Pioneering Work in Marine Research

Bernd Blasius (left) and Helmut Hillebrand: "There is still plenty of room for proper pioneering work in the field of biodiversity."

Biologist Helmut Hillebrand and physicist Bernd Blasius are representative of the interdisciplinarity in Oldenburg University's marine research. In an interview the two scientists from the Institute for Chemistry and Biology of the Marine Environment (ICBM) talk about dramatic extinction rates, open questions, invasions and valuable "green soup". And about the new Helmholtz Institute for Functional Marine Biodiversity in Oldenburg, which got the green light from the Helmholtz Association in October

What does the topic of biodiversity mean for you?

Hillebrand: Biodiversity is a concept that aims to describe the diversity of life forms. These can be different species, different types of habitat within a certain region, or populations comprising different genetic information. It has been a key concept of ecology ever since ecology came into being. Already in the 19th century the zoologist and naturalist Ernst Haeckel, who coined the term "ecology", spent most of his time making wonderful scientific drawings of biological diversity. For me personally, biodiversity was what motivated me to study ecology in the first place. The question of why some species live together and others don't, and how they interact has always fascinated me.

Blasius: Incidentally, from a scientific point of view it is truly amazing how little we know about biodiversity. We don't know exactly how diverse our planet is, nor do we understand the function of biodiversity. Is there a minimum level of biodiversity we need here on Earth? This question has yet to be answered. At the same time it's alarming to see that we live in an age in which biodiversity is declining dramatically. Faster than ever before on Earth. This discrepancy is a strong motivation for many of our students to study biodiversity.

The loss of biological diversity is one of the greatest threats to humanity – would you subscribe to this sentence from a Green politician?

Hillebrand: First of all it's important to ascertain how many species really have died out and how quickly this has happened – in other words the number of species that have become extinct and the rate at which they are dying out. If we take the example of amphibians, many of which are at great risk, the actual number of properly documented extinction events is not particularly high. Of course today we are still well below the kind of extinction quotas reached during the five major mass extinctions of this geological era. Between 75 and 98 percent of all species died out during these events. What really worries us today is the rate at which species are becoming extinct. This has the same impact for mankind as climate change.

Blasius: But the problem is that we can't even assess the scope of these developments accurately. There are basic theoretical papers from the 1960s which say that more complex, more diverse systems are inherently unstable. Conversely, that would mean that lower diversity leads to more stable systems, which in theory would be a good thing. These theoretical statements, however, stand in stark contrast to the findings of numerous field studies which show that systems with lower biodiversity are considerably less stable and more vulnerable to invasion and parasites. We have already observed this with monoculture farming. To date, the whole diversity-stability debate per se is entirely unresolved. We still don't know whether lower diversity means that vital functions of the ecosystem as a whole are lost.

Hillebrand: ... and for me, too, this is precisely the question that drives my research. With climate change we already have global models that can tell us with relative certainty how the temperatures or rainfall in specific regions are going to change. But we don't have them for biological diversity.

Speaking of the climate, what impact do climate changes have on biodiversity? Is it possible to make any clear statements on this?
Blasius: No. Or at least there is no clear pattern. It may well be that changes in the climate increase biodiversity in certain regions because they allow other species to specialize there. But they may also have the opposite effect – so when it comes to species diversity there are winners and there are losers. That's why it's very difficult to make these predictions. A key factor that contributes to changing biodiversity patterns on our planet is invasion ...

Your speciality ...
Blasius: That's right – we are working with several colleagues on this topic. The vectors of bioinvasion are global transport systems like ships, which carry species and organisms back and forth across the world. If we look at the impact, once again there are no clear patterns: in some areas invasion can lead to greater biodiversity. The Pacific oyster in the Wadden Sea is a good example. So far it hasn't caused any apparent damage and in fact appears to have enriched the ecosystem. But from a global point of view such invasions could lead to increased homogenization and ultimately to less species diversity on our planet. In this scenario all that would be left across the world is a handful of dominant species that are very similar to each other. Particularly in coastal regions, invasion is a significant factor behind changes in aquatic communities.

