with sandy unstable sediments and relatively steeply sloping banks. This is why the riparian zone, which is important for biodiversity, accounts for a small proportion of the total pond area in many quarry ponds. We teamed up with angling clubs to create shallow water zones at selected sites, and introduced bundles of deadwood, which can provide shelter and substrate for a variety of organisms. The shallow water zones are particularly conducive to increasing fish diversity; they also have multiple positive effects on other groups of organisms such as insect larvae and aquatic plants. Another important measure is the initial stocking of fish in quarry ponds, which is beneficial to fish species diversity. However, once a fish species community has become established, there is no need for fish stocking. At this stage, measures that enhance the structure of the riparian zone are then important for species richness.

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DR DOMINIK ZAK

DR MARTIN PUSCH

Restoration does not automatically mean leaving ecosystems to their own devices. Mr Zak, you are investigating how peatlands can be restored from agricultural land. What are your recommendations?

Intact or undrained peatlands provide habitat for many rare or endangered animal and plant species, and are important sinks for greenhouse gases and nutrients. It is therefore right and important to ensure the rewetting of former peatlands. But that alone does not immediately create a functioning peatland: due to past drainage, most of the soil has subsided and the upper peat layers have become mineralised. After rewetting, shallow lakes with an average depth of up to one metre are often formed. However, we have discovered that this process can cause large amounts of methane and nutrients to be released into the environment. In some cases, it therefore makes ecological sense to remove the highly mineralised topsoil before rewetting. In such places, the drainage ditches are filled in with part of the removed soil, causing the water level to rise again naturally. With this method, peatland-typical vegetation can develop again within a few years. Another option is gradual rewetting. This is recommended in places where the technical conditions allow different barrages to be set. However, there is no universal recommendation: parameters such as topography, size, soil degradation, runoff, groundwater levels and current land use should be taken into account when selecting the appropriate method.

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Mr Pusch, you focus on flowing waters and their floodplains. What are the positive effects of restoration, and what conditions must be met?

Riverine floodplains are some of the world's hotspots for biodiversity, plant productivity and biogeochemical nutrient turnover. We humans therefore benefit greatly from their ecosystem services. Unfortunately, around 80 per cent of Germany's rivers and floodplains have been significantly modified – for the benefit of a handful of uses, such as shipping and agriculture. This affects aspects such as biodiversity, self-purification from pollutants, resilience to climate change, and social recreational functions. At the start of the 21st century, we therefore began to shift flood protection barriers further back, enabling floodwater to spread out across larger floodplain areas and to prevent it from reaching disastrous levels. The floodplains reclaimed in this way are simultaneously valuable drinking water reservoirs and have other important regulatory functions, which is why they are also referred to as blue-green infrastructure. In two international flagship projects on behalf of the European Commission, we will investigate how river and floodplain restoration can be accelerated – for example, by involving local actors in the development and implementation of restoration projects. Other approaches include mitigating conflicts of interest by accounting for ecosystem services, or promoting business models based on the sustainable and extensive use of restored land.

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DR CHRISTIAN WOLTER

Nonetheless, in the face of drought and low water levels, artificial damming and regulation are still being mooted as potential solutions. Why is this the completely wrong approach, Mr Wolter?

Because it comes at the expense of the resilience of rivers to the effects of climate change. The straightening and regulation of watercourses lead to faster water runoff and sediment transport. Regulating structures and revetments prevent lateral erosion, making rivers deeper and draining the landscape even more during low flows. Although artificial damming holds back water locally to a limited extent, it fails to enhance natural processes in the river basin. Moreover, it promotes evaporation, retains sediments, which are lacking as habitat structures downstream. Consequently, phases of low water levels start earlier and last longer in regulated rivers – bringing drought to the entire river basin. This process must be stopped and reversed. To make rivers fit for climate change, such artificial interventions should therefore be dismantled as far as possible or, where this is genuinely not possible, made more ecologically compatible. Natural flood control and water retention processes in the landscape should be revitalised, and flooding zones and tributaries reactivated.

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> "Unfortunately, around 80 per cent of Germany's rivers and floodplains have been significantly modified – for the benefit of a handful of uses, such as shipping and agriculture. This affects aspects such as biodiversity, self-purification from pollutants, resilience to climate change, and social recreational functions."
>
> **Dr Martin Pusch**

ROSANNA WIEBE

Ms Wiebe, you address urban waters, which are particularly exposed to multiple stressors and influencing factors and are usually heavily modified. How can we bring about ecological improvements to heavily built-up inner-city watercourses?

It is easy to underestimate or overlook the ecological potential of heavily built-up water bodies because they differ so greatly from near-natural freshwaters. And yet these possibilities should be taken seriously and exploited – even if measures can only be implemented on a small scale. To achieve this, we must view water bodies in terms of their function as a habitat for aquatic organisms, and improve them accordingly. This includes creating the riparian structures and vegetation types that have disappeared from vertically stabilised banks, e.g. due to sheet piling. The vegetation belt at the water's edge is a key element for its aquatic community, because this is where fish, insects, birds and mammals find shelter, food and places to rear their broods – functions that sheet piling lacks. Moreover, exposed dark steel sheet piling heats up considerably on hot, sunny days, and transfers this heat to the water. This is why in the "Vertical Wetlands – Vegetated sheet pile as potential ecological areas along inner-city waterways" project we are investigating how a system of plant boxes on sheet piling can lead to an ecological improvement by artificially recreating elements of a natural bank. Our project partner, the WITE company, designed a planting system for this purpose, which is now being implemented on a Berlin waterway on a trial basis and scientifically monitored by IGB.

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DR THOMAS MEHNER

Small bodies of water are also often underestimated. Mr Mehner, how can ponds, pools and puddles be preserved, and why is it important do to so?

Small standing waters help to retain water in the area; they have a positive impact on the microclimate; they act as important areas of refuge and stepping stone biotopes for endangered species; and provide us with valuable recreational areas, especially in urban spaces. They are often fed by near-surface backwater that forms above impermeable, deeper soil layers, or by groundwater. Both sources make them particularly vulnerable to declining rainfall and groundwater levels in the surrounding landscape. Measures should therefore be taken to ensure the minimum ecological water requirements of small water bodies, such as large-scale percolation of rainwater and treated wastewater to retain water in the landscape. Moreover, these water bodies are located in landscape depressions, causing material flows to accumulate there. In intensive agriculture, fields are sometimes extended into the immediate riparian areas of water bodies. As a result, there are no buffer zones to protect against inputs of field sediments, fertilisers, herbicides, fungicides and insecticides. This must change, for example by providing adequately sized riparian buffer strips that act as a material barrier and reduce hazardous inputs to water bodies by means of retention or chemical transformation.

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DR JÖRN GESSNER

Mr Gessner, you have been working on the reintroduction of European and Baltic sturgeon into the Elbe and Oder rivers for more than two decades. In your experience, what are the obstacles involved when politically agreed restoration goals meet practical implementation on the ground?

