IGB

Leibniz-Institute of
Freshwater Ecology
and Inland Fisheries

Freshwater Research 2018

IGB Annual Report

In the Context of Climate Change
How global warming and extreme weather phenomena affect our freshwaters

City, Country, Waters
Ecosystems with a future?
Lakes, rivers, etc. in urban and rural areas

Focusing on Fish
How fish live and survive, and what we can learn from their behaviour

Angling

Aquaculture & Aquaponics

Biodiversity

Dialogue & Transfer

Freshwater Ecosystems

Use & Management

Multiple Stressors & Pollutants

Environmental Change

Behavioural Ecology & Swarm Intelligence

Water & Matter Cycles

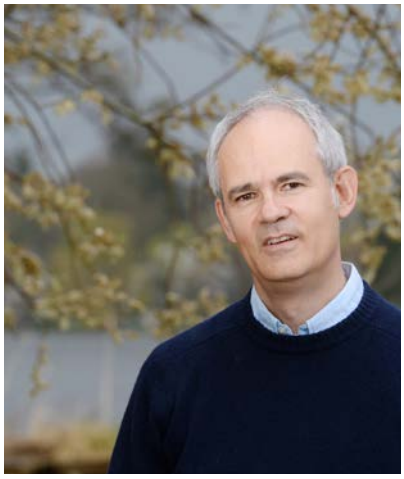
Research for the Future of our Freshwaters

IGB is Germany's largest research centre for freshwaters. At IGB, scientists from a whole range of disciplines work under one roof. They are working together to investigate the fundamental processes in rivers, lakes and wetlands, and join forces to develop measures conductive to sustainable water management.

On the following pages we present selected research results, projects and events from 2018. The content is categorised in ten topics in which we bundle the results of our research work that could be of interest to you. For each topic, you will find further information, materials, experts as well as background information and current news on our website.

We hope you enjoy reading and exploring!

Contents



"Dry inland waters, fluctuating water levels and, above all, rising water temperatures will have an adverse effect on numerous species in the future."

GREGOR KALINKAT

→ **page 14**

"All in all, recreational activities place considerable pressure on freshwaters, particularly in cities; however, so far we know too little about this phenomenon."

MARKUS VENOHR

→ **page 18**

"Many anglers are strongly attached to 'their' rivers. They are often the first to notice when water quality deteriorates or when something new turns up in the river that does not belong there."

SOPHIA KOCHALSKI

→ **page 30**

Photos: David Ausserhofer; Angelina Tittmann; Andreas Gericke; Christian Wolter; Marc Kupetz; David Mandos

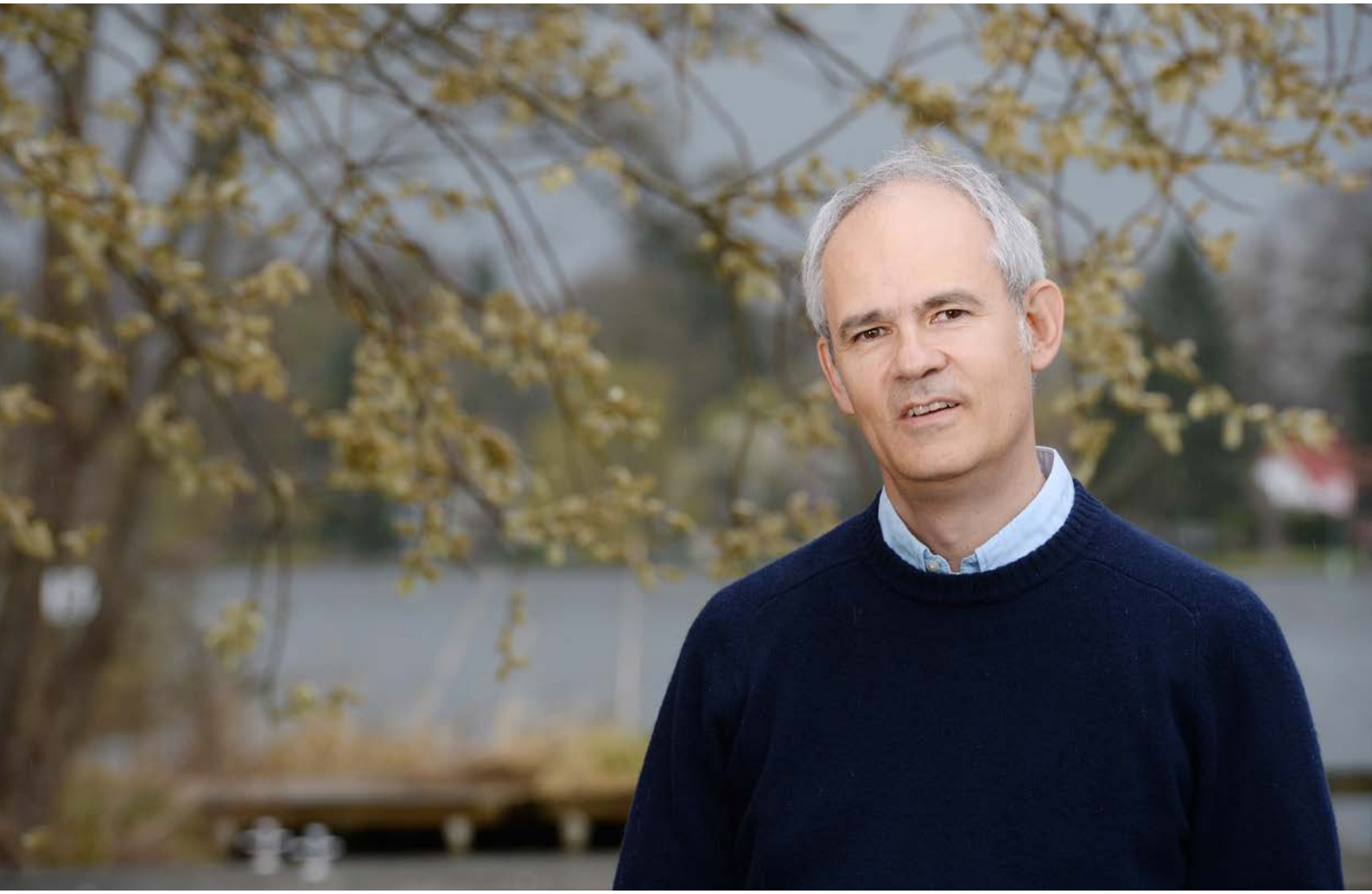


Photo: David Ausserhofer

Dear Reader,

How can science maintain its credibility in the long run when it is questioned by different parties? Earlier this year, for example, a public debate raised the issue about limits on nitrogen oxide emissions, when over a hundred German pulmonary doctors called into question the evidence provided by a wealth of scientific studies. It has since become clear that the medical statement suffered from embarrassing calculation errors. But even though the statement was signed by only a small fraction of Germany's lung specialists, the broad media coverage has troubled political and public confidence in scientific evidence.

"The role of communication beyond the scientific community is likely to grow in the future, since science is increasingly solicited to engage in finding solutions to complex societal challenges. This expectation spurs our efforts to expose our research more and more not just within the scientific community, but for a broader exchange."

This example demonstrates the importance of effective communication between science, policy makers and society. And this role of communication beyond the scientific community is likely to grow in the future, since science is increasingly solicited to engage in finding solutions to complex societal challenges. This expectation spurs our efforts to expose our research more and more not just within the scientific community, but for a broader exchange. The positive feedback we received from the evaluation of IGB in June 2018 on our science-society interface indicates that we are on the right track.

Such a commitment is only possible when based on excellent science that is devoted to unravelling fundamental relationships and that, at the same time, addresses current challenges faced by society. This is the foundation for a proper factual discourse on controversial issues as the basis for wise decision-making. At IGB, where we embrace interdisciplinary collaboration, we can make a difference in this process by exploring under a single roof very different perspectives on freshwater ecosystems, biodiversity and functions.

Three such overarching issues that continued to occupy us in 2018 are presented in this annual report: turn to page 8 to find out about impacts of climate change on freshwater ecosystems, and what we can do about it. Turn to page 16 for an overview of the specifics of urban water bodies viewed both as ecosystems and as a resource for human use. On page 24, you can delve into the world of fishes. We show here how these creatures conquer new habitats, how we can use and protect fish stocks more effectively, and how fish enable us to scrutinize general scientific theories.

By presenting this selection of topics for this year's report, our aim is not only to highlight new insights and achievements of IGB. The report also seeks to encourage broader reflection and inquiry as well as action. We also consider it important to continue promoting dialogue, reflecting our confidence that close and open exchange with policy makers and civil society is crucial if we are to respond effectively to the ongoing severe loss of aquatic biodiversity, consequences of climate and land-use change on fresh waters, and global urbanisation trends.

This preface gives me the opportunity to thank again the many partners who accompanied, supported and inspired our research, teaching and transfer activities in 2018. In particular, I would like to mention our close partners, Freie Universität Berlin, Humboldt-Universität zu Berlin, Technische Universität Berlin and the University of Potsdam, as well as the institute's Scientific Advisory Board, which showed great commitment during the current period of interim directorship, the Forschungsverbund Berlin for its excellent administrative support, the evaluation committee that visited IGB in June 2018, the Leibniz Association, and the authorities and associations that maintain close links with us. My sincere thanks are also due to Berlin's Senate Chancellery for Higher Education and Research, as well as to the Federal Ministry of Education and Research (BMBF) for their financial and practical support, without which our work would be impossible. Finally, it goes without saying that the great progress of the institute made again in 2018 in terms of research, interaction with society and internal strategy and governance processes would be inconceivable without the dedication of our staff in research, administration and technical support. Many thanks for this commitment!

"By presenting this selection of topics for this year's report, our aim is not only to highlight new insights and achievements of IGB. The report also seeks to encourage broader reflection and inquiry as well as action."

I am pleased and proud that the conditions thus continued to be met at IGB in 2018 to generate exciting insights into freshwaters and their biodiversity and, building on this solid foundation, to develop sound solutions to society's challenges today. By doing so, we ultimately make a tangible contribution to maintaining the integrity and credibility of science in these turbulent times.

Yours,

Mark Gessner
Acting Director

Evaluated and Recommended for Continued Funding

IGB came under close scrutiny for two days in June 2018: a committee of nine international scientists thoroughly evaluated the institute and its scientific performance. They were joined by representatives from the State of Berlin, the Federal Ministry of Education and Research (BMBF), the Leibniz Association and our partner universities in Berlin and Potsdam. The committee was impressed by IGB's remarkable publication output and excellent infrastructure. They particularly noted IGB's Science-Society Interface that was developed at the institute to transfer knowledge from research to society at large. The Senate of the Leibniz Association followed the positive assessment and recommended that the Federal Government and the Länder of Germany continue funding the institute. A big thank you goes to all staff members for their dedicated efforts!

Photo: Copernicus Sentinel data (2015) ESA

17 Services

are now listed in the new River Ecosystem Service Index, or RESI for short. The new tool helps practitioners to capture, assess and visualise the ecosystem services of rivers and floodplains. The tool's methodological basis and calculation formulas are summarised in a manual, available for download free of charge. Find out more on → **page 21**.

Fish of the Year

2019 is the year of the Atlantic salmon. This species' particular mode of life, migrating between rivers and oceans, its economic significance for recreational fisheries and aquaculture production, and its role as an umbrella species for revitalisation measures also make the Atlantic salmon an interesting research object. Scientists involved in the IMPRESS project have travelled to hatcheries in Norway, Wales and Germany, where they spoke to angling associations and volunteers about the reasons behind their activities. Sophia Kochalski talks about the results of the project in an interview on → **page 30**.

Graph: Christiane John

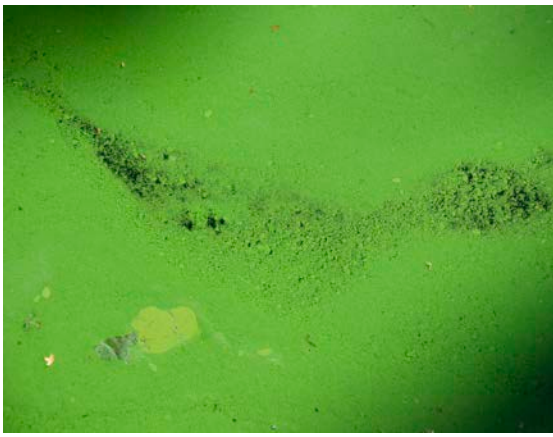


Photo: Angelina Tittmann

Preventing Algal Blooms

Our long-term data on Lake Müggelsee is very revealing: it shows that reducing nitrogen in lakes is the key to preventing algal blooms in summer. It also shows that the amount of atmospheric nitrogen bound by blue-green algae is far too small to be used as an argument against the ecologically necessary reduction of nitrogen inputs. The extensive release of phosphorus from the sediment into the water and of nitrogen from the water into the air is typical for shallow lakes in summer, meaning that many other shallow lakes may behave similarly.

Watch the video
→ www.youtube.com/watch?v=EhEZhUejo3w

Shatwell, T., & Köhler, J. (2019). Decreased nitrogen loading controls summer cyanobacterial blooms without promoting nitrogen-fixing taxa: Long-term response of a shallow lake. Limnology and Oceanography, 64(S1), 166-178. doi:10.1002/lno.11002

15 Articles

on aquatic interfaces were compiled in a special issue of *Limnologica*, published in spring 2018. Under the heading "Aquatic interfaces and linkages: an emerging topic of interdisciplinary research", the topic addresses the complex interactions of geochemical, biological and physical processes in these zones. Interfaces exhibit exceptionally high levels of activity, influencing material and energy flows in freshwaters and the surrounding landscape. To more capably assess the effects of management measures or environmental change, scientists need to understand how these interfaces function, as well as the services that they provide. Nine authors from four IGB departments were involved in creating the special issue. IGB was proactive to focus on this issue, such as by establishing a dedicated cross-cutting research domain and initiating two graduate schools *AQUALINK* and *Urban Water Interfaces*.

Hupfer, M. et al. (2018). Aquatic interfaces and linkages: an emerging topic of interdisciplinary research. Limnologica, 68, 1-4. doi:10.1016/j.limno.2017.12.002

Together we are Strong

The *Alliance for Freshwater Life* (AFL) was officially launched in Stockholm at the end of August 2018 during World Water Week. AFL is an international network, currently with 23 partners, including founding member IGB. "Researchers, nature conservationists and politicians are all interested in protecting biodiversity. But still, we do not work together closely enough. AFL is a commitment for all participants to pool our expertise and to ensure that the general public is made aware of this topic," is how IGB researcher Michael T. Monaghan described the alliance's mission.

Find out more
→ www.allianceforfreshwaterlife.org

Darwall, W. et al. (2018). The Alliance for Freshwater Life: a global call to unite efforts for freshwater biodiversity science and conservation. Aquatic Conservation, 28(4), 1015-1022. doi:10.1002/aqc.2958

A Newcomer

"I am very keen to progress further towards a deeper integration of science and science support, joining forces to create the best possible conditions for research at IGB," says Gwendolyn Billig, who was appointed the new Head of Administration at IGB on 1 January 2019. Our reply: welcome to the team!

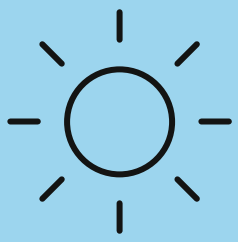
Photo: David Ausserhofer/IGB

Dr. Gwendolyn Billig, verwaltungsleitung@igb-berlin.de

FRESHWATER NEWS

Do you wish to be up to date of the latest developments in our freshwater research and hear 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 the topics we address.

Subscribe now
→ www.igb-berlin.de/en/newsletter



Extreme weather events are a threat to crop yields and soil. Intensive land use is also having an increasingly negative impact on freshwater ecosystems.

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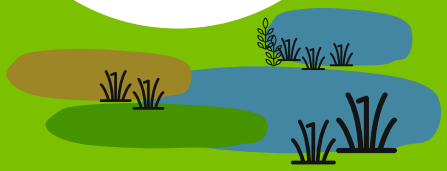
If global warming and nutrient contamination increase simultaneously, lakes emit more greenhouse gases, causing climate change to accelerate.