> "We're still in the very early stages when it comes to marine conservation"
> Helmut Hillebrand

You're talking about marine biodiversity. Is the knowledge gap here as large as it is in terrestrial research? Or even larger?
Hillebrand: Unfortunately our knowledge of marine biodiversity is far more limited. The little we do know is deduced on the one hand using global distribution data on organisms that can be identified relatively easily. For example we know that Steller's sea cow has been wiped out because it is no longer to be found anywhere. On the other hand we work with long-term monitoring data. Unfortunately, long-term time series as done on Helgoland, where data has been gathered for decades, are the exception to the rule. We can't make any realistic projections about the biodiversity of the North Sea in 100 years' time at this stage. Another thing that is lacking is "citizen science": research carried out by enthusiastic amateurs that provides us with additional data, as is the case with terrestrial biodiversity. Unlike birds and butterflies, marine species are hard to get to, and for many people they often remain abstract.

Biodiversity and marine science is a focal topic of research at Oldenburg University. What makes it so special?
Hillebrand: There are above all two things that set us apart from similar research institutions. Firstly we study biodiversity both in the sea and on land. The Institute for Biology and Environmental Sciences is an important partner here. Take the artificial islands near the East Frisian Island of Spiekeroog – created to find answers to questions about species diversity and the colonization of newly formed islands. Thereby we also examine the intersection between land and sea. Secondly, at ICBM we focus on interdisciplinarity. Elsewhere research is primarily organismic and biological, which accounts for only about a third of the work. We also have access to enormous expertise in chemistry and physics.

So a genuinely interdisciplinary approach?
Hillebrand: Absolutely, and it is very rewarding. We can team up with modelling and hydrodynamics experts so that theory and empirics go hand in hand. We can exchange insights with our geochemists about organic substances in the sea – in other words the products and resources of microbes which would normally be the preserve of a biologist. This makes the aspect of ecosystem functioning far more tangible. Around 90 percent of the studies on this topic focus mainly on primary production, or in other words the production of biomass via photosynthesis. By integrating physics and geochemical research groups here at the ICBM we have acquired an unusually strong understanding of the processes involved. With our projects we have become an integral part of interdisciplinary environmental research. This is how we see ourselves and this is what defines biodiversity research in Oldenburg.