The reintroduction of migratory fish populations or the restoration of ecologically functional habitats competes with a multitude of uses. This is particularly the case for large flowing waters. In the past, the objectives of river maintenance were determined by economic benefits, which contributed to the loss of biodiversity. Even today, the management of waterways continues to exhibit massive shortcomings and failures with regard to the implementation of the European Water Framework Directive (WFD) and the establishment of protected areas within the European Habitats Directive (HD). This policy also stems from a lack of prioritisation and harmonisation of various directives and strategies from different policy fields, which are often in direct conflict with each other's objectives. Consequently, vague goals are often included in environmental programmes, which means that there is no effective possibility of sanctions. In order to effectively tackle the biodiversity crisis and the consequences of climate change, it is no longer enough to simply regulate uses and interventions. There is an urgent need for integrative solutions that can, and in some cases must, also be accompanied by restrictions – for example on traffic use. If we want to give nature sufficient space to develop, enhance the resilience of ecosystems and also ensure that society benefits from these measures, we should give priority to the spatial coupling of water bodies and their floodplains, and the restoration of important habitats.

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PHOTOS: DAVID AUSSERHOFER/IGB (5), ANDY KÜCHENMEISTER/IGB (1), NADJA WOHLLEBEN (1), PRIVATE (1)

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

- Restoration of peatlands: Flooding is not the ideal solution
- Floodplains improve the water quality of rivers
- „Fatal risk from dammed rivers"
- Improving quarry ponds
- Ecological improvement of freshwater ecosystems benefits fish and people

Cyrus et al. (2022). Naturnahe Gestaltung von Uferzonen an Baggerseen. Chancen – Schwierigkeiten – Potentiale. Erfahrungen und Ergebnisse aus dem Forschungs- und Umsetzungsprojekt BAGGERSEE. Leibniz-Institut für Gewässerökologie und Binnenfischerei, Berlin.

Heger et al. (2022). Mapping and assessing the knowledge base of ecological restoration. Restauration Ecology. Early view. http://dx.doi.org/10.1111/rec.13676

Tschikof et al. (2022). The potential of large floodplains to remove nitrate in river basins: the Danube case. Science of the Total Environment, 843(2022), Article 156879. http://dx.doi.org/10.1016/j.scitotenv.2022.156879

Matern et al. (2022). Fish community composition in small lakes: The impact of lake genesis and fisheries management. Freshwater Biology, 67, 2130 – 2147. https://doi.org/10.1111/fwb.14001

Van Looy et al. (2022). River Resilience. In: Mehner, T. & Tockner, K. (Ed.) Encyclopedia of Inland Waters, 2nd Ed., Elsevier, Oxford: 412 – 423. https://doi.org/10.1002/rra.3396

Zak & McInnes (2022). A call for refining the peatland restoration strategy in Europe. Journal of Applied Ecology, 59(11). https://doi.org/10.1111/1365-2664.14261

Radinger et al. (2023). Ecosystem-based management outperforms species-focused stocking for enhancing fish populations. Science, 379, 6635. http://dx.doi.org/10.1126/science.adf0895

Flood protection with multiple benefits

Ecological flood control, i.e. measures that restore floodplains, is pertinent, technically feasible and economically efficient. And yet this approach is not consistently implemented worldwide because of complicated administrative and legal hurdles. This was shown in an international study with the participation of IGB. The researchers analysed four river-floodplain restoration projects in Germany and the USA that achieved major synergy effects between flood protection and the regeneration of ecosystems. So-called "multi-benefit projects" are planned in such a way that they achieve several improvements at the same time. Examples include reducing flood risk, restoring habitats and increasing resilience to climate change. Based on the four case studies, the researchers identified factors that can have a facilitating effect. These include obvious factors, such as the availability of undeveloped land, the integration of research knowledge into planning and decision-making processes, appropriate political and regulatory frameworks and sufficient funding. But societal factors are likewise essential, such as perceiving floods not only as a threat, but also as an essential feature of natural water bodies. Goal-oriented project management and constructive involvement and cooperation of all stakeholders also turned out to be crucial to the success of a project.

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Find out more at www.igb-berlin.de:
➔ Flood risk reduction with multiple benefits: more space for the river

Llobet et al. (2022). Restoring Rivers and Floodplains for Habitat and Flood Risk Reduction: Experiences in Multi-Benefit Floodplain Management From California and Germany. Front. Environ. Sci. 9:778568. https://doi.org/10.3389/fenvs.2021.778568

PHOTO: PHOTOGRAPHYBYMK/FOTOLIA

PHOTO: LUC DE MEESTER

The big kill

A chronicle of an environmental disaster on the River Oder

Images of huge quantities of dead fish – covering all species and sizes – shocked the German, Polish and international public in August 2022. Approximately 300 kilometres of river were affected; not only fish, but also mussels, snails and other molluscs perished in the River Oder. Was it a natural disaster? Or a chemical spill? IGB researchers, some with decades of experience in studying the border river, set about tracking down the causes. IGB was the first institution to determine that the disaster was definitely man-made.

PHOTO: NADJA WOHLLEBEN

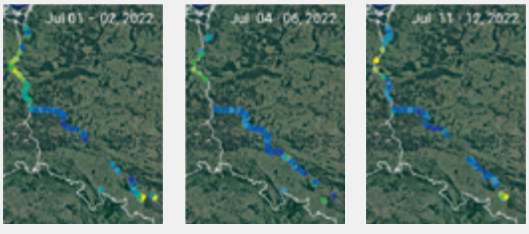
There was great consternation and unease among the public – initially, there was talk of mercury, solvents, pesticides and heavy metals. For this reason, IGB researchers immediately set about conducting their own, independent investigations. Their scientific detective work soon led them to the biological – but nevertheless man-made – cause. But let us first go back to the start of the disaster:

A DEADLY WAVE HITS THE RIVER ODER AND TWO OF IGB'S STURGEON-REARING FACILITIES

9 August 2022 A wave of dead fish reaches the border river. Before that – in late July – there had already been isolated incidents of fish mortality on Polish territory. In response, the municipality of Frankfurt/Oder warns its population not to come into contact with the Oder water or to eat fish from the river. Then everything happens very quickly: within just two weeks, hundreds of tonnes of dead fish are found floating on the river. More than 200 tonnes are recovered, and even greater quantities sink to the bottom or are washed up on the river banks. The creatures exhibit symptoms of suffocation.

10 August 2022 Baltic sturgeon that had been released into the river over the last three years – including more than 1,000 juvenile sturgeon from spring 2022 – also perished in the disaster. "It is impossible to make a reliable estimate of exactly how many of the sturgeon that had been released into the river have died," states IGB researcher Jörn Gessner. Some specimens, up to 90 cm long, are recovered dead from the Lower Oder Valley. Two fish-rearing facilities operated using water from the River Oder, which contained about 20,000 juvenile sturgeon, are also affected by the toxic wave. Virtually no sturgeon survives the incident. "The fish that perished were just one month old, and were supposed to be released into the River Oder in autumn 2022 to help establish a self-sustaining

The diagram shows 15 profiles of chlorophyll concentrations in the River Oder from July to August 2022, with the yellowish colour indicating particularly high chlorophyll levels. | © BROCKMANN CONSULT



stock of sturgeon there in the future," the biologist explains. The events represent the biggest setback for the reintroduction programme, which Gessner has been coordinating since 1996.