→ page 11



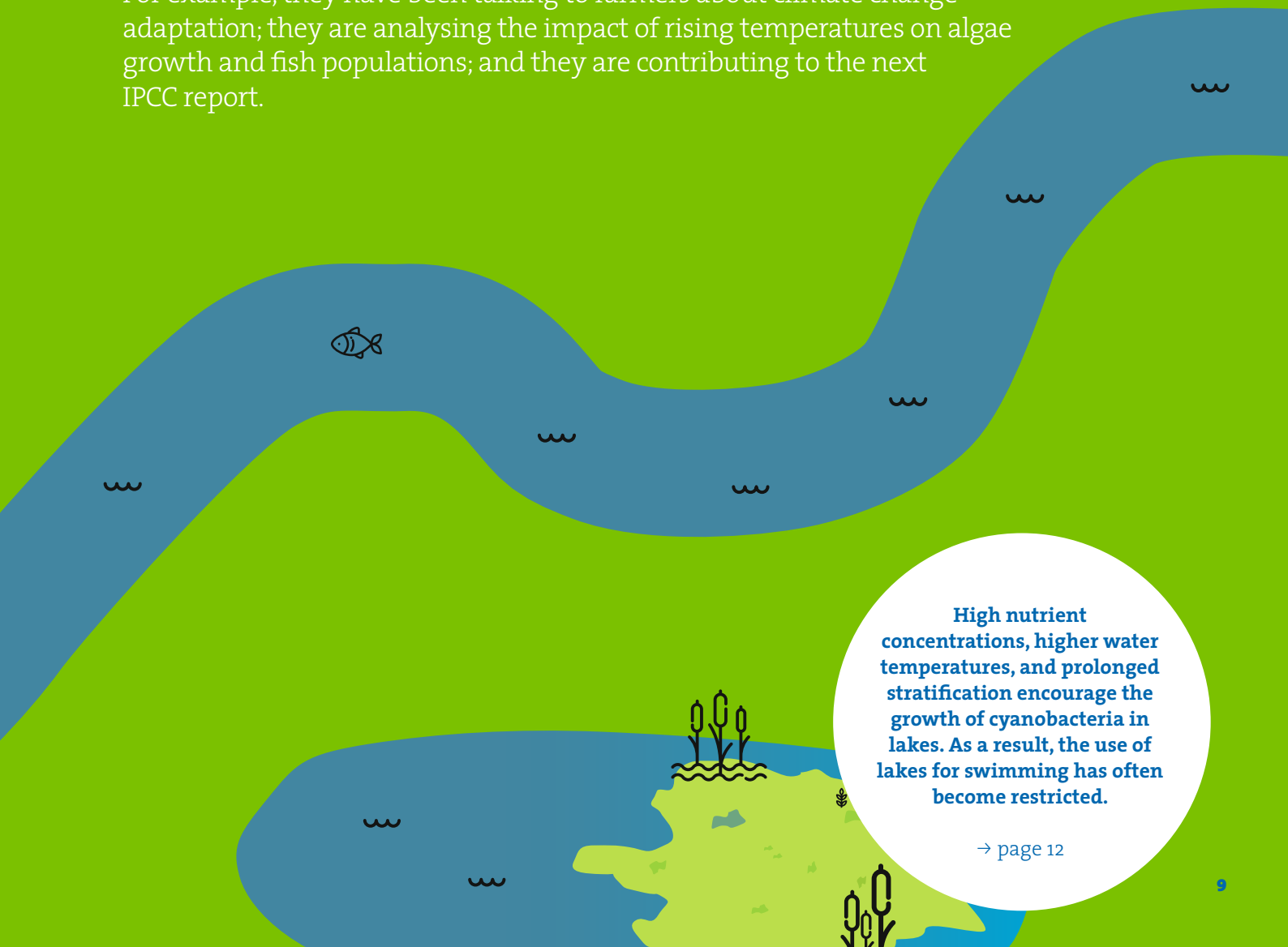
The number of freshwaters throughout the world that intermittently run dry is increasing. Many freshwater fish species are affected by these fluctuating conditions, especially in Southern Europe.

→ page 14

In the Context of Climate Change

How global warming and extreme weather phenomena affect our freshwaters

Global warming is on the rise, as is the frequency of extreme weather phenomena. Climate change is already putting significant stress on freshwater ecosystems. Since the sediments of lakes and rivers also emit greenhouse gases, freshwaters contribute to climate change. IGB researchers are addressing climate change in a wide range of projects. For example, they have been talking to farmers about climate change adaptation; they are analysing the impact of rising temperatures on algae growth and fish populations; and they are contributing to the next IPCC report.



High nutrient concentrations, higher water temperatures, and prolonged stratification encourage the growth of cyanobacteria in lakes. As a result, the use of lakes for swimming has often become restricted.

→ page 12

Lakes suffer from...

Climate

Climate change is putting pressure on lakes, irrespective of whether they are shallow or deep, large or small. This is mainly due to rising temperatures and extreme weather events, as well as excessive amounts of nutrients entering water bodies.

Phenology – the timing of seasonal events over the course of the year– determines the rhythm of lakes. When temperatures rise, they freeze over later and less often, and the ice on the surface starts melting earlier. Increased light and heat cause algae to grow earlier in spring. The thermal cycle of lakes reacts particularly sensitively to rising air temperatures and the corresponding elevated water temperatures. This cycle governs the seasonal mixing of the water column: as if with an engine, oxygen and nutrients are distributed evenly. An increase in hot weather periods in summer also causes shallow lakes, such as Lake Müggelsee in Berlin, to stratify more frequently. Lakes that are very deep, such as Lake Constance, no longer cool down sufficiently during warm winters and, as a result, no longer mix down to the bottom every year. In other words, climate change is altering the types of stratification, usually to the detriment of mixing.

The altered thermal structure is also likely to reduce oxygen levels in lakes. This lack of oxygen poses a further problem: chemical processes trigger the release of nutrients previously captured in the sediment, such as phosphorus. Lakes are unintentionally fertilising themselves, as it were. And yet, nutrient releases such as these are just a small part of the problem: lakes have also suffered badly from decades of nutrient inputs from agriculture (→ page 15) and from wastewater discharges. These two factors are the main contributors to excessive algae growth. Many lakes have been affected by increased precipitation brought on by climate change, due in part to intense rainfall events. This in turn results in increasing nutrient loads from the surrounding area, especially of dissolved organic carbon.

While on the topic of algae growth: not only high nutrient concentrations, but also higher water temperatures and prolonged stratification encourage the prolific growth of cyanobacteria in lakes. This can lead to the formation of dense carpets of algae on the water surface in summer, making it unpleasant to use such lakes for swimming.

Lakes are vital habitats that are crucial to many plant and animal species, as well as to humans; they are also a key component of the global ecosystem. The extent and rate at which climate change will further affect lakes remains to be seen, particularly since increased water use and water scarcity in parts of the world are an additional burden on lake ecosystems. However, one thing seems certain: lakes are in a highly stressed condition, and this is likely to get worse in years to come.

In the IGB Dossier "Lakes under climate change: diagnosis and prognoses from long-term research", we provide a summary of the changes that lakes are already undergoing and of the scenarios that are likely to occur.

The dossier is available for download free of charge
→ http://bit.ly/climate-change-dossier

Professor Rita Adrian, adrian@igb-berlin.de
Dr. Tom Shatwell, tom.shatwell@ufz.de

Lakes cause...

Stress

It is true that lakes are greenhouse gas sinks? Yes. But there's a catch: they may also release increasing amounts of methane and carbon dioxide, making them a major source of greenhouse gases, too. The more gases that are emitted from freshwaters into the atmosphere, the faster the rate of global warming: a vicious circle, therefore, that exacerbates climate change.

Two-thirds of the earth's surface is covered with water, which is most useful: after all, large water bodies are able to bind climate-impacting greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4). This task is mainly performed by oceans, but lakes also play a role.
And yet it seems as though the matter is becoming too "hot" for them. The summer surface temperature of lakes worldwide has risen by an average of 0.34°C over the last 30 years (→ page 12). And as temperatures rise, lakes tend to emit rather than absorb greenhouse gases: a Dutch laboratory study undertaken with the involvement of IGB showed that a temperature increase of 1°C caused 6 to 20 per cent higher methane emissions from water bodies. A 4°C increase in the lab resulted in 51 per cent more methane emissions.

What causes this increase? Methane is normally produced when organic matter is broken down in the sediment of lakes. Methane then rises in small gas bubbles from the sediments to the water surface, where it is released into the atmosphere. This process is dependent on temperature and on the availability of organic matter. This is why tropical reservoirs emit particularly large quantities of methane. Saturated rainforest areas and the higher temperatures experienced in those regions are the ideal conditions for decomposition processes, and therefore also for the development of methane. The global boom in dam building may therefore cause an increase in greenhouse gas emissions, facilitated again by rising temperatures.

But that's not all. Methane is formed not only in the sediment, but also in the water column. Methane-producing cyanobacteria play an important role in this respect. Cyanobacteria like it when lakes have plenty of nutrients; they are also fond of high temperatures: they thrive under these conditions, and methane production is able to "bloom".

Although methane formed in the sediment or water can be broken down directly in the lake by microorganisms that metabolise methane, only part of the methane is degraded. This microbial process is also dependent on temperature. Global warming may therefore intensify the formation and consumption of methane in lakes.

It is plain to see that lakes play an important role in the concentration of greenhouse gases in the atmosphere. Whether they act as sinks or sources of greenhouse gases depends on the environmental conditions. If global warming and nutrient loads increase simultaneously, lakes will emit more greenhouse gases, causing climate change to accelerate.

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Dr. Gabriel Singer, singer@igb-berlin.de
PD Dr. Sabine Hilt, hilt@igb-berlin.de

"The final statements contained in the IPCC report must be solidly scientifically substantiated."

Rita Adrian heads the Department of Ecosystem Research at IGB. Photo: IGB/David Ausserhofer

Professor Rita Adrian is engaged in the long-term and climate impact research of lake ecosystems at IGB. The Intergovernmental Panel on Climate Change has selected her as a lead author of the IPCC Sixth Assessment Report (AR6), which is due to be released in 2021/22. Professor Adrian was also involved in the IPCC Fifth Assessment Report, published in 2014, supporting the work of the lead authors as a contributing author.

Professor Adrian, how exactly have you contributed to the IPCC, and what is your current involvement?
It takes several years to write such a report involving a large international team of authors. For the upcoming IPCC Assessment Report, I (and several other lead authors) am responsible for the chapter on *Terrestrial and freshwater ecosystems and their services*. We have regular email contact, and met in person for the first time in January 2019. Three further meetings will follow. I see this work as my contribution to bring scientific results into policy, something I am happy to do. I consider it part of my responsibility as a researcher for the general public.

What approach do you and your co-authors take?
We draw on existing peer-reviewed scientific literature and previous reports to assess the impact of climate change on terrestrial and freshwater ecosystems and their biodiversity. From this vast array of studies we extract the key impacts of climate change on e.g. freshwater ecosystems that are more or less universally valid and apply labels of confidence. The final statements contained in the report must be solidly scientifically substantiated.
The impacts of climate change e.g. on lakes are extremely complex, and depend heavily on the individual conditions of each lake, such as its size and depth, its geographic location and catchment area. Nevertheless, key responses can be identified and categorized by confidence levels.

How are the effects of climate change and global warming being felt in lakes?
Rising air temperatures result in an increase in water temperatures. The climate impact studies we conduct at IGB are based on the long-term research of Lake Müggelsee and other lakes around the world. We have series of measurements that go back 40 or 50 years, which enable us to calculate trends. For example, the global average temperature of lake surface water in summer has increased by 0.34°C per decade since the 1980s. In addition, ecosystems are increasingly exposed to extreme events such as heatwaves and storms, with the latter often accompanied by heavy rainfall. All these factors affect a lake's thermal structure and nutrient dynamics (→ page 10).

How does warming affect lakes?
The effects are multi-faceted; let me give two examples: First, the warming trend leads to an increase in the duration of the stable thermal stratification of lakes in summer. Fish moving from cold, deep oxygen-free water to higher layers are then exposed to high water temperatures and insufficient oxygen levels. This can lead to mass fish kill as we observed this past summer. The second example of how warming affects lakes involves ice formation. Model calculations for Lake Müggelsee show that the percentage of ice-free years will increase from the current rate of two to sixty per cent by the end of the century. This represents an 800 kilometre geographical shift south for Lake Müggelsee, putting it on a par with northern Italy.

The interview was conducted by Kristina Simons.

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Read the complete version of the interview on our website
→ www.igb-berlin.de/en/news/igb-contributes-ipcc-report

Preparing Urban Lakes for Climate Change

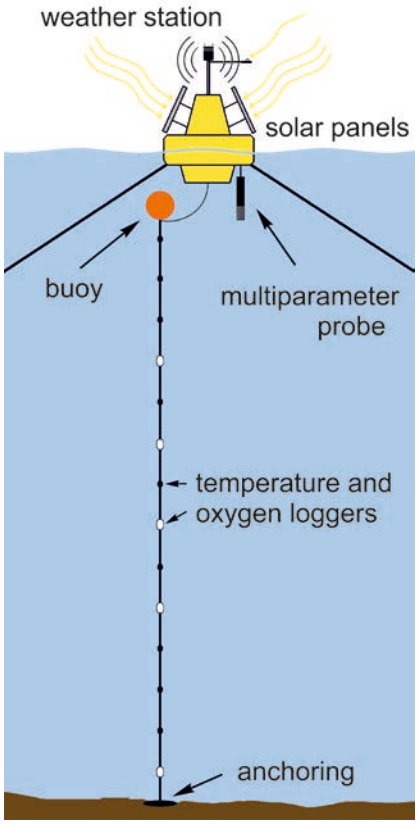
The summer of 2018 was exceptionally hot and dry, and also affected Berlin's urban lakes, which experienced record-breaking temperatures: Lake Müggelsee and Lake Tegel recorded water temperature highs of 29.9°C and 28.6°C; other lakes such as Lake Arendsee, Saxony-Anhalt's largest natural lake, also recorded their highest water temperatures ever. Moreover, there was an increasing number of reports of sudden fish kills and explosions of cyanobacteria throughout Germany.

In view of such developments, the question arises as to how climate change will affect our waters in the future, and which adaptation strategies must be taken to ensure the availability of consistently high-quality water. To investigate these questions, we looked to the future of Lake Tegel, which plays a major role in the provision of drinking water to Berlin's population. Using a modelling study, we examined forecasts of climate impacts and management up to the year 2100. The results of the model show that this urban lake will experience an increase in water temperatures and prolonged summer stratification. We then linked these results to a water resource model, and developed scenarios to quantify the impact of different management options. The model revealed the levels of oxygen, phosphate and nitrate that would be likely to occur throughout the year in the future. Adapted management can influence these levels: climate-induced impacts diminish when operation of the lake's surface-water processing plant is gradually increased.

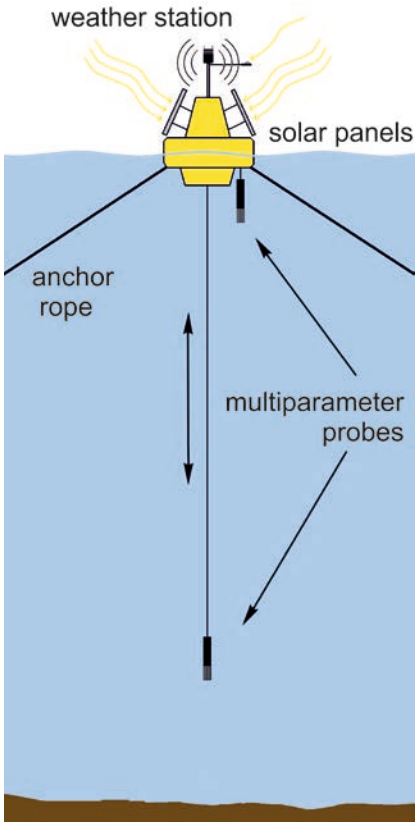
On the whole, our study confirms that climate change may increase the amount of effort required to maintain a good level of water quality in lakes. The calibration and validation of the numerical models was based on long time series that only exist in the necessary temporal resolution for a small number of lakes. IGB is therefore supporting the ongoing efforts of Berlin's Senate Department and of the relevant agencies of other federal states to establish climate impact monitoring for a larger number of lakes. To provide long-term monitoring, the installation of an autonomous measuring buoy at the deepest point of the lake and real-time remote data transmission are the best ways to comprehensively record climate-induced changes in temperature and other parameters. The remote transmission of real-time measurements to specialised agencies can also act as an early warning system, enabling measures to be taken to prevent phenomena such as fish kills.

Dr. Michael Hupfer, hupfer@igb-berlin.de
Dr. Robert Ladwig, ladwig@igb-berlin.de

Ladwig, R. et al. (2018). Climate change demands adaptive management of urban lakes: model-based assessment of management scenarios for Lake Tegel (Berlin, Germany). Water, 10(2), 1-23. doi:10.3390/w10020186



Measuring buoys can be used to monitor the impact of climate change on lakes. These buoys are equipped with meteorological sensors, a near-surface multi-parameter probe, a stand-alone power supply and remote data transmission. At the top is an additional measuring chain featuring temperature and oxygen loggers; at the bottom is an additional multi-parameter probe that collects data at different depths, several times a day. | Graph: Sylvia Jordan



Mediterranean Freshwater Fish Species Susceptible to Climate Change

Climate change significantly affects many European freshwater fish species. Together with an international team, Gregor Kalinkat, a biodiversity scientist at IGB, has been investigating which species are particularly at risk.

Dr. Kalinkat, what are the major challenges facing freshwater fish in the wake of climate change?
Dry inland waters, fluctuating water levels and, above all, rising water temperatures will have an adverse effect on numerous species in the future. According to the Red List of the International Union for Conservation of Nature (IUCN), around one-third of freshwater fish species are affected by the impacts of climate change. Consequently, they are among the world's most endangered species. We are currently witnessing this in heat-afflicted Australia, where hundreds of thousands of fish were found dead in many rivers in January 2019.

What about in Europe, which countries are affected most here?
We analysed 443 European freshwater fish species in our study. According to our results the "Top 20" vulnerable European species are exclusively in Greece, Spain and Portugal. Fish from extreme habitats that are characterised by heat and drought exhibit particular vulnerability when they come under even more extreme environmental conditions.