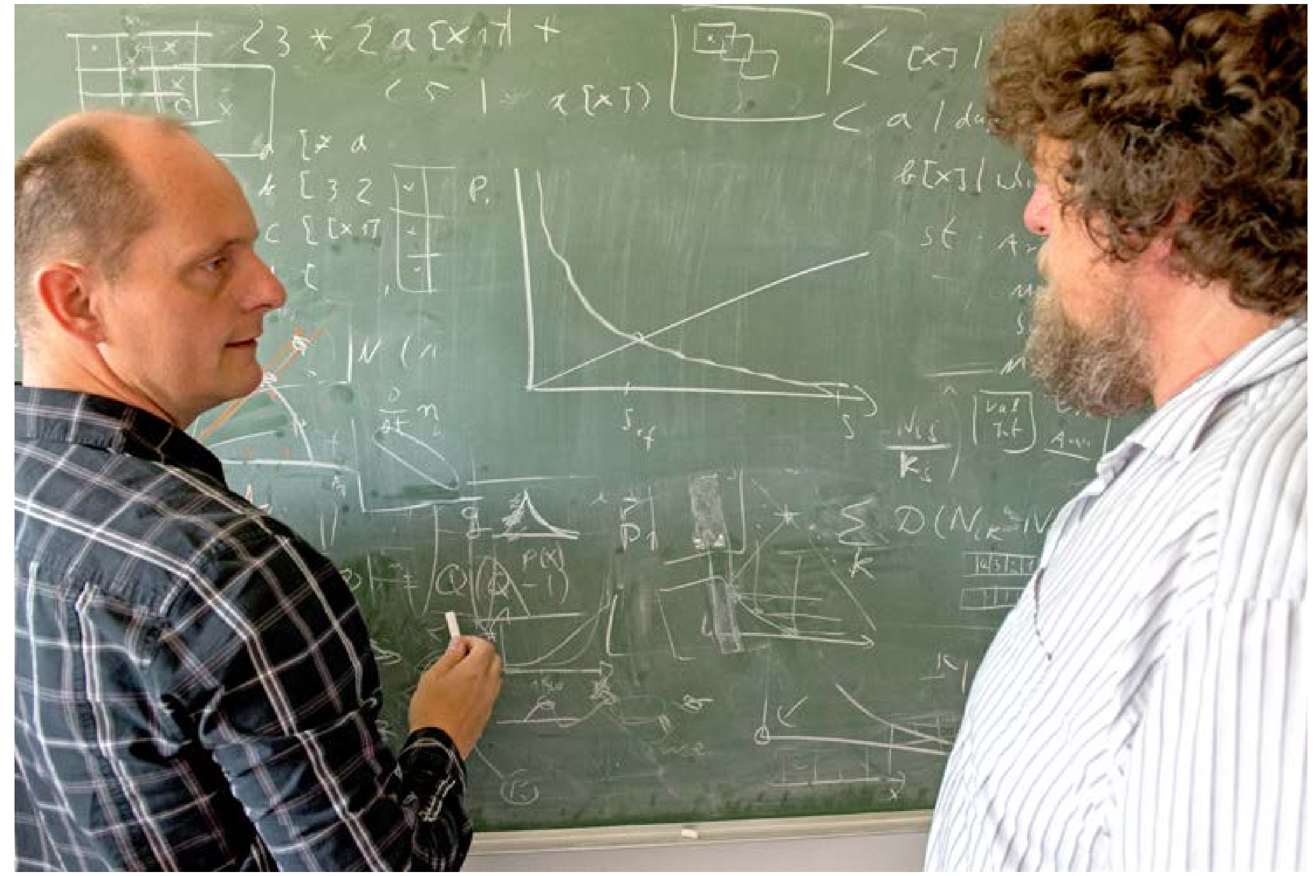
What does that mean for you as a physicist and modeller?
Blasius: That's exactly how I see it too. The fitness of a species, which determines whether or not it is threatened by extinction, depends as much on its chemical and physical environment as it does on its biological environment. It is only through the interaction between biologists, geochemists, modellers and physical oceanographers that we can gain a comprehensive understanding of an environmental system. Another exciting incentive is that there is still plenty of room for proper pioneering work in the field of biodiversity! Even students often explore unknown territory during their research internships.

So what are the questions of the future for you?
Hillebrand: One area we want to focus on in future is the fundamentals of marine conservation. The central question here is: How do you protect marine ecosystems? The problem is that the underlying concepts all come from terrestrial nature conservation research. The focus so far is on establishing areas for conservation, thus reducing or stopping exploitation in certain protected areas. There are already professorships for the conservation of terrestrial ecosystems. We don't have all these things in marine research yet. For very plausible reasons: for example how does one go about protecting mobile species that use extensive areas? Would an area-based approach using so-called "Marine Protected Areas" be adequate here? Firstly, most of the areas in question don't belong to any one nation. That means that national legislation and initiatives can't achieve much here. Secondly, the things that can be used to change and influence marine biodiversity are not localised. On land the situation is clear: a square metre of land that I convert into farmland is definitely no longer uncultivated land. At sea, by contrast, it's mainly about food extraction, but this doesn't change the sea's surface. There is no impact on the surface, which means area-based conservation would be extremely difficult to implement. So we're still in the very early stages when it comes to marine conservation.

A second important question is strongly linked to the social sciences.
Hillebrand: Yes, the second topic we want to make headway with is so-called "ecosystem services". This refers to the services that the ecosystem performs for us which benefit society. These can be anything from providing food in the form of fish to breaking down harmful substances. They can't be defined from the perspective of the

Prof. Dr. Helmut Hillebrand

Marine biologist and biodiversity expert Helmut Hillebrand heads the „Planktonology" research group at the ICBM and coordinates the „Marine Biodiversity" research centre with the University of Bremen. Also a coordinator of the BEFmate research project on biodiversity and ecosystem function relationships, his research topics include monitoring concepts for the German Bight and marine food chains in the Southern Ocean. Hillebrand has been appointed as the director of the new Helmholtz Institute for Functional Marine Biodiversity in Oldenburg, which will commence its activities in 2017. He is one of the most frequently cited scientists worldwide in his field.