SUSPICION CONFIRMED: RESEARCHERS IDENTIFY THE BRACKISH WATER ALGA PRYMNESIUM PARVUM

15 August 2022 Data measured at the monitoring station in Frankfurt/Oder by the Brandenburg State Office for the Environment (LfU) reveal an unusual picture: "Oxygen levels were well above 100% saturation, and pH was elevated. At the same time, we noticed strong fluctuations over the course of the day," explains Jan Köhler, algae specialist at IGB. "Such dynamics can only be explained by photosynthesis. To us, this meant that we were dealing with a massive algal bloom." At first, the reason for the high electrical conductivity is unknown. The level increases from 800 to more than 2,000 micro-siemens per centimetre (µS/cm) – such high concentrations in a river can only occur as a result of industrial salt discharges.

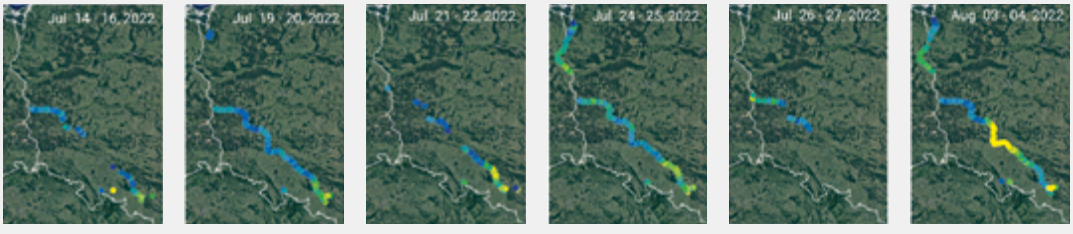
Researchers of IGB immediately start evaluating samples, measuring the algal pigment content and fitness, taking photos and preserving samples for genetic analysis. What they find is more than unusual for European freshwaters: large numbers of *Prymnesium parvum*, a brackwater alga. This species of algae is known to produce a strong toxin that attacks mucous membranes and thin blood vessels, and, in particular, to suffocate fish and molluscs. This alga has the potential to proliferate when there is abundant light, and when the river exhibits low flow velocities, warm water temperatures, and comparatively high salt and nutrient loads. The salt soon proves to be sodium chloride – common "table salt". It is quickly apparent that the discharges originate from Poland – but the specific company – or companies – responsible for the pollution are not identified.

19 August 2022 IGB detects and microscopically identifies *Prymnesium parvum* in all samples collected from the middle reaches of the Oder. The samples are sent to a colleague at the University of Vienna's Department of Food Chemistry and Toxicology for toxin detection. "We were able to unequivocally detect significant quantities of a subtype of the algal toxin, known as 'prymnesins', in samples taken from various parts of the Oder," states Elisabeth Varga, a scientist from the University of Vienna. Tests on fish eggs with Oder water conducted by IGB confirm the lethal effect of the toxin.

In light of the findings obtained thus far, the researchers are convinced that it is not a natural phenomenon. "To my knowledge, such a mass development has never been observed before in our freshwaters," remarks Jan Köhler. "This disaster would not have happened if there had not been man-made discharges and interventions in the river."

A FURTHER INDICATION: SATELLITE DATA CONFIRM A MASSIVE ALGAE BLOOM

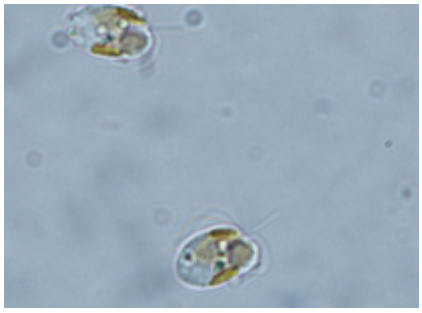
At the same time, IGB scientist Tobias Goldhammer, and colleagues from Leipzig University



and Brockmann Consult, a Hamburg-based environmental data analysis and software company, start analysing data from the Copernicus satellite Sentinel-2. They are looking for early signs of the algal bloom and are keen to reconstruct the temporal-spatial development. From the processed raw satellite data, chlorophyll concentrations can be calculated that indicate the algal bloom.

31 August 2022 The dataset is now complete. It shows that in the second half of July, the concentrations in the entire river course were at a moderate level, while in the upper course around the town of Opole (Poland), they were already elevated. At the beginning of August, the chlorophyll concentration spikes near Wrocław (Poland). The algal bloom then spreads very rapidly, covering almost the entire River Oder within a week. It is not until late August that chlorophyll concentrations return to the average level of early July.

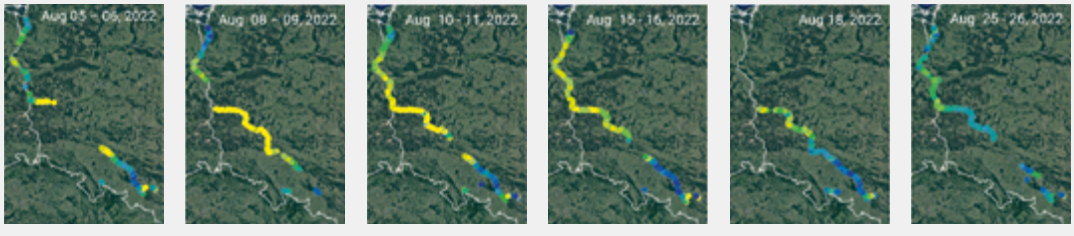
According to the researchers' analysis, the environmental disaster occurred as a result of several stress factors, all of which were caused by human activity. These include development measures that had already reduced the river's natural resilience to hydrological and climate change: "We see the River Oder disaster as a multicausal, man-made event. There have been frequent occurrences of increased salinity due to industrial pollution in the upper reaches of the Oder in the past, without resulting in such massive algal blooms. But the general conditions seem to have changed," explains Tobias Goldhammer.



The alga Prymnesium parvum from the River Oder near Hohenwutzen, taken on 15 August 2022.

PHOTO: KATRIN PREUSS/IGB

> "We see the River Oder disaster as a multicausal, man-made event. There have been frequent occurrences of increased salinity due to industrial pollution in the upper reaches of the Oder in the past, without resulting in such massive algal blooms. But the general conditions seem to have changed."
>
> **Dr Tobias Goldhammer**



RESEARCHERS RECOMMEND APPROPRIATE MEASURES TO PROTECT THE ECOSYSTEM

12 September 2022 In the wake of the River Oder disaster, IGB researchers recommend protecting and restoring the river and its remaining near-natural habitats, instead of implementing further regulation of the river by means of additional river engineering measures. In 2020, the institute had already warned of the ecological risks of developing the Oder in a previous IGB Policy Brief.