What suggestions do you have for managing Europe's freshwater fish?
Our results, and the results of other studies, are a clear indication that management measures should concentrate in particular on the Mediterranean region. The species most susceptible often have smaller body sizes, they are rare species with small distribution areas, and they are therefore not necessarily of direct economic relevance. And yet they sometimes play an important role in food webs and ecosystems. I would like to see protective measures focusing not only on fisheries, but also on conserving species communities and the complex services they provide to nature and humans.

Dr. Gregor Kalinkat, kalinkat@igb-berlin.de

Jaric, I. et al. (2019). Susceptibility of European freshwater fish to climate change: Species profiling based on life-history and environmental characteristics. Global Change Biology 25(2), 448-458. doi:10.1111/gcb.14518

Photo: IGB/David Ausserhofer

Photo: IGB/David Ausserhofer

Global Warming Promotes the Growth of Phytobenthos

Global warming has a profound impact on the functioning of aquatic ecosystems. However, the specific effects on primary producers in combination with their consumers is as yet little understood. This is particularly the case for phytobenthos (periphyton), which grows on all submerged surfaces in aquatic ecosystems. Temperature has an impact not only on the growth of such algae, but also on feeding losses caused, for example, by sea snails. We spoke to Sabine Hilt about the effects that global warming may have on these processes in the future.

Dr. Hilt, do algae generally benefit from higher temperatures, or might they also have an opposite effect?
Different species of algae have different optimum temperatures, but it can generally be said that elevated temperatures usually accelerate growth and increase production. And this is not only the case for phytobenthos, but also for their consumers. So the question is: what is the net effect?

And what is your answer to that question?
We showed that the rate of phytobenthos production doubles in spring with a temperature increase of 4°C. From the month of June, however, this effect was entirely offset by the increased grazing pressure of their consumers. To investigate this phenomenon, my doctoral student Garabet Kazanjian participated in a large-scale experiment on the effects of global warming at the Netherlands Institute of Ecology (NIOO). The experiment involved simulating shallow lake ecosystems in eight large tanks in the lab. In four of those tanks, the water was increased by 4°C compared to the current temperature of the relevant shallow lakes.

What do these changes signify for aquatic ecosystems?
Increased periphyton production not only influences food supplies the increased shading of submersed plants also has an impact on the entire structure of the ecosystem. This may have negative consequences for the ecosystem's biodiversity, for greenhouse gas emissions and for carbon deposition.

PD Dr. Sabine Hilt, hilt@igb-berlin.de

Kazanjian, G. et al. (2018). Impacts of warming on top-down and bottom-up controls of periphyton production. Scientific Reports, 8, 9901. doi:10.1038/s41598-018-26348-x

How Farmers can Adapt Better to Climate Change

Ground cover and timely tillage are increasing in importance, in view of greater aridity in spring and late summer. | Photo: Andreas Gericke/IGB

Extreme weather events such as the heavy rainfall in June 2017 and the dry summer of 2018 inevitably raise the question of what climate action to take and how to adapt to climate change, including in agriculture. After all, the increased occurrence of such events poses a threat to crop yields and soil quality. Intensive land use is also having an increasingly negative impact on freshwater ecosystems. And yet, in contrast to the case of climate action, very few structures concerning climate change adaptation exist up to this point. Researchers involved in the BAUM project have investigated the regional climate of Berlin-Brandenburg as a case study. These scientists have identified the consequences of climate change and measures that farmers may take to adapt to these changes. Their key findings are summarised below:

1 Brandenburg's farmers are aware of climate change; most view these changes in a negative light. Nonetheless, only half of the respondents consider climate change adaptation to be important.

2 Data from weather stations and climate models confirm the farmers' perceptions: not only are temperatures and the number of very hot days on the rise spring droughts and erosive heavy rainfall have also increased over the past 30 years.

3 We can expect to experience a larger number of very hot days (+ 4 to 5 days) and higher mean temperatures (+ 0.7°C in summer and + 1.3°C in winter) by the middle of this century. There is also a growing risk of soil erosion, with an increase of up to 40 per cent. Groundwater recharge will increase by 10 per cent in winter, and will tend to decline in summer.

4 The major climatic fluctuations currently being experienced show that agriculture must generally respond more rapidly and flexibly to climate change and weather anomalies. To achieve this, there must be greater use of regional, data-based climate analyses in practice.

5 There will always be a degree of uncertainty surrounding statements on climate. By cultivating a wider range of varieties and species, and by increasing the humus layer in the soil, farmers will be better prepared to face the challenges of climate change. Switching to organic farming may also mitigate the risks of climate change, since it involves greater ground cover and less fertiliser use. Less than 10 per cent of arable land in Berlin-Brandenburg is farmed organically, although there are significant regional differences.

6 Conservation tillage, involving the (partial) absence of ploughing, is one effective method of protecting soils, which many farms consider to be an attractive alternative. This method of tillage is used on more than half of Brandenburg's arable land. However, conservation tillage requires the increased use of herbicides.

7 Rising temperatures and rainfall shifts in winter will increase the importance of retaining water in the soil. This also involves the more effective protection of wetlands.

8 The state administration is also been called upon to act: in light of the 50 per cent average increase in erosive intense rainfall events as well as the nitrogen balances calculated in the BAUM project, it is necessary to require a new designation of risk areas for high nutrient emissions into water bodies for the European Water Framework Directive.

9 Local authorities need to expand and optimise their wastewater treatment plants. For example, a third of the nutrient inputs that enter water bodies in Berlin-Brandenburg originate from agriculture. But in order for the River Havel to achieve good chemical status by 2027, for instance, nitrogen loads would have to be reduced by one third, and phosphorus loads by 16 per cent. This goal cannot be achieved by agricultural measures alone.

The results of the project are provided in a brochure, available for download (in German only). The brochure also suggests further reading → http://bit.ly/BAUM-Broschuere

Project: Climate change and weather anomalies: Assessment of agri-environmental measures (BAUM), **Duration**: 10/15-06/18, **Funded by:** Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMU), **Overall coordination: Dr. Andreas Gericke**, gericke@igb-berlin.de, **Involving:** Department 1, Research Domain 3

Growing urbanisation calls for new food security concepts, such as urban farming. The potential of urban aquaponics is being evaluated in a new project.

→ page 23

Regions that have experienced a sharp decline in flying insects also have high levels of light pollution.

→ page 20

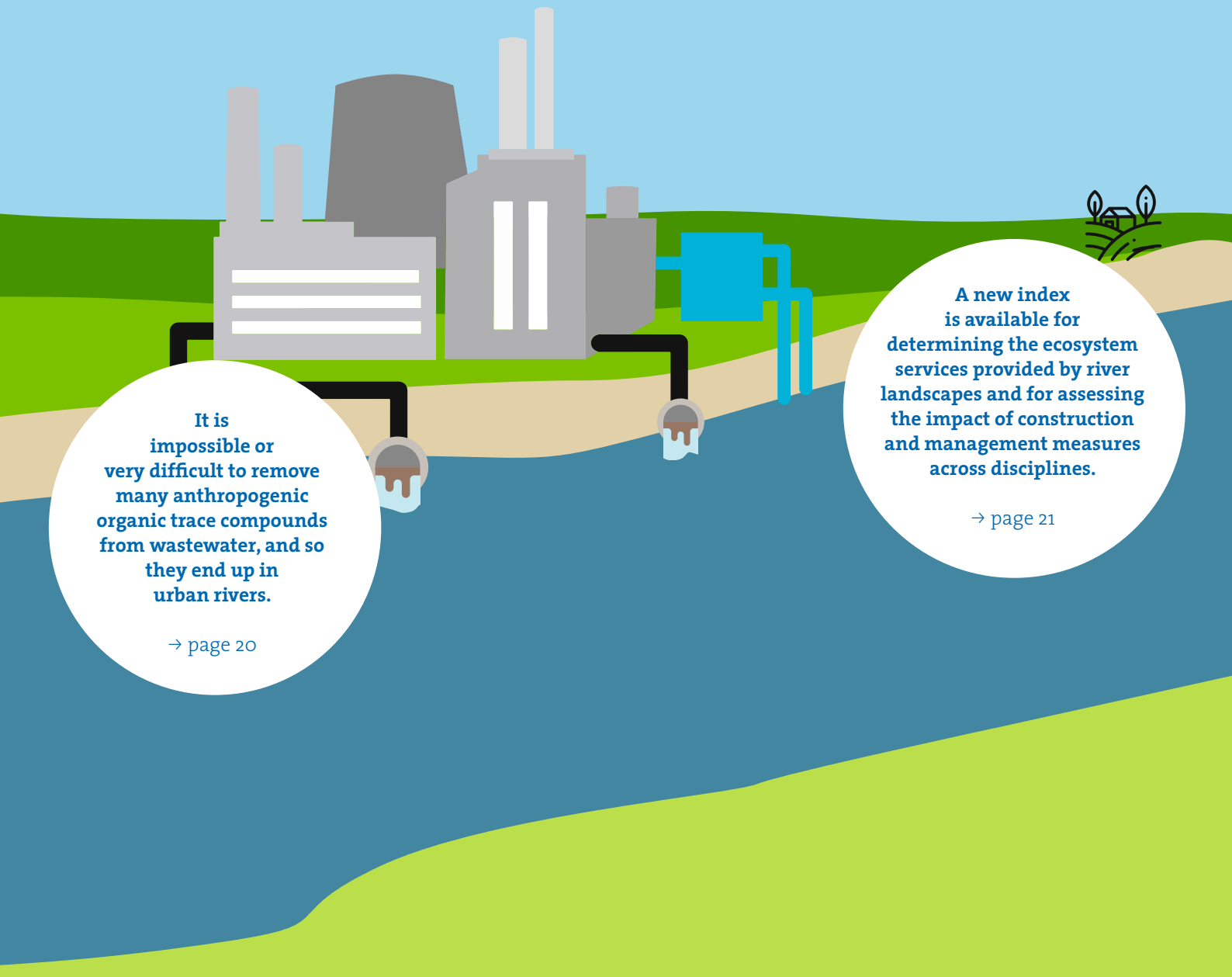
As popular places for recreation, there is considerable pressure on urban waters in particular. Even though there are usually only a few days each year when recreation activities are extremely high, they may have a considerable and long-term impact on freshwater ecosystems.

→ page 18

City, Country, Waters

Ecosystems with a future? Lakes, rivers, etc.
in urban and rural areas

Life without freshwaters is hard to imagine, whether in the city or the country. And yet they are at risk from all sides, from factors such as microplastics and overuse – both of which are issues being scrutinised by IGB researchers. These researchers have also developed an index that can be used to measure the value of river landscapes and to determine water cleanliness in urban ponds – and how they are perceived by the locals.



It is impossible or very difficult to remove many anthropogenic organic trace compounds from wastewater, and so they end up in urban rivers.

→ page 20

A new index is available for determining the ecosystem services provided by river landscapes and for assessing the impact of construction and management measures across disciplines.

→ page 21

“Fencing in is not an option.”

Scarcely any research has been undertaken on many different recreational uses of freshwaters. | Photo: Florian Möllers/AVN

Freshwaters play a central role when it comes to recreational activities. The impact of such activities on lake and river ecosystems has so far largely been ignored in water management or has, at best, resulted in use restrictions. Markus Venohr and Christian Wolter want to change this – and also revealed in an interview what users prefer and what disturbs them most when seeking waterside relaxation.

Mr. Venohr, Mr. Wolter, in your latest project AQUATAG you explore the extent to which human recreation affects freshwaters. How did this come about?

Christian Wolter: Anthropogenic effects on freshwaters are an important aspect of our research. In the past, however, we focused mainly on commercial use, i.e. impairments due to shipping or the input of agricultural nutrients. Regarding the question of how to revitalise freshwaters, recreational use automatically became the focus of attention after all, motorboats are also used privately...

Photo: Andy Küchenmeister/IGB

“The environmental burden on freshwaters sets in long before recreational users perceive any changes.”
MARKUS VENOHR

Markus Venohr: ...and then there are also canoeists, dog-walkers and swimmers, all of whom use lakes and rivers for different purposes. All in all, recreational activities place considerable pressure on freshwaters, particularly in cities; so far, however, we know too little about this phenomenon. What conditions determine the number of people who go to rivers and lakes at particular times? There is very little data on this; and the information that is available, such as the annual average number of bathers, is inappropriate for identifying use peaks. Although peaks usually only occur on a few days each year, they may, under certain circumstances, have a considerable and long-lasting impact on ecology.

What distinguishes such peaks, and why do they have such an impact on freshwaters?

MV: Bathing waters in particular are very popular on hot, sunny days; further the number of visitors is much higher on weekends and during the holidays compared to on working days. We want to find out at which point the burden becomes problematic for the ecology of freshwaters.

CW: In this context, we are also interested in the question of any feedback effects there may be between use and burden. If large numbers of


Photo: Andy Küchenmeister/IGB

"It would be conceivable for waters that already attract visitors to be defined as 'victim waters' where good infrastructure should then be installed including access roads, car parks and toilet facilities. In this way, use pressure can be managed, and other waters in the area will become less busy."
CHRISTIAN WOLTER

people visit a bathing lake and its ecosystem suffers, will this affect the use of the lake? Surveys have revealed that visitors prefer moderately damaged ecosystems such as a "tidy" beach with little plant cover and no aquatic plants on the shoreline where user satisfaction is much higher than with near natural conditions.

What do bathers consider to be particularly important?
MV: Those wishing to swim attach great importance to clear water; waste was also often mentioned a disturbing factor. Interestingly, other users are likewise undesirable. If a bathing area is overcrowded, this may be considered more annoying than waste or other disturbances. However, preferences differ depending on the type of user. For example, a good water quality means something completely different to anglers; they prefer murkier, i.e. nutrient-rich water where fish are able to thrive. Boaters, on the other hand, prefer to see less aquatic plants. In any case, the environmental burden on freshwaters sets in long before recreational users perceive any changes. We are interested in such threshold values: what level of use pressure results in the permanent impairment of ecosystems?

CW: We have already managed to define such a value for commercial shipping on federal waterways. Juvenile fish near river banks are adversely affected when more than six to eight cargo vessels pass by each day. We want to identify similar thresholds for recreational uses. To do so, we are investigating both less used and heavily used freshwaters, also to differentiate between the effects resulting from recreational use and those resulting from other phenomena. The Spreewald region, for example, has watercourses that are used to different extents: ranging from completely protected ditches and less frequented tributaries to the heavily used main routes this provides us with the ideal opportunity to compare the different types of watercourse. We are also investigating the lakes of the Kaulsdorf district, located in the city of Berlin, which are very busy in summer, as well as lakes in Brandenburg where at most a few village children go swimming.

The aim of your studies is to adapt water protection measures. Can you give me an example of such an adaptation?
MV: We consider it important to include both user satisfaction and ecological impacts in our studies. Some water authorities, for example, have imposed a maximum permitted number of canoes. So far, however, limits have not been defined on the basis of scientific findings; and user's acceptance is often low. But if we are able to prove that the environmental burden is indeed critical from a certain number of canoes, there will be greater acceptance of such limitations.

CW: It would also be conceivable for waters that already attract visitors to be defined as "victim waters" where good infrastructure should then be installed including access roads, car parks and toilet facilities. In this way, use pressure can be managed, and other waters in the area will become less busy. It is virtually impossible to achieve complete protection after all, fencing waters in is not an option. However, our objective should be to ensure that natural water landscapes do not continue to deteriorate, but are able to recover.

In a city like Berlin, this is obviously only possible to a limited extent. What can be done there?
MV: In Berlin, many waterside areas are built up; people are unable to access or enjoy them. Opening up such areas to a certain extent would offer potential for better enjoyment of urban waters and for protecting species and biotopes.

The interview was conducted by Wiebke Peters.

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Dr. Christian Wolter, wolter@igb-berlin.de

Project: AQUATAG, **Duration:** 03/17-12/17 and 03/19-02/22, **Funded by:** BMBF, **Overall coordination:** Dr. **Markus Venohr**, venohr@igb-berlin.de, **Involving:** Departments 1 and 4, Research Domain 3

Venohr, M. et al. (2018). The underestimated dynamics and impacts of water-based recreational activities on freshwater ecosystems. Environmental Reviews, 26(2), 199-213. doi:10.1139/er-2017-0024

Potentially Self-Cleaning: Urban Waters

It is impossible – or at least very expensive and difficult – for wastewater treatment plants to completely remove anthropogenic organic trace compounds, such as those originating from pharmaceutical products, from wastewater. This means that they end up in urban rivers. This is why high concentrations of such substances are often found in rivers, such as the Erpe, a small river near Berlin. IGB researchers have explored whether urban river systems have a "self-cleaning potential" for trace substances, i.e. whether their concentrations in aquatic ecosystems can be reduced by degradation processes within the river itself. The researchers have shown that the riverbed plays an important role in this process: part of the water penetrates the sediment bed (the hyporheic zone), continues to flow through this zone, and then returns to the river. The levels of some anthropogenic trace substances, such as the anti-epileptic drug gabapentin, decrease along these flow paths. Investigations of longer river sections have demonstrated that intensive hyporheic exchange may significantly reduce concentrations of trace substances. Near-natural or revitalised river courses are also conducive to this type of exchange.

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→ www.uwi.tu-berlin.de
→ www.bayceer.uni-bayreuth.de/hypotrain

Schaper, J. L. et al. (2018). The fate of polar trace organic compounds in the hyporheic zone. Water Research, 140, 158-166. doi:10.1016/j.watres.2018.04.040
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Light Pollution Affects Insects

Research area at *Naturpark Westhavelland* | Photo: Maja Grubisic/IGB

Native insect communities are highly vulnerable to climate change, pesticides and land use change. IGB scientists have discovered that regions that have experienced a sharp decline in flying insects also have high levels of light pollution.