Interdisciplinarity in action: Biologist Helmut Hillebrand watches physicist and modeller Bernd Blasius at work.

Prof. Dr. Bernd Blasius

Physicist Bernd Blasius is the director of the ICBM and heads the interdisciplinary research group „Mathematical Modelling" there. Blasius is an expert in global transport routes, bioinvasion and the spread of infectious diseases, and is also one of the ICBM's researchers at the Helmholtz Virtual Institute „Polar Time". There he is developing mathematical models for developing krill populations and also studying the adaptability of marine invertebrates.

natural sciences. Expertise in the social sciences is what is needed here! Take the ocean, for example: it extracts most of the carbon dioxide from the atmosphere and deposits it in the deep sea, using it as a kind of warehouse. It's like a biological carbon pump. This process requires the production of large amounts of algae. So one conclusion would be that stopping climate change will require large-scale production of algae. In other words, this green soup may not look very nice but it is incredibly valuable. But try telling that to a tourism manager! So there are ecosystem services that definitely have a divisive impact. This calls for a perspective that takes into account society in all its complexity. This is the second big gap we would like to close in marine biodiversity research.

> **"Data and knowledge about all the world's oceans at our disposal"**
> Bernd Blasius

Blasius: And we want to do this together with the Alfred Wegener Institute (AWI). We've just started setting up a research cluster called "Marine Diversity", and at the same time we're establishing the Helmholtz Institute for Functional Marine Biodiversity. This means we will have a Helmholtz centre here on the Oldenburg campus. The key elements of this project are two new professorships: one for "Marine Conservation" and one for "Marine Ecosystem Services". In addition we are planning a theory and computer science professorship to advance modelling in these areas. It's also worth mentioning that Germany's two largest research vessels will be among this new research consortium's "resources". The ICBM is the home institute of the "Sonne" research ship and the AWI has the "Polarstern". If we add the Senckenberg am Meer research centre and the Centre for Tropical Marine Ecology to the equation, both of which we also work closely with, we have data and knowledge at our disposal about all the world's oceans, from the tropics to the polar regions. In combination with the interdisciplinarity we practice in Oldenburg this puts us in a unique and clearly visible position internationally.

Interview: Volker Sandmann, Deike Stolz

Further research needed: Realistic predictions about how the North Sea's biodiversity will develop over the next 100 years are not yet possible.

What is the secret of the Roseobacter clade's success? Microbiologist Meinhard Simon is edging closer to unravelling this mystery.

The Allrounders of the Oceans

Marine Roseobacter reduce the greenhouse effect, supply algae with vital vitamins and help fish to grow. Professor Meinhard Simon is studying these multi-talented and versatile marine bacteria in a Collaborative Research Centre at Oldenburg

A library full of mutants – what sounds like something out of a horror film is actually cutting-edge biological research. The scientists of the "Roseobacter" Collaborative Research Centre (CRC) keep 4,000 bacteria with genetic variations, mutants, at the ready. Frozen in little plastic tubes at minus 80 degrees, they are kept on standby to be activated whenever needed. These genetically manipulated tiny living organisms serve as comparison material for various analyses conducted on "normal" organisms. All with the sole objective of unravelling the mystery of the Roseobacter clade bacteria and discovering the secret of their success.

Prof. Dr. Meinhard Simon started working towards this vision almost 20 years ago. He is a microbiologist at Oldenburg's Institute for Chemistry and Biology of the Marine Environment (ICBM) and the coordinator of the Collaborative Research Centre "Ecology, Physiology and Molecular Biology of the Roseobacter Clade: Towards a Systems Biology Understanding of a Globally Important Clade of Marine Bacteria". Eighty researchers, from PhD students to professors, are investigating the particularities of this group of bacteria at three different locations: Oldenburg, Braunschweig and Göttingen. The team comprises microbiologists, physiologists, ecologists, geneticists, genomics scientists, biotechnologists, organic chemists, and geochemists. "We have the leading German experts in this field of research all working together here, so we can cover every conceivable question almost perfectly," Simon explains.

And there are plenty of questions. "These bacteria are capable of pretty much anything," the scientist says. They are found in almost all oceanic ecosystems – from the surface to the deep sea, and from the tropics to the