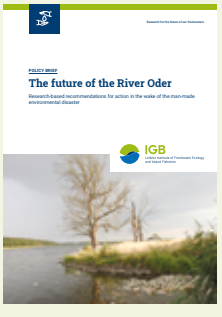
In another Policy Brief, the researchers now recommend a review of the infrastructure project on both sides of the river and the implementation of further measures to stabilise the Oder's ecosystem and ensure its sustainable use in the future. "The future of the River Oder and its wildlife will depend on whether policymakers and authorities decide to enhance the natural resilience of the ecosystem," emphasises Jörn Gessner.

FIRST TEST FISHING DOCUMENTS A HUGE DECLINE IN FISH STOCKS

27 September to 19 October 2022
To get a better overview of the remaining fish populations, IGB performs several test fishing procedures in the River Oder. Their results are sobering: species such as burbot, loach, common bream and white bream have suffered massive losses. Larger fish with a body length of 10 centimetres or more are now virtually non-existent.

The researchers are particularly concerned about the Baltic golden loach, which in Germany occurs exclusively in the River Oder. The only known stable population near Reitwein was estimated to comprise about 500 individuals. Not a single specimen can be detected there now. Instead, the IGB team finds ten specimens at Ratzdorf and a single specimen in the lower River Neiße. "It is not known whether the fish fled and migrated from upstream stocks before

The only known stable population of the golden loach near Reitwein was estimated to be around 500 strong, but now seems to have disappeared.
PHOTO: JÖRG FREYHOF



IGB Policy Brief on the future of the River Oder

Researchers have summarised in an IGB Policy Brief what needs to be done from an ecological perspective to ensure the recovery and sustainable use of the river.
As is the case with all the information on what happened, the Policy Brief is also available in German and Polish, and can be downloaded free of charge.

IGB Policy Brief: The future of the River Oder

the toxic wave struck, or whether it is a stable population that has already been existing for a while; nor how long the specimens have been present there," remarks fish ecologist Christian Wolter.

Also in October, the LfU measuring station at Frankfurt/Oder again shows highly elevated conductivity, even though more water is flowing in the Oder than in the summer months. This means that even higher quantities of salt are being discharged into the river than at the time of the acute disaster situation.

NO SIGN OF RECOVERY

29 November 2022 Following the first scientific test fishing procedures along the banks in September and October, the first extensive fishing event in the middle of the Oder since the disaster now gets underway. This inventory is sobering: the scientists catch much fewer fish, and species such as blue bream and asp are lacking completely. In total, the researchers catch only half as many fish as in previous years on average. But not only are there fewer fish: mussels and snails have also almost disappeared. "Data from August already provided us with indications that the Oder disaster has reduced mussel biomass by half," remarks Christian Wolter. They are the most important filter-feeders in the ecosystem. "It will take a very long time for stocks to replenish, because mussels are not mobile enough to leave their refuge and repopulate areas quickly. This is particularly the case for native large mussels, which also face competition from invasive mussel species," says the ecologist.

Measurements of conductivity taken during fishing show once again that salinity levels are still far too high for the river ecosystem. At the Frankfurt/Oder gauge, conductivity has been more than 1,900 µS/cm since mid-November already; by the end of November, the figure even exceeds 2,000 µS/cm. The major component of the salt load continues to be sodium chloride. "We detected around 400 milligrammes of sodium chloride per litre of water in water samples from the Lower Oder, which equates to about half of the total amount of salt in these samples. Obviously, large quantities of salt are still being discharged into the river," explains biogeochemist Tobias Goldhammer.

LOOKING TO THE FUTURE: A DISASTER THAT IS BOUND TO HAPPEN?

After the disaster, IGB researchers detected so-called dormant stages of *Prymnesium parvum* in sediment of the Oder. These dormant algae can hatch as soon as environmental conditions become favourable again. This also means that there could be a repeat of the disaster when temperatures increase and all other conditions are in place – summer after summer.

Consequently, the recommendations made by IGB researchers remain unchanged. Above all, the river engineering works to deepen the Oder should be stopped: "When we look at the indirect causes of the Oder disaster, low water levels and longer water retention times promoted the mass development of the alga. Further regulating the Oder would encourage the onset and duration of low water levels, because when water is there, it flows more quickly into the sea in spring. Instead, we need greater retention in adjacent floodplains," explains Christian Wolter. "To protect the Oder ecosystem, habitats should be restored and substance inputs significantly reduced," he adds. This also includes switching discharge permits from loads to concentrations for which an ecologically sound threshold urgently needs to be set and complied with.

It may take several years for stocks to recover. The prerequisite would be that measures are taken to improve the situation – and there is no repeat of the disaster.

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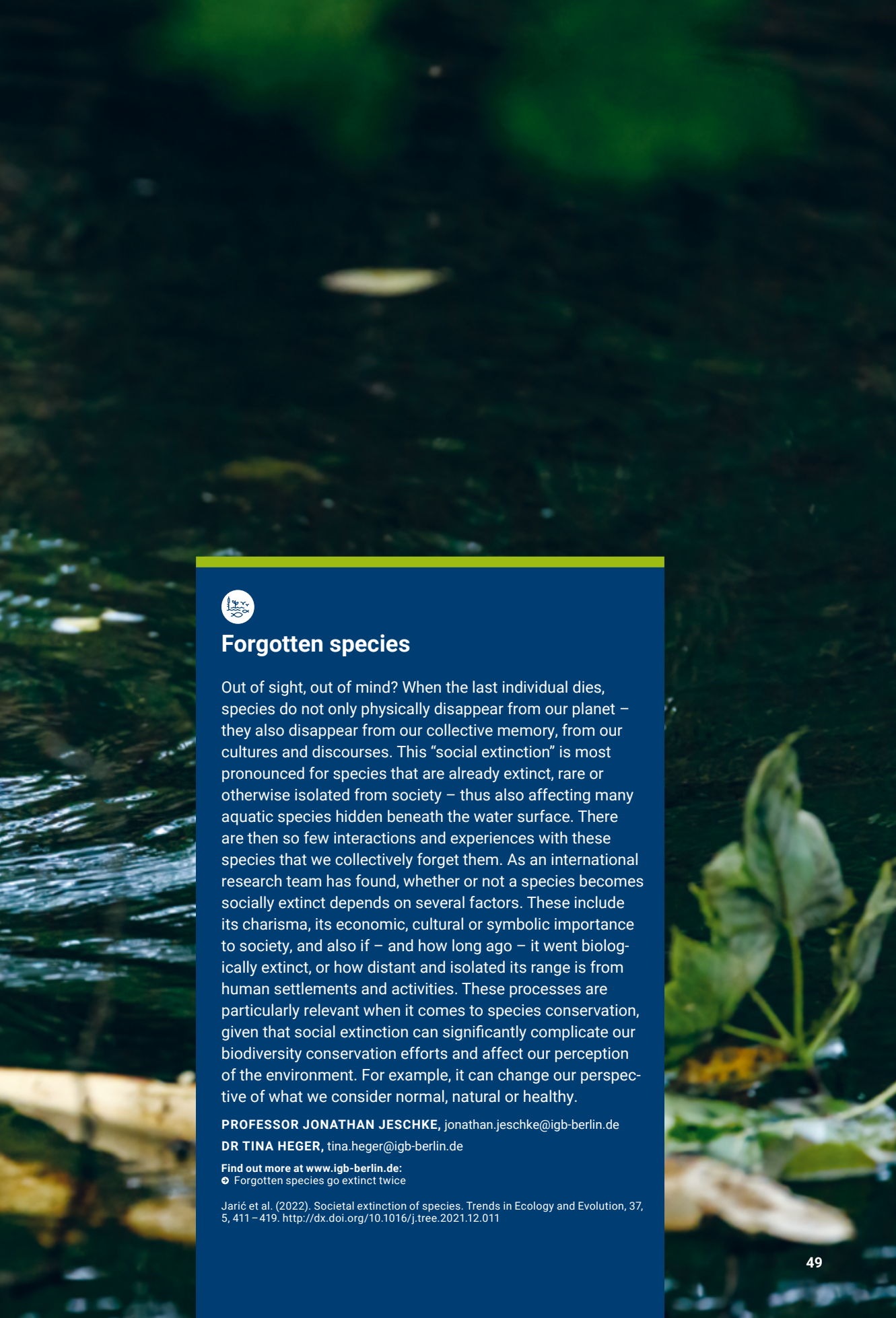
Find out more at www.igb-berlin.de:
- Fishing in the wake of the Oder River disaster shows no sign of recovery
- Lessons learned from the River Oder disaster: research-based recommendations for action
- In the wake of the Oder River disaster: Is there any hope for the sturgeon and its habitat?