The team, led by Maja Grubisic and Franz Hölker, analysed reserach areas from a 2017 long-term study, and demonstrated that these areas exhibit above-average levels of light pollution. The researchers then evaluated individual studies on the effects of artificial light on insects at night, and found that there is strong evidence to suggest a credible link between light pollution and declines in insect populations. For example, flying insects are attracted by artificial lights and, at the same time, are drawn away from other ecosystems. As a result, they die from exhaustion or are taken as easy prey. Additionally, rows of light prevent flying insects from spreading. The resulting lack of genetic exchange could reduce insect populations' resistance to other negative environmental influences.

The results of the overview study show that artificial light at night is widely present, and can have complex effects on agricultural areas, with unknown consequences for the biodiversity in agroecosystems. For this reason, light pollution should generally be taken into account as a potential stress factor in future studies.

Find out more
→ www.igb-berlin.de/en/news/light-pollution-reason-insect-decline

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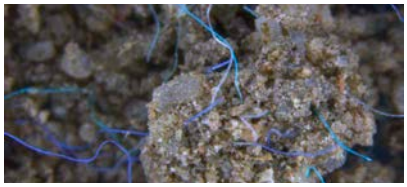
Dr. Maja Grubisic, grubisic@igb-berlin.de

Grubisic, M. et al. (2018). Insect declines and agroecosystems: does light pollution matter? Annals of Applied Biology, 173(2), 180-189. doi:10.1111/aab.12440

Microplastics: Risks and Side Effects

Millions of tons of microplastics end up in soils and freshwaters each year. In previous studies, researchers from IGB have demonstrated that these tiny plastic particles may be harmful to ecosystems, such as when ingested by key aquatic organisms. Microplastics may even have direct damaging effects on the health of aquatic organisms and ecosystems, e.g. surfaces of microplastics can be densely colonised by harmful and toxic microorganisms. Such complexes, one example being biofilms, are a contributing factor to the faster spread of antibiotic-resistance genes and pathogens in the environment.

Chemical effects are also problematic at the decomposition stage of microplastics, as spotted by Anderson Abel de Souza Machado and his colleagues. Additives such as phthalates and Bisphenol A leach out of plastic particles. These additives can potentially disrupt



Polyacrylic fibres are prevalent in aquatic and soil systems. | Photo: Anderson Abel de Souza Machado/IGB

the hormone system not only of vertebrates, but also of several invertebrates. In addition, nano-sized particles may cause inflammation; they may permeate or change cellular barriers, and even cross highly selective membranes such as the blood-brain barrier. Microplastics also disrupt the naturally occurring interactions between soils and freshwaters. Microplastics could therefore turn out to be a new long-term stress factor for humans and the environment.

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Dr. Anderson Abel de Souza Machado, machado@igb-berlin.de

Arias-Andres, M. et al. (2019). Collateral effects of microplastic pollution on aquatic microorganisms: An ecological perspective. TrAC Trends in Analytical Chemistry, 112, 234-240. doi: 10.1016/j.trac.2018.11.041

Machado, A. A. d. S. et al. (2018). Microplastics as an emerging threat to terrestrial ecosystems. Global Change Biology, 24(4), 1405-1416. doi:10.1111/gcb.14020

Machado, A. A. d. S. et al. (2018). Impacts of microplastics on the soil biophysical environment. Environmental Science and Technology, 52(17), 9656-9665. doi:10.1021/acs.est.8b02212

Quantifying the Value of Rivers and Floodplains

River landscapes are subject to intensive use and management. So far, it has been difficult to assess the "services" that they provide from which humans benefit. A team of researchers and practice partners led by IGB has developed the River Ecosystem Service Index. This tool enables the ecosystem services provided by river landscapes to be depicted and the impacts of construction and management measures to be assessed across disciplines for the first time. The project was headed by Martin Pusch.

Dr. Pusch, rivers and floodplains are an integral part of the environment. What particular, possibly underrated, importance do humans attach to them?

Growing numbers of people spend their free time at or in surface waters (→ page 18-19), the quality of which has improved considerably in recent decades. At the same time we must ensure the health of our river ecosystems, as this also contributes to e.g. improving the water quality of the North Sea and the Baltic Sea, and to preserving aquatic biodiversity.

Why is it so important to be able to capture and quantify what is referred to as the "ecosystem services" provided by river landscapes?

Rivers are managed by water or shipping authorities, for example, which were traditionally only interested in ensuring compliance with their respective statutory provisions. Today, however, a wide range of objectives must be taken into account. What's more, according to the EU's Water Framework Directive, rivers should achieve a "good ecological status". We believe that the concept of ecosystem services is an appropriate basis for visualising the diverse interests and objectives involved. The visualisation of ecosystem services can

Rivers still featuring flood areas, such as the Spree shown here, are able to mitigate the height of flood waves. Photo: Martin Pusch/IGB

facilitate objective and targeted communication among various stakeholders, enabling multifunctional management methods to be found.

Which ecosystem services have you taken into consideration? Are some more important than others?
The "River Ecosystem Service Index" (RESI), which we developed in collaboration with ten project partners from across Germany, is based on the Common International Classification of Ecosystem Services (CICES), and treats all services equally. With the support of RESI, priorities should then be set within a transparent political process. Thereby most experts now agree that good water quality, species-rich floodplains and future-proof flood control can only be achieved if the priorities of other policy areas are subordinated to these three.

This is also why construction projects and other proposals involving river landscapes are considered complex and lengthy. What concrete benefits does RESI offer on site for such processes?
Until now, the impacts of such projects on the environment have been investigated using individual expert reports, which are often difficult to understand and are assessed in an incoherent way. RESI brings together large volumes of environmental data in an easily comprehensible manner. The tool thus enables an integrative comparison of planning scenarios. Besides, it also makes it easier to involve environmental associations and citizens in the process.

An index for everybody, in other words?
We are pleased that RESI has attracted great interest among federal and state environment agencies, as well as engineering companies. RESI also has a great potential for application to other rivers during implementation of two federal programmes, the "National Flood Protection Programme" and "Blue Ribbon Germany" *(Blaues Band Deutschland)*.

What do users need to calculate values using RESI? Where does the data come from?
Thanks to the legally enshrined right to access environmental data, these days there is luckily extensive satellite data, monitoring data and regional planning data available digitally at the EU, federal or state level. The effort required to collect and compare such data should not be underestimated however, but is worthwhile nevertheless.

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→ www.resi-project.info

Project: River Ecosystem Service Index (RESI), **Duration:** 06/15-10/18, **Funded by:** BMBF (Regional Water Resources Management for Sustainable Protection of Waters in Germany programme), **Overall coordination: PD Dr. Martin Pusch**, pusch@igb-berlin.de, **Involving:** Departments 1 and 2

A Look at the Book: the RESI Manual

The manual contains a detailed and clear summary of the River Ecosystem Service Index – a useful tool for organisations such as specialised authorities, water authorities and planning companies, available for download free of charge.

The section entitled **Ecosystem services of rivers and floodplains** provides an introduction to the topic, and describes the theoretical concept used as well as the classifications.

The authors present the methods used in the section on **Methodological foundations**: from the spatial scale and levels of evaluation to the individual model regions.

The section **Assessment and Valuation** gives an overview of the RESI tools, and describes how to assess the 16 different ecosystem services. A detailed description is given of the steps required for the calculation, indicators used and data sources, as well as the synthesis of data.

Specific case studies for the rivers Danube, Nahe, Nebel and Wupper are presented and calculated in the section on **Application in practice**.

Download (only available in German) → https://bit.ly/RESI-Handbuch

Podschun, S. A., Albert, C., Costea, G., Damm, C., Dehnhardt, A., Fischer, C., Fischer, H., Foeckler, F., Gelhaus, M., Gerstner, L., Hartje, V., Hoffmann, T. G., Hornung, L., Iwanowski, J., Kasperidus, H. D., Linnemann, K., Schmidt, M., Scholz, M., Schulz-Zunkel, C., Stammel, B., Thiele, J., Venohr, M., von Haaren, C., Wildner, M., Pusch, M. T. (2018). RESI-Anwendungshandbuch: Ökosystemleistungen von Flüssen und Auen erfassen und bewerten (Berichte des IGB; Vol. 31). Berlin: IGB. doi:10.4126/FRL01-006410777

Urban Algae: Ecology and Perception of Urban Ponds

In the "Urban Algae" project, 97 young researchers from a number of European limnological societies are investigating the ecological status of urban ponds and analysing how citizens perceive the ecosystem services provided by these waters. The project was developed by early-career scientists from IGB and from the Netherlands Institute of Ecology.

In summer 2018, the team took samples from 56 urban ponds across Europe to determine their ecological status on the basis of water chemistry and primary producer community composition. Since many urban ponds are used intensively for recreation (→ page 18), the team links the environmental data to data on citizens' perception of these ponds. This will be done using an online survey in spring 2019. With the aid of photographic material, the young researchers are keen to find out the extent to which the population values these waters. The initial results will be presented at the 11th Symposium for European Freshwater Sciences in Zagreb in 2019.

→ https://freshproject-urbanalgae.jimdo.com

Project: Urban Algae, **Duration:** 07/18-06/20, **Funded by:** European Federation for Freshwater Sciences, **Overall coordination: Sonia Herrero,** herrero@igb-berlin.de, **Cleo Stratmann**, cstratmann@posteo.net, **Susanne Stephan**, s.stephan@igb-berlin.de, **Dr. Mandy Velthuis**, velthuis@igb-berlin.de, **Involving:** Departments 2 and 3

A Futuristic Concept for Urban Farming: Using Aquaponics to Supply Urban Areas

Smart integrated multitrophic CITYFOOD production systems provide a water and energy saving approach to global urbanisation.

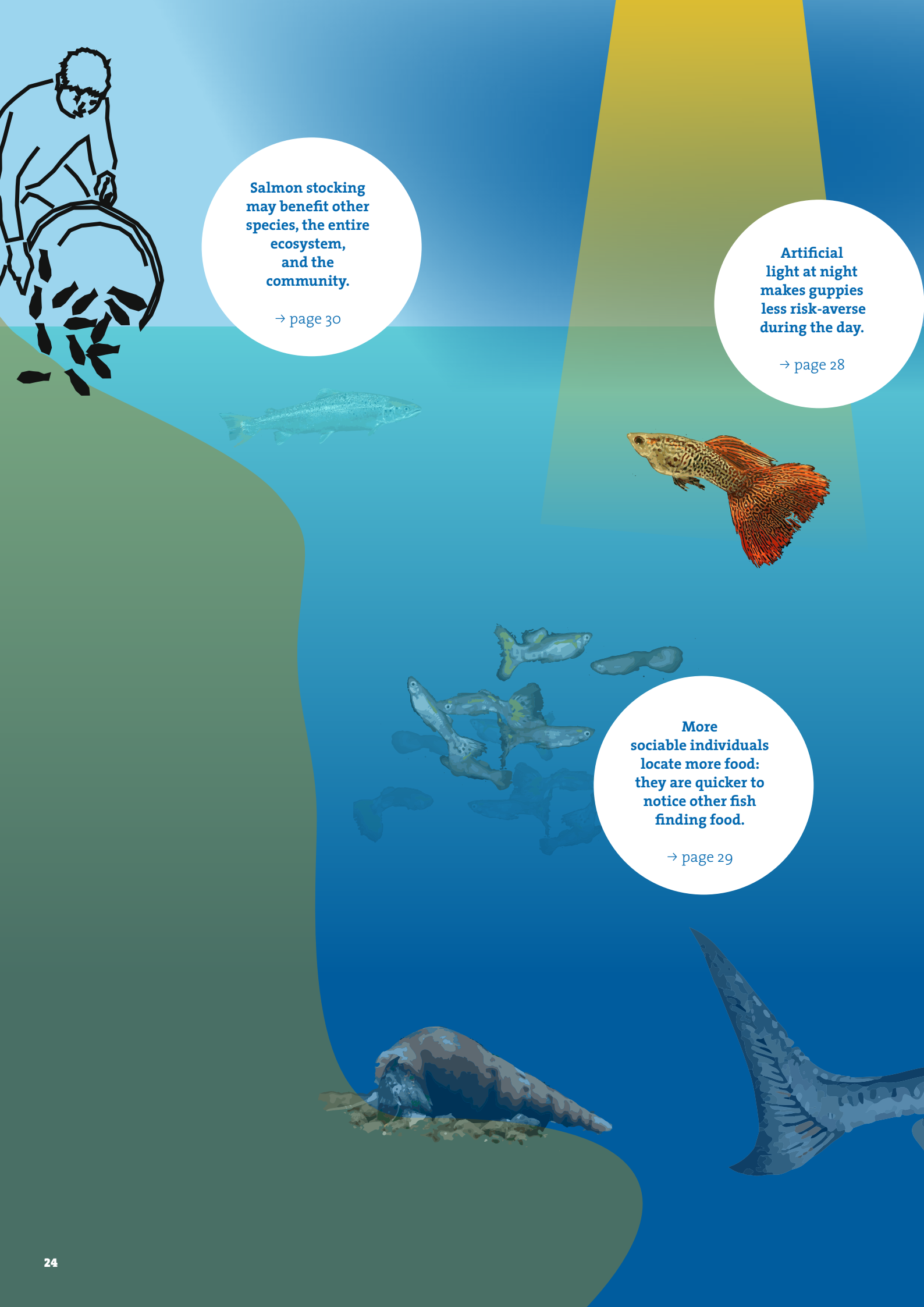
Graph: Holger Klimek

Projected increases in the world population and the urbanisation that will accompany it will require new concepts to ensure everyone has enough to eat. In light of this, urban agriculture opens up new opportunities. The CITYFOOD project investigates the potential of smart aquaponic systems for urban farming. Aquaponics simultaneously produces fish and plants in recirculation systems where fish water is used as fertiliser for the plants, which enables near zero-emission production of food from animals and vegetables. The project's team members are also analysing the water, energy and nutrient management of urban aquaponics, and evaluating urban planning conditions to apply these methods. Moreover, CITYFOOD is developing strategies to promote the popularity and application of this compact, resource-efficient system in urban areas. The international project team involves city planners, urban farmers, scientists, business leaders, politicians and citizens to achieve mutual goals.

→ www.cityfood-aquaponics.com

Project: CITYFOOD, **Duration:** 05/18-04/21, **Funded by:** the Belmont Forum and the European Union's Horizon 2020 (726744), **Overall coordination: Professor Werner Kloas**, werner.kloas@igb-berlin.de, **Dr. Daniela Baganz**, baganz@igb-berlin.de, **Involving:** Departments 4 and 5, Research Domain 3

Suhl, J. et al. (2018). Prospects and challenges of double recirculating aquaponic systems (DRAPS) for intensive plant production. Acta Horticulturae(1227), 449-456. doi:10.17660/ActaHortic.2018.1227.56


Salmon stocking may benefit other species, the entire ecosystem, and the community.
→ page 30
Artificial light at night makes guppies less risk-averse during the day.
→ page 28
More sociable individuals locate more food: they are quicker to notice other fish finding food.
→ page 29

Focusing on Fish

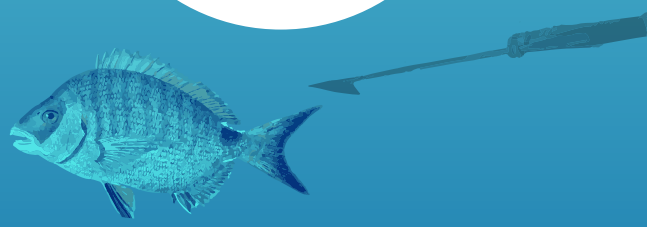
How fish live and survive, and what we can learn from their behaviour

Two new Clusters of Excellence investigate the topics of swarm intelligence and collective behaviour.

→ page 33

Fish can tell exactly whether or not a diver is carrying a speargun. They adjust their escape behaviour accordingly.

→ page 28



Fish play a key role in the research undertaken at IGB: as a food, as social beings, and as central players in aquatic ecosystems. We analyse their behaviour, put our heads together with other stakeholders to ensure their better protection, and reveal why it is that one species of cloned fish has been able to survive for 100,000 years. Fish are incredibly versatile – and a fascinating subject of research.

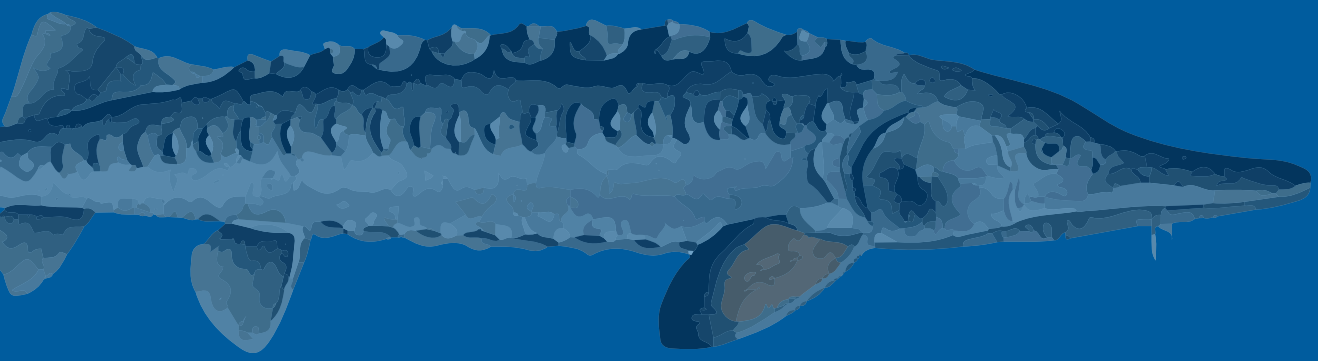


Photo: IGB/David Ausserhofer

Big Fish = Bold Fish?