Efforts to reintroduce regionally extinct species, such as the Eurasian beaver (Castor fiber), may suffer from their absence in collective memory as a natural part of the ecosystem, and thus receive less public support.

PHOTO: SUTTERSTOCK 2193392865



Forgotten species

Out of sight, out of mind? When the last individual dies, species do not only physically disappear from our planet – they also disappear from our collective memory, from our cultures and discourses. This "social extinction" is most pronounced for species that are already extinct, rare or otherwise isolated from society – thus also affecting many aquatic species hidden beneath the water surface. There are then so few interactions and experiences with these species that we collectively forget them. As an international research team has found, whether or not a species becomes socially extinct depends on several factors. These include its charisma, its economic, cultural or symbolic importance to society, and also if – and how long ago – it went biologically extinct, or how distant and isolated its range is from human settlements and activities. These processes are particularly relevant when it comes to species conservation, given that social extinction can significantly complicate our biodiversity conservation efforts and affect our perception of the environment. For example, it can change our perspective of what we consider normal, natural or healthy.

PROFESSOR JONATHAN JESCHKE, jonathan.jeschke@igb-berlin.de
DR TINA HEGER, tina.heger@igb-berlin.de

Find out more at www.igb-berlin.de:
➲ Forgotten species go extinct twice

Jarić et al. (2022). Societal extinction of species. Trends in Ecology and Evolution, 37, 5, 411 – 419. http://dx.doi.org/10.1016/j.tree.2021.12.011

Two departments with new leaders

In January 2022, two new departments were established at IGB: the Department of Community and Ecosystem Ecology, led by **Sonja Jähnig**, and the Department of Evolutionary and Integrative Ecology, which is headed by **Jonathan Jeschke**. Find out what drives these two leading scientists, and how they intend to shape the work in their departments, in the interviews we conducted with them.

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

- "We are looking at the bigger picture of biodiversity"

PROFESSOR JONATHAN JESCHKE
jonathan.jeschke@igb-berlin.de

- "Great science is typically teamwork where everyone contributes their strengths, complementing each other"

*In addition, the former departments of "Ecohydrology" and "Chemical Analysis and Biogeochemistry" were merged into the department of "**Ecohydrology and Biogeochemistry**", headed by Dörthe Tetzlaff. The two former departments of "Biology and Ecology of Fishes" and "Ecophysiology and Aquaculture" were merged into the new department of "**Fish Biology, Fisheries and Aquaculture**", led by Jens Krause and Werner Kloas. This merger enables IGB to better integrate its research on inland fisheries and aquaculture with basic research on fish biology. The department of "Experimental Limnology", based in Neuglobsow and led by Mark Gessner, is now called "**Plankton and Microbial Ecology**".*

Honorary professorship for IGB researcher Michael Hupfer

IGB scientist **Michael Hupfer** has been awarded an honorary professorship in "Aquatic Biogeochemistry" at the Brandenburg University of Technology Cottbus–Senftenberg (BTU). This honorary professorship is intended to enhance the university's teaching and research on aquatic ecosystems and its networking activities with IGB. Michael Hupfer's expertise in aquatic research will perfectly complement BTU's "Global Change and Transformation Processes" profile line. The certificate was presented by President Professor Gesine Grande at an awards ceremony on the BTU campus in Cottbus. Michael Hupfer looks forward to his new task: "I would like to contribute to ensuring that graduates of BTU are able to meet future challenges, based on a sound knowledge of both engineering and aquatic ecology," he remarked.

PROFESSOR MICHAEL HUPFER
michael.hupfer@igb-berlin.de

Find out more at www.igb-berlin.de:
- Honorary professorship for IGB researcher Michael Hupfer

Inter Circle U Prize goes to Robert Arlinghaus and his team

Circle U is an alliance of nine European universities that have joined forces, including Humboldt-Universität zu Berlin as the German partner. Together, they seek to develop competencies and solutions for keeping Europe and our planet healthy, peaceful, democratic and prosperous. Particularly outstanding examples of interdisciplinary and transdisciplinary research at the participating universities are awarded the Inter Circle U Prize (ICUP) each year. In 2022, the award went to **Robert Arlinghaus** and his team for their long-term commitment to sustainable fisheries research. The projects Adaptfisch, Besatzfisch, BAGGERSEE and Boddenhecht were highlighted as examples of how knowledge transfer to society can succeed in an effort to manage water bodies sustainably. The award ceremony took place during the "Conference on Inter- and Transdisciplinary Research for Sustainable Development" at the Belgian Université catholique de Louvain.

PROFESSOR ROBERT ARLINGHAUS
robert.arlinghaus@igb-berlin.de

Find out more at www.igb-berlin.de:
Inter Circle U Prize for Robert Arlinghaus

Further awards and successes

Professor Dörthe Tetzlaff was elected as Fellow of the European Academy of Sciences.

Dr Mina Bizic was named a Fellow of the Association for the Sciences of Limnology and Oceanography (ASLO) for her active engagement in aquatic sciences. She is also an elected Member-at-Large of the Board of Directors and Chair of ASLO's Early Career Committee (ECC). In addition, the postdoctoral researcher was recognised as Outstanding L&O Reviewer by the Journal of Limnology and Oceanography.

Dr Lena Heinrich received the Schwoerbel-Benndorf Young Scientist Award of the German Society for Limnology (DGL). The former IGB doctoral student wrote her thesis in Professor Michael Hupfer's research group within the DFG Graduate School "Urban Water Interfaces".

Dr Stephanie Spahr was selected as one of 20 international participants of the 2023 Falling Walls "Female Science Talents Intensive Track" programme. She also received first prize for her poster at Water 2022 – the annual meeting of the Water Chemistry Society.

Dr Lynn Govaert was appointed the new subject editor of the journal Ecological Monographs, which primarily publishes integrative, synthetic papers that elaborate new directions in the field of ecology.

Dr Daniel Mietchen was awarded the Coolest Tool Award 2022 by Wikimedia for his further development of Scholia in the Impact category.

Phillipp Czapla received the Albrecht-Daniel-Thaer-Förderpreis for his outstanding Master's degree in M.Sc. Fish Biology, Fisheries and Aquaculture. Under the supervision of Professor Robert Arlinghaus, he investigated how angling affects the catchability of carp.

Andreas Maday was awarded a €1,000 sponsorship prize by the German Angling Association (DAFV) for his Master's thesis within the BAGGERSEE project. His topic was: Spatial temporal use of littoral habitats by fish in gravel pit lakes.

Timo Rittweg won the poster prize at the Science Slam during the German Fisheries Day in Berlin for his presentation "The importance of correct age reading for the assessment of productivity and the management of fish stocks using the example of pike (*Esox lucius*)".

Dr Kirsten Pohlmann was elected to the spokesperson council of the Leibniz Association's Equal Opportunities and Diversity Working Group.

Johannes Graupner was re-elected as spokesperson for the Leibniz Association's Knowledge Transfer Working Group.

Review of the year 2022

INTERNAL MATTERS

New departments

JANUARY As of 1 January 2022, IGB's research departments have been restructured and renamed. Two new departments have been established: the Department of Community and Ecosystem Ecology, headed by Sonja Jähnig, and the Department of Evolutionary and Integrative Ecology, led by Jonathan Jeschke.

PROFESSOR SONJA JÄHNIG
PROFESSOR JONATHAN JESCHKE

Page 50

GEO AquaWatch Node

JANUARY Together with the international organisation GEO AquaWatch, IGB established a thematic node for the calibration and validation of satellite data. It aims to support the establishment of a global network for calibration and validation activities of remote sensing-based water quality products.

DR IGOR OGASHAWARA

Page 10

For more diversity

SEPTEMBER IGB signed the Diversity Charter, committing to making diversity an integral part of the institute's culture. We set out associated goals, measures and structures in our Diversity and Inclusion Strategy. These include, among other things, a conflict counselling centre and targeted professional development for our staff.

DR KIRSTEN POHLMANN

Successful rehearsal

SEPTEMBER For its audit, IGB's Scientific Advisory Board reviewed the state and activities of the institute, exchanged views with the management and staff, and heard about the work carried out at the departments. In its thoroughly positive report, the reviewers emphasised the successful implementation of the internal restructuring, while increasing scientific quality, and expressly supported IGB's efforts to obtain an extraordinary item of expenditure.

PROFESSOR LUC DE MEESTER

New programme areas

NOVEMBER The research activities of IGB are pooled in three new programme areas. Their main purpose is to serve as incubators for creative ideas and approaches, promoting interdisciplinary research within IGB and with national and international partners.

PROFESSOR LUC DE MEESTER

www.igb-berlin.de/en/our-programme-areas

PROJECT LAUNCH

CliWaC

JANUARY The Einstein Research Unit "Climate and Water under Change" (CliWaC) is a transdisciplinary research initiative of the Berlin University Alliance dedicated to the investigation of water-related risks of climate change in the Berlin-Brandenburg region. IGB contributes in particular with its expertise in isotope-based and ecohydrological investigations and modelling in the Spree catchment area and in the city of Berlin.

PROFESSOR DÖRTHE TETZLAFF

www.cliwac.de

BiNatUr

PHOTO: THILO WELLMANN

APRIL Progressive climate change is having an increasingly negative impact on the quantity, quality and distribution of water in urban habitats, limiting biodiversity and local recreation. The project combines hydrological, social and ecological approaches, and investigates the consequences of climate change and the potential of nature-based solutions.

PROFESSOR DÖRTHE TETZLAFF
PROFESSOR MICHAEL MONAGHAN

GeoFRESH

APRIL NFDI4Earth uses pilot projects to determine requirements for the management of research data. One of them is GeoFRESH: Within 12 months, an online portal for freshwater data is being created, which will allow high-resolution spatial queries of the global river network and direct download of the associated environmental parameters.

DR SAMI DOMISCH

http://geofresh.org

Fish invasions on the Isthmus of Panama

MAY Ship channels such as the Panama Canal connect water bodies and oceans, making them corridors for alien species. This project investigates whether the recent widening of this canal increases the translocation of aquatic alien species between the Pacific and Atlantic oceans. The findings will also shed light on the mechanisms that determine the success of an alien aquatic species in a new environment.

DR GUSTAVO CASTELLANOS-GALINDO
PROFESSOR JONATHAN JESCHKE

BioAgora

JULY The European joint project BioAgora brings together scientific research results on biodiversity with the processes of political decision-making. This aims to improve interaction between science and policy, and to contribute to the EU Biodiversity Strategy 2030.

PROFESSOR SONJA JÄHNIG
DR SIBYLLE SCHROER

https://bioagora.eu

SOS-Water

OCTOBER The EU project aims to identify a safe action space for water resources in a changing climate and society. The results are expected to improve understanding of water resource availability, and contribute to management that distributes water more equitably across societies, economies and ecosystems.

DR SAMI DOMISCH

https://sos-water.eu

ADVICE

Taking action against climate change

FEBRUARY Former IGB Department Head Rita Adrian was involved as lead author in the Working Group II on the Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report. She contributed to the chapter "Terrestrial and freshwater ecosystems and their services", which, among other things, emphasises the relevance of inland waters and their ecology as well as water as a resource.

PROFESSOR RITA ADRIAN (EMERITUS)

www.igb-berlin.de/en/news/ipcc-report-published-what-state-inland-waters

Curbing microplastics

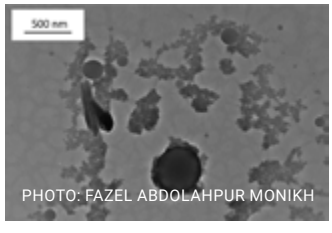


PHOTO: FAZEL ABDOLAHPUR MONIKH

MARCH Once microplastics and sub-microplastics have entered ecosystems, they are almost impossible to remove. In a response to the EU Call for Evidence, IGB researchers therefore urgently recommend improved EU policies to effectively prevent and control these emissions, as well as a harmonised EU-wide monitoring system. Priority should be given to direct prevention at source, rather than costly end-of-pipe solutions.

DR STEPHANIE SPAHR
PROFESSOR HANS-PETER GROSSART

www.igb-berlin.de/en/news/microplastics-pollution-scientists-recommend-prevention-and-monitoring

Do not prioritise hydropower

APRIL Measures that speed up approval procedures for renewable energies must not violate key European or national environmental standards. This is especially true for hydropower, which is a renewable resource, but in most cases not an environmentally friendly one. This was pointed out by IGB researchers in their feedback to a European Commission Call for Evidence on energy policy.