An IGB study partially refutes the pace-of-life syndrome hypothesis

Fish are very diverse and fascinating study objects. Not only are these rapid-growing creatures ideal for exploring environmental topics, they are also of interest in behavioural and swarm research. In this interview, Thomas Mehner, Deputy Director of IGB, talks about a special doctoral project where fish play the main role: his doctoral student, Giovanni Polverino, was able to show that the pace-of-life syndrome, much discussed in biology at present, does not appear under all conditions. Read on to find out what exactly Polverino, now working in Australia, discovered – and why Thomas Mehner did not believe that the results were accurate at first.

Dr. Mehner, the pace-of-life syndrome is hotly debated among scientists, but otherwise little is known about it. What exactly does the hypothesis imply, and why did you decide to make it a subject of IGB research?
The fascinating thing about the pace-of-life syndrome is that basic theories from the fields of ecology, physiology and behavioural research were integrated into one single concept. This concept implies that an individual's metabolic activity, life history and behavioural patterns are interdependent and inter-related. Active, risk-prone individuals require a lot of energy; the interlinking of physiology and behaviour means that active individuals often reproduce earlier and have shorter lifespans. Slow, risk-averse individuals need less energy, and are therefore expected to reproduce later and have longer lifespans. We wanted to test this concept, asking ourselves: do these systematic differences among individuals exist regardless of their habitat? Do certain environmental variables only influence individual parts of the pace-of-life syndrome or the entire syndrome?

What exactly did you investigate?
We compared two populations of a fish species originating in very different conditions: the first mosquitofish population was taken from a pond that was regularly harvested, with around 80 per cent of adult individuals being taken each time, mimicking enormous predation pressure. The second mosquitofish population inhabited an undisturbed quarry. We maintained 40 first-generation individuals of each population of fish under identical conditions, and

"The fast-growing offspring from the heavily fished pond did not fit the pattern: despite being large with a high energy turnover, the fish were not bold."
THOMAS MEHNER

monitored their behaviour for six months, i.e. across all development stages.

And what did you find out?
It was remarkable that we were unable to assign particular behavioural types to early juvenile fish. Their behavioural patterns were not repeated each day. This changed as they got older; the behavioural spectrum became narrower, and easily distinguishable types evolved. After around three months, the mosquitofish had found their "personality", and variability in their own behaviour decreased. As expected, the populations differed in line with their variation in life history. The population from the quarry grew slowly and reproduced later, while the population harvested from the pond grew faster and reproduced earlier.

And did this confirm the pace-of-life hypothesis in the comparison between populations?
No. The dispersion of behavioural types in the comparison between populations should have differed markedly, because their environmental conditions differed considerably. The example of metabolism is striking: according to the hypothesis, animals are only bold and active if they eat a lot and allocate relatively few resources to reproduction, because an active life is very energy-intensive. We were able to confirm this for the slow-growing fish, offspring from the quarry lake. However, the fast-growing offspring from the heavily fished pond did not fit this pattern: despite being large with a high energy turnover, the fish were not bold.

What explanation do you have for this?
We have a hunch: as soon as there is strong selection pressure on an axis of the pace-of-life syndrome, it breaks, and the predicted correlations no longer exist. We do not know why that is, but predation pressure may well play a major role. One thing is for sure: the syndrome does not apply under all selection conditions.

You and Giovanni Polverino's project team had originally set out to find further confirmation of the pace-of-life syndrome. That was not the case – quite the contrary. What conclusion can be drawn from this?
Even celebrated constructs must be challenged. Sometimes biologists want to be like physicists, defining simple rules that apply everywhere. This is why the hypothesis caused such a sensation in the community: it was fascinating to formulate a cross-thematic theory for individuality. I, too, thought that we would find what we had expected. I was certain that the two populations would differ, but that the traits of individuals would develop in correspondence with the pace-of-life syndrome. I never thought that it would not be the case for one population.

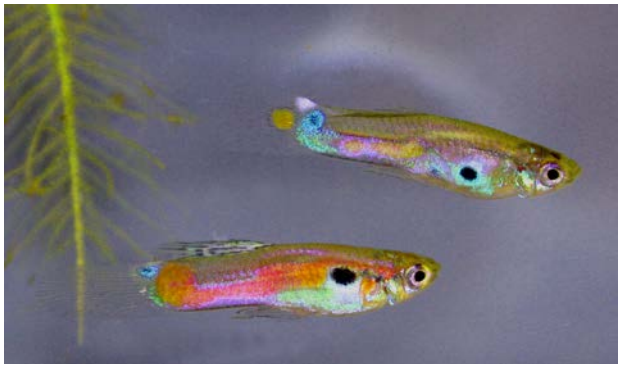
When did you realise what had happened?
When Giovanni showed me the schematic diagram reflecting the correlations between behaviour, physiology and life history. This interaction was apparent with the slow-growing fish, but not with their fast-growing counterparts. I thought there must be an error, that something had been calculated wrongly. But everything was correct, and we were delighted to have proven that the pace-of-life syndrome does not apply under all conditions. Because it now opens up another door, and we can ask: why is this not the case? There will certainly be more research on this aspect.

The interview was conducted by Wiebke Peters.

PD Dr. Thomas Mehner, mehner@igb-berlin.de

Project: B-Types, **Duration:** 07/13-06/17, **Funded by:** Leibniz Competition, **Overall coordination: Dr. Max Wolf,** wolf@igb-berlin.de, **Involving:** Department 4

Polverino, G. et al. (2018). Ecological conditions drive pace-of-life syndromes by shaping relationships between life history, physiology and behaviour in two populations of Eastern mosquitofish. Scientific Reports, 8, 14673. doi:10.1038/s41598-018-33047-0



Light pollution makes guppies more daring during the day. | Photo: David Bierbach/IGB

Light Pollution **makes Fish more Daring**

Artificial light at night makes guppies more daring, even during the day, according to a behavioural study led by researchers from IGB and the Max Planck Institute for Human Development. Exposing fish to artificial light at night not only made fish more active during the night, but also made them emerge quicker from hiding places during the day, which could increase their exposure to predators.

The scientists studied three groups of animals. Each group was exposed to the same bright light conditions during the day, but to different illumination levels at night. The first group experienced complete darkness at night; the second group was kept at a low light level at night, comparable to nocturnal illuminance under a street lamp; and the third group experienced bright light at night. After ten weeks of exposure, the scientists conducted behavioural tests to study the consequences of night-time light exposure on daytime behaviours.
The results: fish left their hiding places faster during the day and swam more often in the riskier, open areas of the aquarium when exposed to strong as well as weak artificial light at night. The light-exposed fish thus increased their willingness to take risks independent of the intensity of the light. The scientists suspect that the nocturnal light causes a stress response in the fish, and fish generally increase risk-taking when experiencing stress.

Read more → www.igb-berlin.de/en/news/light-pollution-makes-fish-more-courageous

Dr. Ralf Kurvers, kurvers@mpib-berlin.mpg.de
Dr. David Bierbach, bierbach@igb-berlin.de

Kurvers, R. H. J. M. et al. (2018). Artificial light at night affects emergence from a refuge and space use in guppies. Scientific Reports, 8, 14131. doi:10.1038/s41598-018-32466-3

Spearfishing **makes Fish more Timid**

Fisheries scientists from IGB and their international counterparts have been studying the response of fish in the Mediterranean Sea to spearfishing. The fish are able to carefully determine whether or not divers carry a speargun. They adjust their escape behaviour and keep a safe distance outside the shooting range.

The research team observed the behaviour of five coastal fish species in three areas of the Mediterranean Sea within and outside areas protected from spearfishing. The field study involved simulating a harmless diver on the surface simply wearing fins, but no speargun, and divers carrying spearguns.
The "flight initiation distance" was used as a behavioural indicator of fish timidity. This measure is defined as the distance a predator can approach its prey before the prey flees. Outside protected areas, the large fish started fleeing if a diver with a speargun approached from the water surface, even if it was still a far distance away. With divers without spearguns, these fish remained more relaxed and let them come closer. This discriminatory ability was especially evident in species known for being spearfishing targets: the more coveted and therefore hunted the species, the more pronounced the animals' apprehension toward the spearfishermen.

Read more → www.igb-berlin.de/en/news/spearfishing-makes-fishes-more-timid

Professor Robert Arlinghaus, arlinghaus@igb-berlin.de
→ www.ifishman.de/en

Sbragaglia, V. et al. (2018). Spearfishing modulates flight initiation distance of fishes: the effects of protection, individual size, and bearing a speargun. ICES Journal of Marine Science, 75(5), 1779-1789. doi:10.1093/icesjms/fsy059

A diver with a speargun approaching a fish from the water surface. | Photo: David Mandos, david@monvirtual.net

Social Fish **Find More Food**

How can you get hold of food when it is never present at the same time or in the same place? Wild guppies living in the rainforest of Trinidad are faced with this vital question every day. IGB researcher Lysanne Snijders has taken a closer look at such guppies in their natural environment, and has discovered what makes it easier for them to find food.

Three social, female guppies. | Photo: Lysanne Snijders

Trinidadian guppies live in rainforest streams that change rapidly between seasons, but sometimes also within a few hours. Next to algal remains, these fish eat small fruits or insects that drop into the water at random moments and in unpredictable places. Remarkably, some individual guppies appear to be consistently better at finding such unpredictable food items than others. Since having a good memory is probably not very useful in such a changing environment, some other individual traits or processes must have helped some fish to be consistently more successful than others.
To find out whether variation in being social might have played a role in their search for food, Lysanne Snijders' team gave wild guppies individual colour marks, and presented food items at random moments and at various locations in a natural pool.
The researchers discovered that more social individuals found more of the food items: they were quicker to notice other fish finding food. Also, males found more food resources than females. Possibly, being attracted to females, which themselves are strongly attracted to food, led the males to more food items.

Watch the video
→ www.youtube.com/watch?v=N9Z1Zai_eTg

Read the interview → www.igb-berlin.de/en/news/social-individuals-find-more-food

Dr. Lysanne Snijders, snijders@igb-berlin.de

Snijders, L. et al. (2018). Individual- and population-level drivers of consistent foraging success across environments. Nature Ecology & Evolution, 2(10), 1610-1618. doi:10.1038/s41559-018-0658-4

Amazon mollies *(Poecilia formosa)* only exist as females (on the left), which propagate by sperm-dependent parthenogenesis. They require sperm of foreign species, which, however, does mostly not contribute genetically to the offspring – on the right, the photo shows a male sailfin molly *(P. latipinna)*. | Photo: Manfred Schartl/University of Würzburg

Successfully Surviving **Without Sex**

They reproduce through gynogenesis. Their offspring are usually one-hundred-percent clones of the mother. According to established theories, the Amazon molly (related to the well-known aquaria fish: guppies) should have become extinct a long time ago. An international study conducted by the University of Würzburg in collaboration with IGB has clarified why this has not happened as predicted.

There are two main reasons that argue against asexually reproducing species surviving in the long run. First, harmful changes (deleterious mutations) occur in any genome at some point. In organisms whose offspring are pure clones, these defects would accumulate over generations until there were no more healthy individuals left. The second argument against the long-term survival of a species, whose offspring consists of pure clones of their mothers, is that these lineages are not usually capable of adapting to environmental changes as quickly as their sexually reproducing counterparts. Thus, within a few generations, they are hypothesised to form an "evolutionary dead end", and would not be expected to compete in the race for "survival of the fittest".
Nevertheless, Amazon mollies have survived for a long time, as the researchers were able to show by sequencing whole genomes and complete mitochondria: in fact, only a single (or very few) hybridisation event(s) between two parental species led to the emergence of the all-female hybrid Amazon mollies. In addition, the research confirmed the considerable age of the species: up to 100,000 years old. However, the researchers found very little evidence of genetic degeneration in the genome of the Amazon molly, but instead a unique genetic variability and clear signs of ongoing evolution. A key to understand this might be tiny amounts of paternal DNA, contributing rarely to the – in this case not 100% clonal – offspring, refreshing genetic material by replacing genes that were damaged by clonal reproduction. Such an exceptional uptake of sperm-DNA is called "paternal leakage".

Read more
→ www.igb-berlin.de/en/news/no-sex-all-female-fish-species
→ www.nature.com/articles/s41559-018-0473-y

PD Dr. Matthias Stöck, matthias.stoeck@igb-berlin.de

Warren, W. C. et al. (2018). Clonal polymorphism and high heterozygosity in the celibate genome of the Amazon molly. Nature Ecology & Evolution, 2(4), 669-679. doi:10.1038/s41559-018-0473-y

A low flow helps fry and juveniles to find appropriate habitats. Three elements are typical of how angling clubs in Germany perform volunteer work for endangered migratory fish: creating and improving habitats; stocking juveniles; and working to remove barriers to migration.
Here at River Wümme, sea trout *(Salmo trutta trutta)* stocking started in the 1980s. Stocking measures are now no longer required, because the species is able to maintain itself. This is the outcome that anglers are hoping for in other waters where they have introduced Atlantic salmon *(Salmo salar)*, a migratory fish that has even more challenging habitat requirements. | Photo: Sophia Kochalski

Good for Salmon – and the Community

The 2019 Fish of the Year – the Atlantic salmon – is returning to German rivers! A team of German and Norwegian researchers has visited angling clubs, associations and foundations that have been supporting the reintroduction of salmon on a voluntary basis. We spoke to Sophia Kochalski about the lessons learned from these investigations.

Dr. Kochalski, you were engaged as a scientist at IGB for three years, and you are one of the authors of the study on voluntary hatcheries. Why did you devote your study to the reintroduction of salmon?
Being a migratory fish, the salmon is especially fascinating. Salmon are born in rivers, but migrate to the sea as juveniles. In order to spawn, i.e. reproduce, salmon must return to their river of origin, which may mean them having to swim upstream for hundreds of miles. A major feat. Salmon disappeared completely from German rivers in the last century. Thanks to the efforts of voluntary groups (mainly anglers) and the support of government organisations, the fish species has returned in a few places. In other countries, too, wild stocks have diminished. For this reason, European salmon are classed as "vulnerable" on the Red List.

How are salmon being reintroduced to Germany?
Salmon stocking functions as follows: every autumn, adult fish are taken from the river, their eggs are carefully harvested, and the adult fish are then released into the river. Salmon fry hatch out of eggs in a hatchery. Once the fry are large enough to stand a good chance of survival in the wild, they are released into different parts of the river in spring and summer. It can generally be said that healthy fish stocks can only exist in healthy waters, which is why attempts have been made to improve spawning grounds or to remove migration barriers as part of stocking projects.


Photo: private

"Stocking projects for one particular fish species may benefit other species and the entire ecosystem. In all three countries, the groups operating the hatcheries also support other vulnerable species. It also gives rise to cooperative alliances and networks that would not have evolved otherwise."
SOPHIA KOCHALSKI

Your study also involved visiting stocking projects in Norway and Wales, countries where such programmes are not without controversy. Why is that?
The major difference compared to Germany is that some other European countries still have natural populations of salmon. Recent discoveries indicate that fish adapt to the conditions in the hatchery to a certain extent. In hatcheries, they are fed and have no predators. The fear is that hatchery fish find it harder to cope with the natural conditions in the river, and pass on this deficit to their offspring. This is why salmon fry are released into the river as early as possible.

And why is it that angling clubs, of all things, are involved in reintroduction programmes?
The desire to fish for salmon in the future plays only a subordinate role. Many anglers are strongly attached to "their" rivers. They are often the first to notice when water quality deteriorates or when something new turns up in the river that does not belong there. Preserving the species is the greatest incentive for those involved in reintroduction projects. This is why volunteers actually enjoy the hard work in the hatcheries, it gives them great satisfaction.

You can therefore say that salmon stocking not only makes sense, but is also meaningful?
Exactly that. And what is more – as we soon came to realise during our visits to hatcheries – the social aspect has a motivating effect on the voluntary work. They are engaging in something meaningful together with like-minded people, often with multiple generations working side by side. All those involved can share or add to their knowledge.

What do you consider to be the key finding of your study?
Stocking projects for one particular fish species may benefit other species and the entire ecosystem. In all three countries, the groups operating the hatcheries also support other vulnerable species. It also gives rise to cooperative alliances and networks that would not have evolved otherwise. Good cooperation fosters cohesion. This is useful for future environmental measures. The salmon projects also increase people's knowledge of fish and rivers, and raise public awareness of these topics. For example, anglers invite school

In a Norwegian hatchery: anglers check every day if the salmon fry are doing well. | Photo: Hannah Harrison

classes to come and help them on the river or in the hatchery. The benefit to society as a whole goes far beyond the reintroduction of salmon.

The interview was conducted by Katharina Bunk.