PROFESSOR SONJA JÄHNIG
DR MARTIN PUSCH
DR CHRISTIAN WOLTER

ww.igb-berlin.de/en/news/european-energy-policy-why-hywdropower-should-not-be-prioritised

Exploiting the opportunities of open science, taking action against drought

MAY Opening up research can enhance not only its scientific quality, but also its social impact. Nevertheless, it is a challenge to realign research processes accordingly. During an expert discussion within the "Leibniz in the Bundestag" event, IGB scientist Daniel Mietchen explained to SPD MP Ruppert Stüwe, a member of the Research Committee, the possibilities available.
In the same format, IGB researcher Jörg Lewandowski provided information on the effects of drought on aquatic ecosystems – and what countermeasures can be taken. His discussion partner was Harald Ebner, MP for the Greens and Chair of the Environment Committee.

DR DANIEL MIETCHEN
DR JÖRG LEWANDOWSKI

Reducing flood risks

JUNE German scientists led by the Senckenberg Gesellschaft für Naturforschung (SGN) summarised in a policy brief what smart flood protection should look like. The policy brief, to which IGB also contributed, recommends a combined flood protection of nature-based and technical measures, as well as the restoration of rivers and floodplains, the rewetting of peatlands and the transformation of German forests.

PROFESSOR SONJA JÄHNIG
PROFESSOR DÖRTHE TETZLAFF

www.igb-berlin.de/en/news/new-policy-brief-flood-control

Managing water bodies sustainably

JUNE Is the mass development of aquatic plants a natural and welcome phenomenon or a serious problem that should be contained? An IGB Fact Sheet provides a brief research-based overview of this question. Our researchers explain how mass developments can occur – and also why their management requires a rethink by the public, authorities and conservation associations.

DR SABINE HILT
DR JAN KÖHLER

www.igb-berlin.de/en/news/mass-development-aquatic-plants-natural-phenomenon-or-serious-problem
Page 26

Reducing nutrients

PHOTO: MYRIAMS-FOTOS ON PIXABAY

SEPTEMBER The European Commission is developing an action plan for better nutrient management. This is important because far too high emissions of nitrogen and phosphorus are polluting most inland waters in Europe, with negative consequences for aquatic ecosystems, their biodiversity, their functions and thus also their ecosystem services. IGB researchers see an urgent need for action, and contributed their expertise to the consultation process.

DR STEPHANIE SPAHR
DR TOBIAS GOLDHAMMER

- www.igb-berlin.de/en/news/nutrients-inland-waters-need-be-reduced

Facing water scarcity

SEPTEMBER Drought and water scarcity are affecting Berlin's water bodies. In addition, after the coal phase-out, less pumping water will support the already low discharge of the Spree. At the same time, the pressure of use continues to increase. During a background discussion at IGB, the institute's researchers discussed with Benedikt Lux, MP of the Greens in the Berlin House of Representatives and environmental policy spokesman for his parliamentary group, about what this development means ecologically and what challenges the capital city faces.

DR MARTIN PUSCH
DR JÖRN GESSNER

Lessons learnt from the Oder River disaster

SEPTEMBER An IGB Policy Brief created by IGB researchers spells out what can be done to help the river and reduce the risk of such severe ecological and economic damage in the future. According to the document, it is crucial to protect and restore the river and its remaining near-natural habitats – instead of endangering it even further with additional river engineering measures. The IGB researchers also informed Brandenburg's Minister-President Dietmar Woidke and Environment Minister Axel Vogel about the ecology of the Oder River and possible options for action at an expert discussion in the Brandenburg State Chancellery. IGB was also invited to the environmental committees of the federal state's Landtag and the Berlin House of Representatives, where it presented the situation from a research perspective.

DR CHRISTIAN WOLTER
DR JÖRN GESSNER
DR JAN KÖHLER
DR THOMAS MEHNER

- www.igb-berlin.de/en/news/lessons-learned-river-oder-disaster-research-based-recommendations-action
- Page 42

National Water Strategy

DECEMBER IGB researchers have commented on the National Water Strategy government draft. In their feedback, they recommend, among other things, a better consideration of ecological aspects.

JOHANNES GRAUPNER

- www.igb-berlin.de/en/news/no-water-without-freshwaters
- Page 20

EVENTS

Girls' Day

APRIL In 2022, Girls' Day was at last held again in person, rather than online. For 15 girls, this felt like real water research work. At our site in Berlin, they were able to discover what happens to drug residues in water, besides taking water samples and getting to know about the sturgeon. IGB will also be taking part in next Girls' Day, scheduled for 27 April 2023.

NADJA NEUMANN

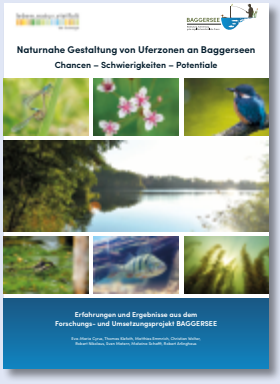
PHOTO: NADJA NEUMANN

Spotlight on underwater plants

APRIL What impact does climate change have on underwater plants in German inland waters? Representatives from research and practice exchanged their experiences at an IGB Academy. In keynote speeches and working groups, they gained an overview of the current state of knowledge and collected unresolved issues from the perspective of science and practice.

DR SABINE HILT
DR JAN KÖHLER

Page 26



Improving quarry ponds

MAY How angling clubs can promote fish and biodiversity was the topic of the final conference of the IGB project BAGGERSEE. Those who missed it can still obtain information: The brochure entitled "Naturnahe Gestaltung von Uferzonen an Baggerseen. Chancen, Schwierigkeiten, Potentiale" (Near-natural riparian zone development at quarry ponds. Opportunities, Difficulties, Potentials) provides information on the project findings – for example, how shallow water zones and deadwood promote species richness.

PROFESSOR ROBERT ARLINGHAUS

www.igb-berlin.de/en/news/improving-quarry-ponds

RIVER

JUNE In cooperation with Kino Union in Berlin, IGB presented the visually powerful documentary RIVER, which deals with the relationship between people and rivers. Under the title "Rivers – fascinating, species-rich, threatened: insights from water research", IGB researchers then discussed the value and threats to these lifelines with the audience.

PROFESSOR SONJA JÄHNIG

100 years of SIL

PHOTO: K.I.T.

AUGUST The International Society of Limnology (SIL) celebrated its 100th anniversary with an international conference in Berlin – co-hosted by IGB. About 800 scientists from 60 countries exchanged their ideas on research and protection measures for freshwaters and groundwater.

DR THOMAS MEHNER
PROFESSOR RITA ADRIAN
PROFESSOR MARK GESSNER

Recreation at the water's edge

AUGUST What impact do bathing, water sports, fishing and other activities have on water bodies? The IGB Academy for officials in politics, authorities, interest groups, user and environmental associations presented current research findings on recreational ecology and marked the conclusion of the IGB project AQUATAG.