Dr. Sophia Kochalski, kochalski@igb-berlin.de

Project: IMPRESS, **Duration:** 01/15-12/18, **Funded by:** EU, **Overall coordination at IGB: Professor Robert Arlinghaus**, arlinghaus@igb-berlin.de, **Dr. Jörn Gessner,** sturgeon @igb-berlin.de, **Dr. Sven Würtz**, wuertz@igb-berlin.de, **Involving:** Departments 4 and 5, Research Domain 3

Harrison, H. L. et al. (2018). „Nature's little helpers": a benefits approach to voluntary cultivation of hatchery fish to support wild Atlantic salmon (Salmo salar) populations in Norway, Wales and Germany. Fisheries Research, 204, 348-360. doi:10.1016/j.fishres.2018.02.022.

More Fish Facts: Aquarium Dwellers in Native Streams

At IGB, Juliane Lukas, Gregor Kalinkat and David Bierbach have been exploring how, and why, fish from the tropics are able to colonise brooks and rivers at our latitude. The scientists have written a book together with Michael Kempkes and other scholars. In "Tropische Neozoen in heimischen Fließgewässern" (Tropical Neozoa in Domestic Streams), the researchers explain why it is that South American guppies, Central American convict cichlids, Malaysian trumpet snails and other exotic animal and aquatic plant species have come to feel at home and become established in European watercourses and how they interact with native species. The book is not only aimed at experts from the fields of biology, nature conservation and aquaristics, but also at specialists from water management and nature conservation authorities, as well as at teachers.

Dr. David Bierbach, bierbach@igb-berlin.de
Juliane Lukas, lukas@igb-berlin.de

Kempkes, M., Lukas, J., & Bierbach, D. (Eds.). (2018). Tropische Neozoen in heimischen Fließgewässern: Guppys und andere Exoten in Gillbach und Erft - Ursachen, Folgen, Perspektiven. Magdeburg: VerlagsKG Wolf.

European States sign up to an **Action Plan for the Conservation of Sturgeons**

At the 40th meeting of the Standing Committee of the Bern Convention, 50 European states have signed up to a transnational plan to save these fascinating species of fish. The Action Plan was developed under the lead of the World Sturgeon Conservation Society and the WWF in a joint effort with a team of international experts.

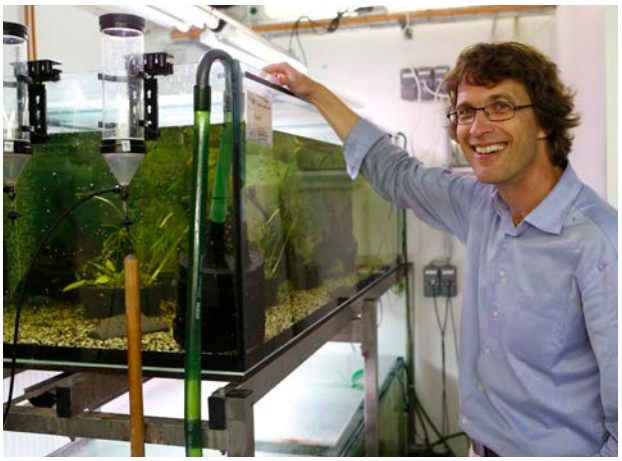
Globally, 85 per cent of sturgeon species are threatened with extinction, making them one of the most endangered species group in the world, according to the International Union for the Conservation of Nature (IUCN). There were once eight species of sturgeon in Europe: Russian sturgeon, Adriatic sturgeon, Ship sturgeon, Stellate sturgeon, Atlantic sturgeon, Beluga sturgeon, Baltic sturgeon and Sterlet. All eight species are now classified as endangered or vulnerable to extinction. The Pan-European Action Plan is now applicable to these species. The plan aims to conserve the last surviving populations, restore their habitats and reintroduce sturgeons into previously inhabited waters. The European countries also agreed to establish ex situ measures for sturgeons (the collection of species filled with roe in controlled culture). The plan also addresses a critical issue: it includes measures to clamp down further on poaching and the illegal trade in wild sturgeon products.
Jörn Geßner, coordinator of the reintroduction of sturgeons to Germany and a member of the core group for the Action Plan development, is optimistic about it: "Cracking down on poaching and the illegal trade in wild caviar in conjunction with the agreed upon ex situ measures will buy the necessary time to allow conservation efforts to safeguard and support the species to become viable in the long-term." Signing the agreement is just the first step; countries must urgently take steps to implement it and work together. The IGB scientist believes that the plan paves the way for a more effective protection of sturgeons due to its international approach based upon harmonised measures to be implemented.

Dr. Jörn Geßner, sturgeon@igb-berlin.de

Read the Action Plan
→ https://rm.coe.int/pan-european-action-plan-for-sturgeons/16808e84f3

Discover the STURGEoNOMICS project
→ www.igb-berlin.de/en/project/sturgeonomics

A juvenile sturgeon being released into its native environment. | Photo: Marco Prosch



Jens Krause is an expert on collective behaviour and is also head of the Department of Biology and Ecology of Fishes at IGB. He also holds a professorship at Humboldt-Universität zu Berlin. | Photo: IGB/Andy Küchenmeister

Excellent Prospects for **Collective Intelligence**

From January 2019 on, IGB will be involved in two Clusters of Excellence on intelligence and collective behaviour. The clusters receive funding through the "German Excellence Strategy" programme.

The *Science of Intelligence*, a Joint Cluster of Excellence of Technische Universität Berlin and Humboldt-Universität zu Berlin, is a project focusing on understanding intelligence more comprehensively in all its facets. IGB's Jens Krause and his group are contributing with their expertise on collective behaviour and collective intelligence. The cluster's methodological strategy is a very new approach in which all knowledge, methods, concepts and theories must be incorporated into technological artefacts, such as robots or computer programmes. These artefacts serve as a common "language" that is intended to facilitate scientific exchange across disciplinary boundaries.
The *Centre for the Advanced Study of Collective Behaviour* is an initiative from the University of Konstanz that is dedicated to data-based research on collective behaviour, from swarm intelligence of animal groups and human decision-making processes to economic networks. This means bringing together expertise from the fields of biology, psychology, physics and economics, as well as computer science. Jens Krause is involved as an external scientist.

Professor Jens Krause, j.krause@igb-berlin.de

Review of the Year

2018 at IGB


IGB

The Year 2018

Graduate Research School on Post-Mining Landscapes

One sub-project of the Graduate Research School (GRS) Microcluster "Signatures of severely disturbed landscapes case study mining landscapes", initiated in January 2018, explores the impact of mining on neighbouring river and lake ecosystems. Together with Brandenburg University of Technology Cottbus-Senftenberg, IGB is exploring the dispersion of iron minerals and sulphate in the River Spree from Lusatia to Berlin, and the impact of this dispersion along the watercourse. The insights gained should contribute to improving recultivation measures and may also be transferable to other post-mining areas.

Dr. Michael Hupfer, hupfer@igb-berlin.de

→ www.b-tu.de/projekte/en/landscape/research/research-projects/grs-cluster-signatures

IGB Academy: Sustainable Trout Breeding Management

The third *IGB Academy* was held on 24 February 2018. The topic of the academy was sustainable breeding management in trout aquaculture. Keynote speeches by experts from the fields of research, government and fish farming gave rise to lively debate about the advantages of regionally adapted breeding lines and the practical challenges posed by time and cost pressures.

Johannes Graupner, ssi@igb-berlin.de

JANUARY

Photo: Lydia Koglin

A Week Devoted to Open Access

We spent a week in January delving into the issue of open access publishing, developing an understanding about the topic, and discussing the difficulties encountered in publishing freely and independently. The daily dose of information was disseminated by newsletters, curated by IGB librarian Lydia Koglin. A coffee talk on the pros and cons of preprints was also held with IGB scientist Gregor Kalinkat.

Lydia Koglin, bib@igb-berlin.de

FEBRUARY

Photo: Nadja Neumann

Aquaponics at Green Week

IGB was present at the International Green Week in Berlin from 19 to 28 January, where it showcased its INAPRO aquaponics project and the Aquakulturinfo consumer portal at the Federal Ministry of Food and Agriculture (BMEL) stand.

Professor Werner Kloas, werner.kloas@igb-berlin.de

Fungi Affect Food Web Dynamics

All kinds of algae can be infested by parasitic fungi (chytrids). This allows zooplankton to feed on large, poorly edible algae, to the benefit of smaller, fast-growing algae species. In March 2018, IGB researchers started investigating how this parasitism affects the diversity of phytoplankton, and hence the dynamics of aquatic food webs, within the new DFG FungiTrait project, the second phase of the DynaTrait Priority Programme.

Professor Hans-Peter Grossart,
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Dr. Sabine Wollrab, wollrab@igb-berlin.de

Between Groundwater and Surface Water

IGB hosted the final meeting of the project "Groundwater-surface water interactions in metropolitan areas", funded by the German Academic Exchange Service (DAAD), in April 2018. IGB and Flinders University (Adelaide, Australia) teamed up to explore how organic trace compounds, especially those originating from pharmaceutical products, behave in urban waters (→ page 20).

PD Dr. Jörg Lewandowski, lewe@igb-berlin.de

MARCH

Invasions in the Spotlight

In March 2018, members of the Invasion Dynamics Network (InDyNet) came together for the third time in Berlin to address temporal dynamics in biological invasions and their impacts. In February, 20 experts had already discussed concepts in invasion biology and how they should ideally be visualised.

Professor Jonathan Jeschke,
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Florian Ruland, ruland@igb-berlin.de

→ http://indynet.de

APRIL

Innovative Ideas for Biodiversity Conservation

An international research training programme, Inspire4Nature, set out to train a total of 15 doctoral fellows. Since then, students have focused on the topic of biodiversity conservation, and have benefited from a network-wide training programme, including workshops, courses and joint projects. The Inspire4Nature network has brought together research centres, universities and conservation organisations from eight countries.

Dr. Jörg Freyhof, freyhof@igb-berlin.de
Professor Robert Arlinghaus,
arlinghaus@igb-berlin.de

Photo: Johannes Graupner

Excursion to the Havel: River Restoration Success Factors

At the end of April 2018, IGB researchers visited the Havel restoration project, undertaken by the German Nature and Biodiversity Conservation Union (NABU). Whilst sharing information and ideas, the researchers and practitioners came to realise that ecological knowledge alone is not enough to achieve river restoration. Another crucial factor is positive interaction among policymakers, local government, associations and local users, as well as mutual trust.

Johannes Graupner, ssi@igb-berlin.de

Lakes in Flux

May 2018 saw the start of a new project called CONNECT, which brings together experts from the fields of freshwater ecology, agrolandscape research and remote sensing. The scientists have teamed up to investigate the extent to which lakes connected by river systems develop in synchronous ways. Examples of issues that will be explored include the propagation of nutrient loading and any resulting algal blooms, and the effects of local extreme weather events on a chain of lakes. The project is funded through the Leibniz Competition.

Dr. Stella Berger, berger@igb-berlin.de
Dr. Sabine Wollrab, wollrab@igb-berlin.de

APRIL

Girls' Day at IGB

National Girls' Day on 26 April gave girls the opportunity to gain greater insights into male-dominated occupations. IGB's scientists gave twelve schoolgirls a glimpse of their work. For example, the girls carried out an observational trial to investigate the collective behaviour of fish.

Nadja Neumann,
nadja.neumann@igb-berlin.de

MAY

Visit to the LakeLab

The German Science Journalists' Association (WPK) paid a visit to IGB's site on Lake Stechlin in May 2018. In all, 15 science journalists gathered to learn about the latest developments in freshwater research and to take a look at our LakeLab. Sonia Herrero presented data on urban water bodies; Mina Bizic-Ionescu and Danny Ionescu shared insights about methane-producing blue-green algae and the world's largest freshwater bacterium; Mark Gessner gave a brief introduction to synthetic chemicals, microplastics and nanoparticles; and Peter Casper talked about greenhouse gases in fresh waters.

Dr. Martina Bauchrowitz,
seelabor@igb-berlin.de

Photo: Marc Kupetz

Full House during the Summer Break

We were delighted about the fantastic response to our research for the Long Day of Urban Nature on 17 June, which attracted 300 visitors to IGB in Berlin. A boat trip to the LakeLab and a wide range of hands-on activities and lectures attracted around 550 interested individuals to our Open Day at the LakeLab on Lake Stechlin on 30 June.

Nadja Neumann, nadja.neumann@igb-berlin.de

Photo: Bernd Hiepe

Science Meets Art

The installation "Of Colour and Light" was on display at the Kleine Orangerie in Berlin-Charlottenburg between July and September 2018. The installation was part of a transdisciplinary project undertaken by artist Jenny Brockmann and IGB researchers, in which they reflect on the inner logic, as well as the strengths and limitations, of scientific knowledge production.

Dr. Stella A. Berger, berger@igb-berlin.de
Professor Jonathan Jeschke, jeschke@igb-berlin.de

JUNE

Photo: Paul Winkler

Research to Go

On 1 June, there was a series of short scientific talks outside the lecture hall in Berlin's Park at Gleisdreieck. At the Soapbox Science event, 12 female scientists stepped up to the mic to present their research. Every year, the international event transforms public places into areas for shared learning and scientific debate. IGB co-organised the Berlin version of the event.

Dr. Carolina Doran, doran@igb-berlin.de

JULY

Photo: Sabine Hilt/IGB

IGB Young Researchers at the Water Research Horizon Conference

Experts from the fields of science, policy and practice gathered at the 9th Water Research Horizon Conference in July 2018 in Dresden to discuss current challenges in water research. The meeting focused on effective water management in urban areas. Three doctoral students from the DFG-funded "Urban Water Interfaces" Research Training Group, in which IGB and Technische Universität Berlin jointly conduct research, presented their results.

PD Dr. Sabine Hilt, hilt@igb-berlin.de

IGB Academy: Ecosystem Services Provided by Rivers and Floodplains

The fourth IGB Academy, held on 19 September 2018, revolved around the application of the River Ecosystem Service Index (RESI), developed under the leadership of IGB. This index can be used to capture, assess and visualise the ecosystem services provided by rivers and floodplains (→ page 21). Potential updates and the limitations of the tool were discussed with the participants.

Johannes Graupner, ssi@igb-berlin.de

A Rather Different Colloquium

In October, IGB's Library, PR and Knowledge Transfer team hosted a film afternoon, featuring the documentary "Paywall The Business of Scholarship". The audience enjoyed a lively debate about the risks and opportunities of open access and open science. A vital component of the afternoon: popcorn!

Cliff Buschhart, bib@igb-berlin.de

JULY

Hierarchy of Hypotheses

The Hierarchy-of-Hypotheses (HoH) approach was the focus of a symposium series in 2018, initiated by IGB and the University of Potsdam. Researchers and experts from the fields of biodiversity, statistics, open science and philosophy of science attended the events, held in July and October. One of the key topics was Hi-Knowledge, a visualisation tool that structures scientific evidence in hierarchical networks. The symposia were supported by the Volkswagen Foundation.

Professor Jonathan Jeschke, jeschke@igb-berlin.de
Dr. Tina Heger, tina.heger@uni-potsdam.de

→ www.hi-knowledge.org

SEPTEMBER

Photo: Nadja Neumann

The Female Side of Limnology

"Passion makes people take notice and realize that some things are special." This quote by Kathleen Carpenter (1891-1970) marked the start of the exhibition Women in Limnology. The exhibition, devised by the Iberian Association of Limnology (AIL), was on display at IGB in Berlin from 21 September to 5 October. Carpenter was one of the very few renowned female limnologists of her time. This scientist and other female researchers took centre stage at the exhibition.

Sonia Herrero, herrero@igb-berlin.de

OCTOBER

Photo: Thomas Mehner

What Swims in Lake Müggelsee?

Which fish species live in Berlin's biggest lake, Lake Müggelsee, how many of them are there, and how big do they get? These were the questions investigated by around 20 IGB researchers in October. Back in 2015, they launched a joint initiative to fish the lake on an annual basis. All fish caught in the nets are measured and weighed, and then released back into the water. The scientists then combine this data with measurements recorded by our Müggelsee Monitoring Station, enabling them to derive trends from the data.

PD Dr. Thomas Mehner,
mehner@igb-berlin.de

Photo: Nadja Neumann

Mind the Lab!

As part of the Berlin Science Week, residents of Berlin were able to experience research and researchers live at six metro stations during a science rush-hour on 8 November. At Alexanderplatz station, IGB generated interest in freshwater biodiversity.

Nadja Neumann, nadja.neumann@igb-berlin.de

CBD: Disregarded Diversity

The UN Convention on Biological Diversity came to a close in December 2018 with a call to protect biodiversity. Regrettably, inadequate attention was given to the threat to the biodiversity of inland waters. For this reason, multiple organisations, including the Alliance for Freshwater Life, published a statement, calling for the explicit inclusion of the conservation of inland water ecosystems and their biodiversity in all Aichi targets.

Professor Michael T. Monaghan, monaghan@igb-berlin.de

→ https://bit.ly/FreshwaterBiodiversity

NOVEMBER

Photo: Nadja Neumann

Joining Forces for Freshwater Biodiversity

The aim of the Alliance for Freshwater Life (AFL), co-initiated by IGB, is to bring freshwater biodiversity to the forefront of the social and political agenda (→ page 7). The AFL hosted a symposium from 5 to 7 November to bring together around 50 international experts at the Botanical Museum Berlin to expand the network and to collaboratively develop research and communication strategies.