DR MARKUS VENOHR
DR CHRISTIAN WOLTER
PROFESSOR ROBERT ARLINGHAUS

https://aquatag.igb-berlin.de

Discovering urban nature

AUGUST Berlin is a big city. Blue, green and wild – that is Berlin, too! This is what visitors were able to discover at Spreepark Berlin, where IGB, together with many other partners, invited the public to join an urban nature expedition. We provided information on the species that live in Berlin's waters, how smart fish are, and why rainwater is becoming an increasingly important resource.

ANGELINA TITTMANN
NADJA NEUMANN

www.igb-berlin.de/en/news/berlin-blue-green-wild


PHOTO: KONSTANTIN BÖRNER

Berlin Science Week

NOVEMBER The institutes of FVB e.V., including IGB, celebrated 30 years of cooperation. Large audiences experienced elevator pitches and scientific crosstalk between fish scientists and quantum experts, wild animals, crystals, pharmacological research, maths and ultra-short laser pulses.

Integrated Earth System Research

NOVEMBER This first conference on "Integrated Earth System Research" hosted by the Leibniz Research Network of the same name was dedicated to scientific progress towards a coherent understanding of the increasing human impact on the Earth system, its societal consequences and the related challenges for policy. Researchers from the natural sciences, engineering, social sciences and humanities gathered to intensify their collaboration in the future.

PROFESSOR HANS-PETER GROSSART

www.leibniz-integrierte-erdsystemforschung.de/en

Sustainable aquaculture

NOVEMBER Prophylaxis or hygienisation with agents based on peracetic acid is a promising approach to improve fish health in aquaculture facilities. At the IGB Academy "Sustainable aquaculture through environmentally friendly prophylaxis", researchers and practitioners exchanged results and recommendations from field and laboratory work on this comparatively environmentally, consumer and fish-friendly method.

DR THOMAS MEINELT
DR DIBU LIU

PHOTO: THOMAS MEINELT/IGB

GUEST

Face to face

SEPTEMBER At an on-site visit to the Oder River, Federal Foreign Minister Annalena Baerbock was informed first-hand by IGB expert Christian Wolter about the causes of the man-made environmental disaster and the consequences of the fish kill. Afterwards, she called for increased efforts to preserve this vulnerable ecosystem.

DR CHRISTIAN WOLTER

PHOTO: ANGELINA TITTMANN

2022 in numbers

Overall budget	**€ 23,119,600**
Proportion of external funding (related to the core budget)	**35 %**

Institutional funding from the federal government	**€ 15,435,000**
of which core budget	€ 14,521,000
of which Leibniz Competition levy	€ 414,000
of which for major construction projects	€ 500,000

External grants, including externally managed funds	**€ 7,684,600**
of which from the federal government	€ 1,771,690
of which from the federal states	€ 279,600
of which from the DFG	€ 2,298,300
of which from the Leibniz Competition	€ 265,800
of which from other public funding	€ 616,160
of which from non-public funding	€ 11,550
of which from the EU/international	€ 1,923,450
of which from foundations	€ 518,050

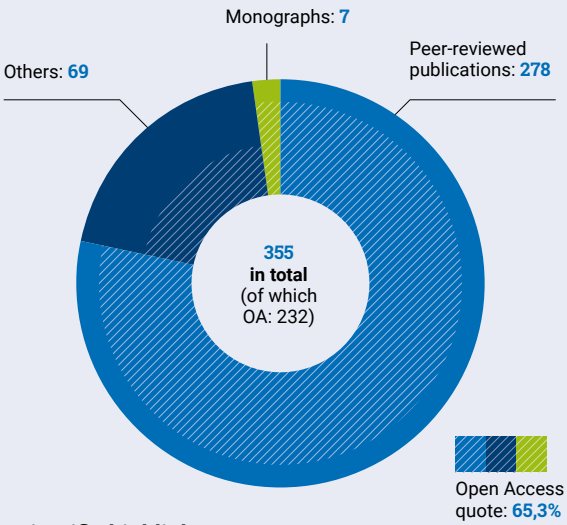
The most cited article from 2021/2022 was

Doran et al. (2022). Fish waves as emergent collective anti-predator behaviour. CURRENT BIOLOGY, 32, 3. https://doi.org/10.1016/j.cub.2021.11.068

Page 14

Source: Web of Science (15 March 2023), articles with IGB corresponding authorship

PUBLICATIONS



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

JANA RUMLER
library@igb-berlin.de

INSTITUTE MEMBERS *

130
scientists
including 39 leading scientists
including 43 postdoctoral scientists
including 28 doctoral candidates

130
science supporting staff
including 3 apprentices
including 30 student assistants

27
fellows
including 9 postdoctoral scientists
including 16 doctoral candidates

110
guests
including 31 postdoctoral scientists
including 16 doctoral candidates supervised by IGB

397
in total

BY SEX

scientists:

37%
women

63%
men

0%
diverse

science supporting staff:

54%
women

46%
men

0%
diverse

BY FUNDING

scientists:

39%
funded from core budget

61%
externally funded

science supporting staff:

86%
funded from core budget

14%
externally funded

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

DEGREES & CO.

6
Bachelor theses

10
Diplom and Master's theses

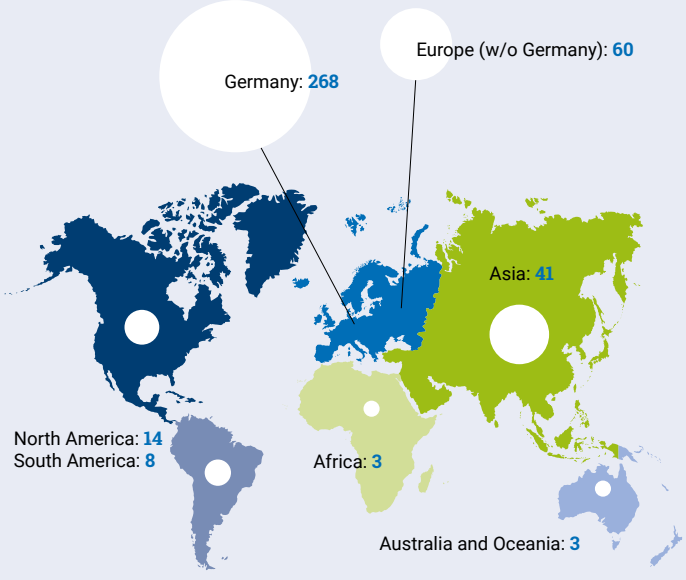
11
dissertations

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 2022

Structure

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

STATUS AS OF 1 MARCH 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 Masigo

Disability Representative
Georg Staaks

Works Council
Marén Lentz (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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We would like to thank all colleagues who contributed to this annual research report and supported us!

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Register of Associations:
Forschungsverbund Berlin is entered in the Register of Associations of Amtsgericht Berlin-Charlottenburg (Berlin-Charlottenburg Local Court) under Register Number VR 12174 B.

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FRESHWATER NEWS

Are you interested in freshwater research and would like to learn about new activities at IGB? Then simply subscribe to our newsletter, which will be sent to your mailbox every two months, packed with information about IGB and our topics.

Subscribe now:
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