Dr. Sonja Jähnig, sonja.jaehnig@igb-berlin.de

DECEMBER

Müggelsee Dialogue: Ecological Aspects of Urban Waters

Representatives from the political sector, governmental agencies, water recreation bodies, environmental associations and research organisations gathered at IGB on 11 December 2018 to share information about the environmental aspects of urban waters. Taking Berlin as an example, the participants highlighted the challenges, unresolved issues and options for action on the protection and use of urban waters.

Johannes Graupner, ssi@igb-berlin.de

Internal Information Exchange on Science Day

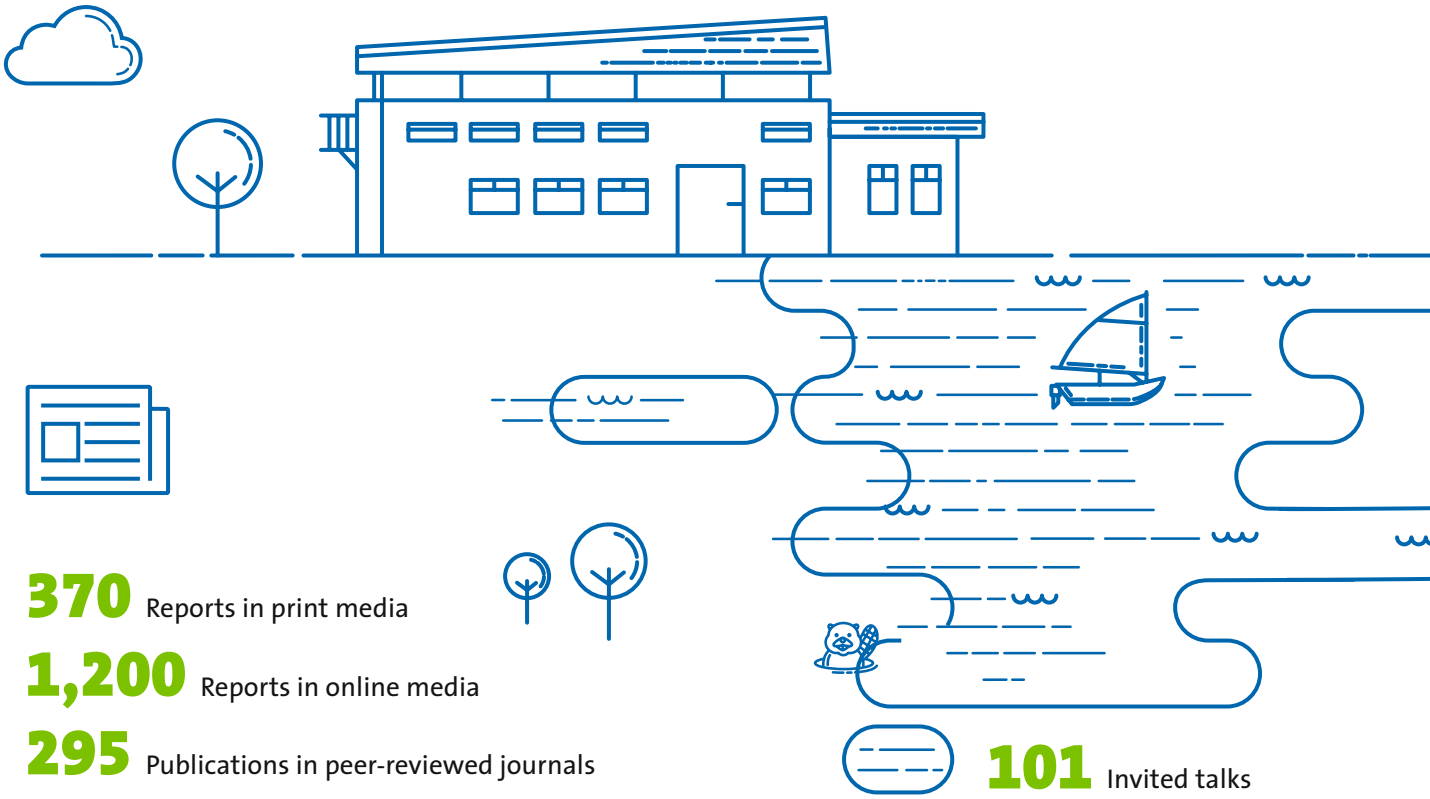
Members of IGB came together for the annual Science Day on 13 December. After a keynote lecture by Ferdi Hellweger (Technische Universität Berlin), current projects and initiatives were presented to the audience. The afternoon was devoted entirely to early career researchers: postdoctoral researchers and doctoral students were given the opportunity to showcase their work.

Inside IGB

Key Figures at a Glance

233 Employees
(including **140** scientists)

15 Employees active in committees and expert associations



370 Reports in print media

1,200 Reports in online media

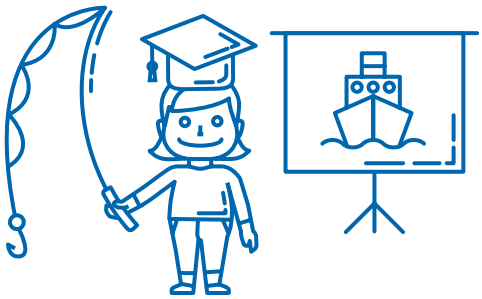
295 Publications in peer-reviewed journals

101 Invited talks including plenary talks and keynote lectures as well as **114** other scientific talks

35 Scientific events and workshops including **31** with international participation

with in total

1,837 participants



Status as of 31 December 2018

30 Employees active in teaching

66 Doctoral students
16 Doctoral dissertations
24 Diploma, master and bachelor theses

10 Joint professorships with universities

40 IGB colloquia (public scientific talks with internal and external speakers)

External grants: **8,007,685.02 €**
including **1,870,991.60 €** EU grants

Internal budget: **12,808,272.98 €**

Overall budget: **20,815,958.00 €**

Proportion of external funding: **38 %**

Arousing Curiosity, Changing Perspectives, Building Skills

Remaining curious, thinking outside the box, facilitating our personal development – we take all these aspects seriously. This is why we offer our employees a comprehensive programme of workshops and courses, as well as the option to pursue advanced training externally, to collaborate in activities and projects, and to explore new research opportunities – regardless of their department or career stage. Here is a small selection of our wide range of opportunities.

Our Young Talents: Broad Diversity and New Horizons

We are especially proud of the diversity and commitment of our early career researchers, more than half of which are from countries outside Germany – from 31 different countries, to be exact. Such diversity makes IGB a special, multicultural and lively place to work. It is a pleasure working with our young scientists, whose enthusiasm is contagious. Their creativity was recently demonstrated at the IGB Science Day, which involved doctoral and postdoctoral researches putting on an informative and entertaining programme to present their research.

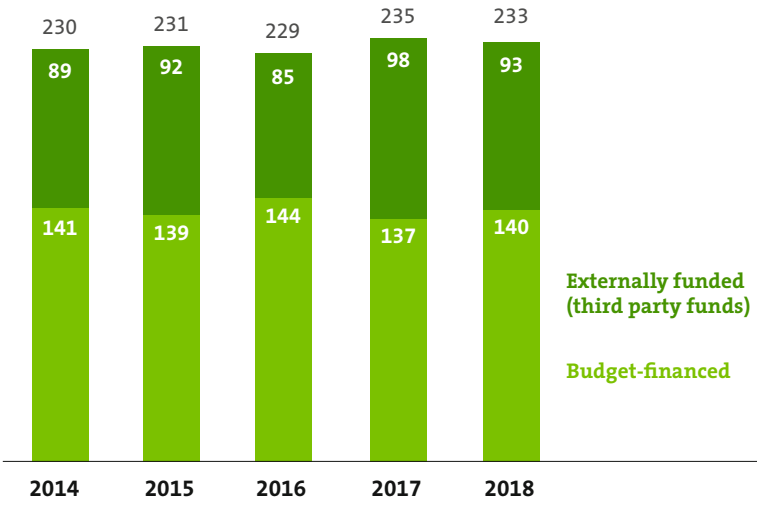
The IGB doctoral programme offers a wide range of courses to give our doctoral students the best possible support and to help prepare them for a career both within and outside academia. All courses combine theoretical knowledge with practical elements. Our basic, intermediate and advanced courses in statistics – tailored to meet our scientists' needs – are especially popular. IGB postdocs design courses on the complex foundations of mixed linear models and on Bayesian statistics. Our intensive course on writing scientific articles remains a favourite with our doctoral students, who learn the skills required to more or less complete a manuscript for publication within one week. The course was held for the 14th time in 2018. Many doctoral projects are part of post-graduate schools that offer their own compulsory training programmes in addition to IGB. In 2018, IGB participated in seven post-graduate schools, where one-third of our doctoral students are pursuing their research.

Our postdocs were – and continue to be – curious, focusing on a new issue each year for their own training opportunities. Most recently, they trained performing peer reviews for scientific publications.

Separate retreats for doctoral students and for postdocs were held in 2018, organised by their respective elected representatives. Although these retreats were held as separate events, the two groups jointly organise social activities, and engage in lively debate.

Dr. Kirsten Pohlmann, kpohlmann@igb-berlin.de

Employees by financing



Employees at IGB 2018

Total: 233

59	Researchers
36	Postdocs
45	Doctoral students
91	Non-scientific staff
2	Apprentices
4	IGB-funded fellows
18	Assistants and temporary staff
88	Others active at the institute (visiting scientists, foreign fellows, doctoral and other students, interns)

Status as of 31.12.

Video Shoots and Interviews: Researchers Enter Uncharted Waters

Photo: Angelina Tittmann

Videos have become ubiquitous, including in science communication. Short videos are the number-one choice, particularly for young people in search of information. So why not create a video about scientific work? In a workshop on "Making Smartphone Videos", we showed researchers and technical staff what they need to produce their own videos, and which formats are appropriate. The first attempts, available on our YouTube channel, are quite impressive:
→ www.youtube.com/channel/UCCs1m_eu_qMdFguWU2CTjKg

Researchers attended our media training courses to learn how to present their research findings in a clear and understandable way, both in front of and behind the camera and the mic. They changed their perspective for a while and became journalists, planning their own topics and interviewing each other in front of a camera. The training sessions are part of IGB's series of workshops "Uncharted Waters". These workshops are part of the Science-Society Interface initiative and enable our researchers to discover how to take advantage of the various channels of communication available, and how to share knowledge with different stakeholders in society.

Angelina Tittmann and Johannes Grauper, ssi@igb-berlin.de

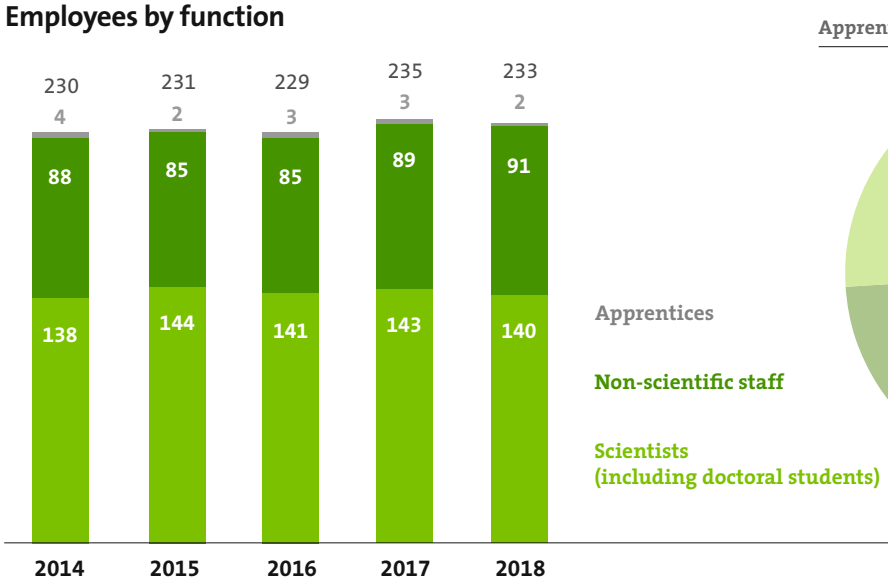
Adventure Kayak Roll: Training Done Differently

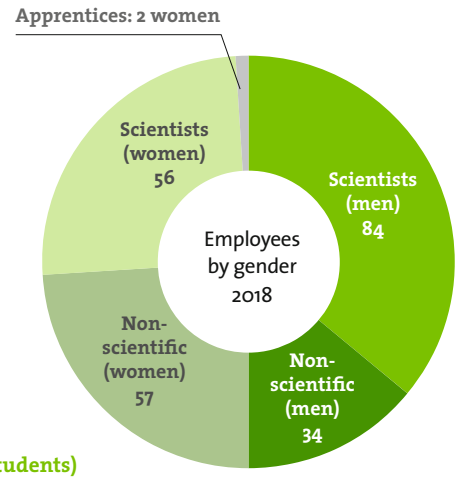
What else do limnologists do in their spare time? They venture out onto the water! In spring 2018, Alexander Sukhodolov, IGB ecohydrologist and experienced whitewater kayaker, and his daughter Anna, runner-up kayak champion of Germany, taught courageous IGB employees the ins and outs of kayaking after work. And what is the best way for scientists to learn how to kayak? You got it – based on theory! The course covered fluid mechanics, river turbulence, kayaking techniques, safety and rescue training, finding the right equipment, and the famous kayak roll. The practical part, on Lake Müggelsee and River Spree, started with the beginning of spring.

Dr. Alexander Sukhodolov, alex@igb-berlin.de

To find out more about our philosophy and about the work and research conducted at IGB, take a look at our website, which also features our current vacancies.
→ www.igb-berlin.de/en/about

Employees by function





Status as of 31.12.

People

Dörthe Tetzlaff elected AGU Fellow

Photo: IGB/David Ausserhofer

Dörthe Tetzlaff, head of IGB's Department of Ecohydrology and Professor of Ecohydrology at Humboldt-Universität zu Berlin, has been elected to the 2018 class of Fellows of the American Geophysical Union (AGU). AGU Fellows are recognised for their scientific eminence and the groundbreaking nature of their contributions. Tetzlaff was nominated by the Hydrology Section of AGU for her "fundamental insights into physical processes controlling stream flow in headwaters, and their influence on stream chemistry and aquatic ecology." This makes her the first female hydrologist in Germany and one of three in all of Europe to be honoured with an AGU Fellowship.

Professor Dörthe Tetzlaff, d.tetzlaff@igb-berlin.de

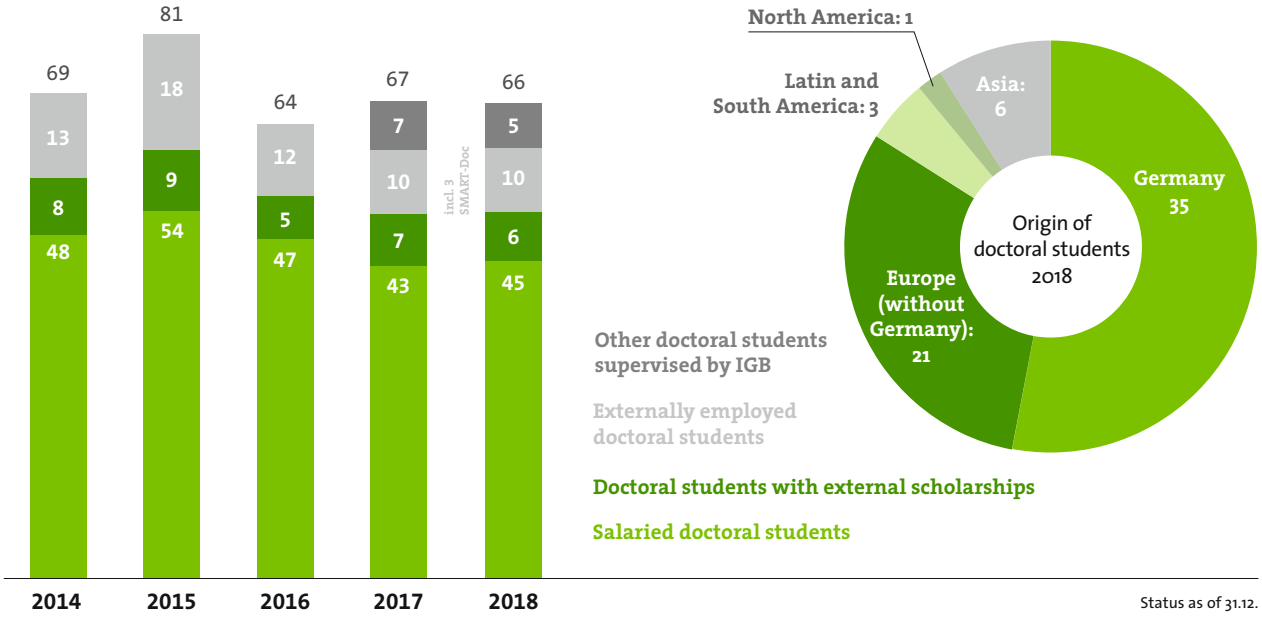
Michael T. Monaghan honoured by Freie Universität Berlin

Photo: IGB/Andy Küchenmeister

Michael T. Monaghan has been awarded the title of Honorary Professor of Biology at Freie Universität Berlin. Since 2009, he has been a lecturer in the Faculty of Biology, Chemistry, Pharmacy, and the Faculty of Mathematics and Informatics. The title is a formal recognition of his special commitment to the Freie Universität, not only in the context of the Genome Center leadership, but in teaching. This also strengthens IGB's close partnership with the universities in the Berlin area. We congratulate him on this special achievement!

Professor Michael T. Monaghan, monaghan@igb-berlin.de

Doctoral training development



Status as of 31.12.

IGB researcher Thomas Mehner elected as SIL President

Photo: IGB/David Ausserhofer

Thomas Mehner, limnologist and fish ecologist at IGB, was elected as the new President of the International Society of Limnology (SIL) in summer 2018. In May 2019, he will take office as the Society's 13th President. You can read more about his ideas and goals in an interview on our website:
→ www.igb-berlin.de/en/news/sil

PD Dr. Thomas Mehner, mehner@igb-berlin.de

Public Outreach Award for Robert Arlinghaus

Photo: IGB/David Ausserhofer

Robert Arlinghaus, Professor of Integrative Fisheries Management at Humboldt-Universität zu Berlin and at IGB, won the Excellence in Public Outreach Award of the *American Fisheries Society* (AFS). The AFS cited his tireless commitment to communicating his research results to anglers and the general public.

Professor Robert Arlinghaus, arlinghaus@igb-berlin.de

We also congratulate:

- BAGGERSEE: Project of the UN Decade of Biological Diversity
- Philipp Czapla: Winner, Award of the DAFV (German Angling Association)
- Valerio Sbragaglia: Winner, Francesca Gherardi Memorial Prize
- Thomas Klefoth: Winner, Albrecht Daniel Thaer Award for outstanding PhD performance
- Christopher Monk: 3rd place, DGL's Schwoerbel-Bendorf Young Talent Award
- Maja Gubisic: 2nd place, EFFS (European Federation for Freshwater Sciences) Award for the best PhD dissertation
- Sebastian Theis: Winner, Albrecht Daniel Thaer Award for the best master thesis

Professional development

Status as of 31.12.

Publications

In 2018, IGB produced a total of 360 publications, including 295 articles in peer-reviewed journals. All publications are collected centrally in our library; they are indexed in our library catalogue (OPAC) at → www.igb-lib.igb-berlin.de/alipac, and are available to all interested readers.

IGB supports open access to knowledge and research results. In 2018, 32 per cent of our articles were published in open access. IGB also adopted a mandate for Green Open Access in 2018, enabling the publication of metadata and accompanying documents from 37 articles in the Life Sciences Repository (ZB MED) that were originally not freely accessible. These articles are now directly available to the public, free of charge, taking into account possible embargo periods. In addition, IGB established its own Open Access Publishing Fund to cover the article processing charges (APC) for at least 12 articles each year. Additional 24 IGB articles were funded by the Leibniz Association's Open Access Publishing Fund.
Altmetric badges have been available to our researchers since the end of the year. These badges are an addition to the number of citations, and aid in demonstrating the sociopolitical impact of our scientist's research.

By the way , the article with the highest Altmetric score (1.202) in 2018 is:

Schulze-Makuch, D. et al. (2018). Transitory microbial habitat in the hyperarid Atacama Desert. Proceedings of the National Academy of Sciences of the United States of America, 115(11), 2670-2675. doi:10.1073/pnas.1714341115

The most cited article from 2018 is:

Machado, A. A. d. S. et al. (2018). Microplastics as an emerging threat to terrestrial ecosystems. Global Change Biology, 24(4), 1405-1416. doi:10.1111/gcb.14020

As a central services facility, the library primarily serves the institute's employees, and provides IGB with scientific information. External guests are very welcome to use the library after calling to make an appointment.
→ www.igb-berlin.de/en/library

Lydia Koglin & Ute Hentschel
bib@igb-berlin.de

A list of all IGB publications from 2018
→ http://bit.ly/IGB-Publications-2018

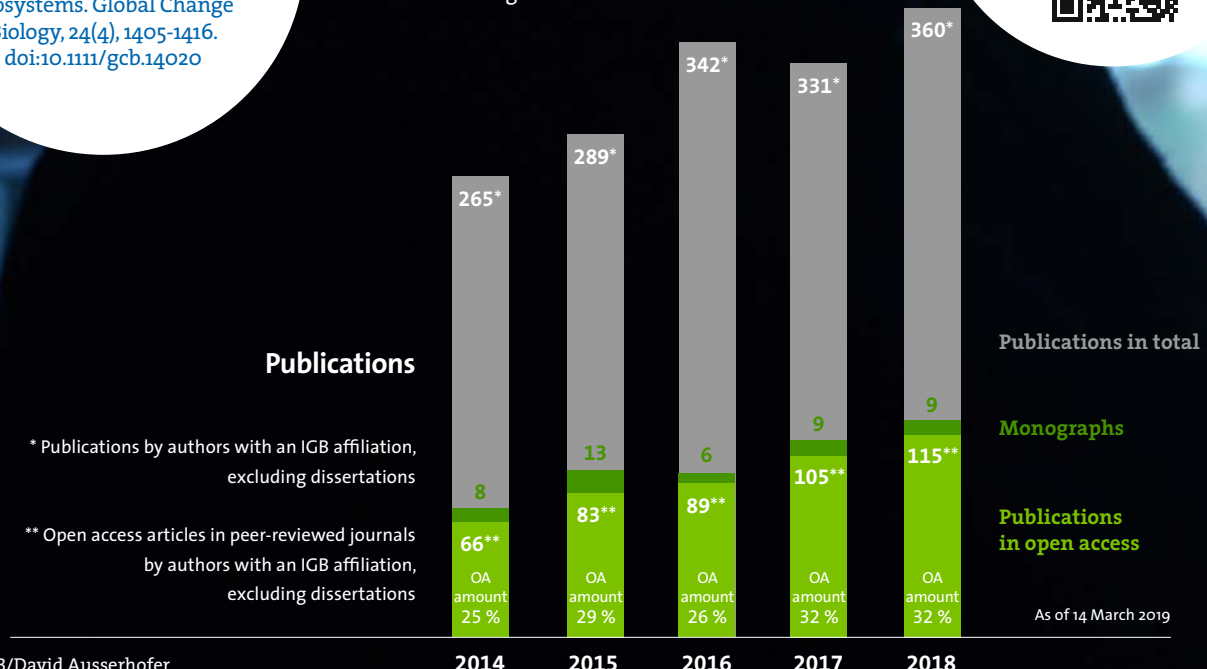
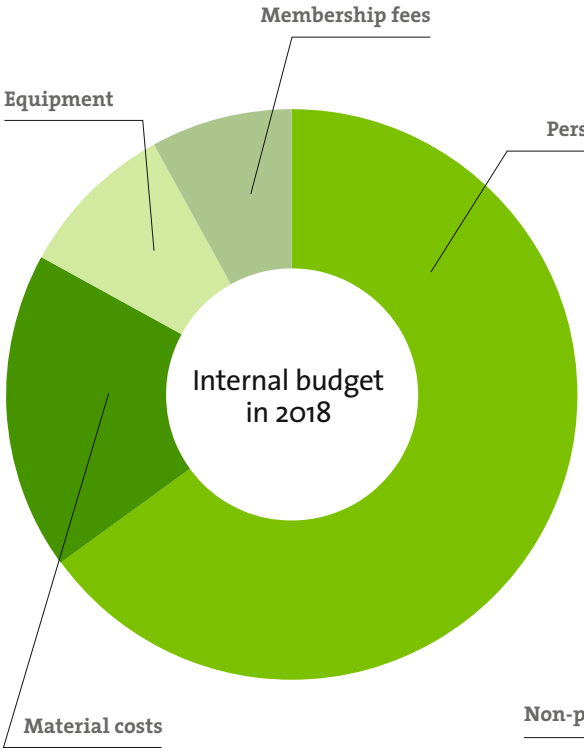


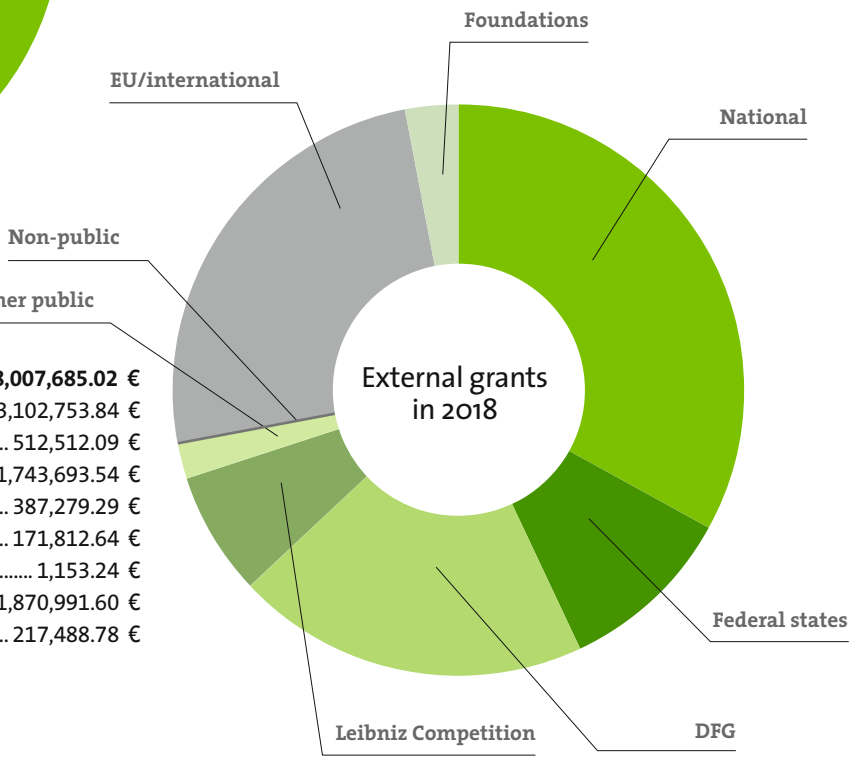
Photo: IGB/David Ausserhofer

Finances

all figures on expenditure basis (as of 31 December 2018)



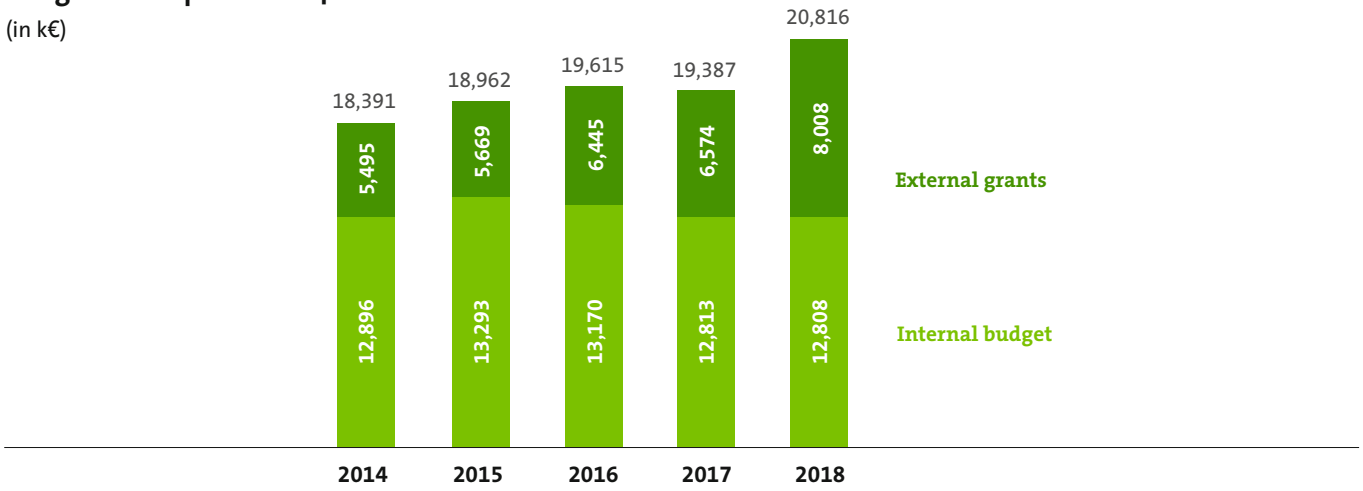
Total	**12,808,272.98 €**
Personnel	9,043,298.05 €
Material costs	2,543,011.00 €
Equipment	485,383.91 €
Membership fees	563,798.44 €



Total (including externally managed funds)	**8,007,685.02 €**
National	3,102,753.84 €
Federal states	512,512.09 €
DFG	1,743,693.54 €
Leibniz Competition	387,279.29 €
Other public financing	171,812.64 €
Non-public financing	1,153.24 €
EU/international	1,870,991.60 €
Foundations	217,488.78 €

Budget development 2014-2018

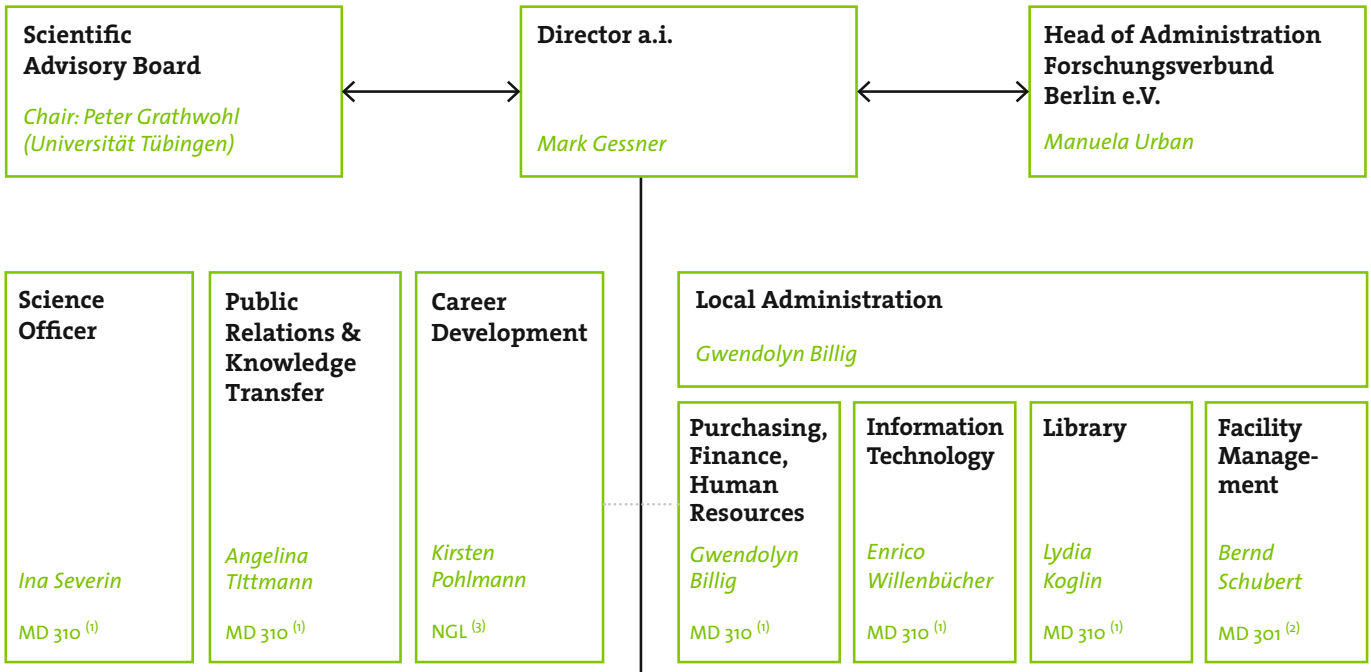
(in k€)



Structure

Leibniz-Institute of Freshwater Ecology and Inland Fisheries

Forschungsverbund Berlin e.V.



Research Departments

Cross-cutting Research Domains

CCRD 1 – Aquatic Biodiversity

Hans-Peter Grossart & Jonathan Jeschke
NGL (3) & FU Berlin

CCRD 2 – Aquatic Boundaries and Linkages

Tobias Goldhammer (a.i.)
MD 301 (2)

CCRD 3 – Human-Aquatic Ecosystem Interactions

Christian Wolter
MD 310 (1)

(1) MD 310: Müggelseedamm 310, Berlin (2) MD 301: Müggelseedamm 301, Berlin (3) NGL: Neuglobsow

Status as of 1 May 2019

Scientific Advisory Board

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Mediterranean Institute of Marine and Terrestrial Biodiversity and Ecology (IMBE), France

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School of Geography, University of Leeds, UK

Professor Ken Irvine
UNESCO-IHE Institute for Water Education, the Netherlands

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Geography Department, Humboldt-Universität zu Berlin, Germany

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Department Surface Waters Research & Management, Eawag, Switzerland

Professor Karen Wiltshire
Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research & Biological Institute Helgoland & Wadden Sea Station Sylt, Germany

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Susanne Stephan

Status as of 28 February 2019

Our annual research report 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 look forward to your visit!

Imprint

We would like to thank all colleagues who contributed to this annual research report and supported us!

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Leibniz Forschungsverbund Berlin e.V.

Leibniz Association

Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB)
Forschungsverbund Berlin e.V.

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D-12489 Berlin

Location in Neuglobsow:
Alte Fischerhütte 2
OT Neuglobsow
D-16775 Stechlin

Urban waters – such as the River Spree in Berlin – are under double pressure: climate warming, drought and nutrient inputs lead to algal blooms. At the same time, they are used intensively both economically and for recreational activities. Read more in this report. | Photo: Angelina Tittmann

www.igb-berlin.de/en