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HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

Coastal Research

At the Interface between Sea and Land

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GEMEINSCHAFT

Photo: U. Nettelmann

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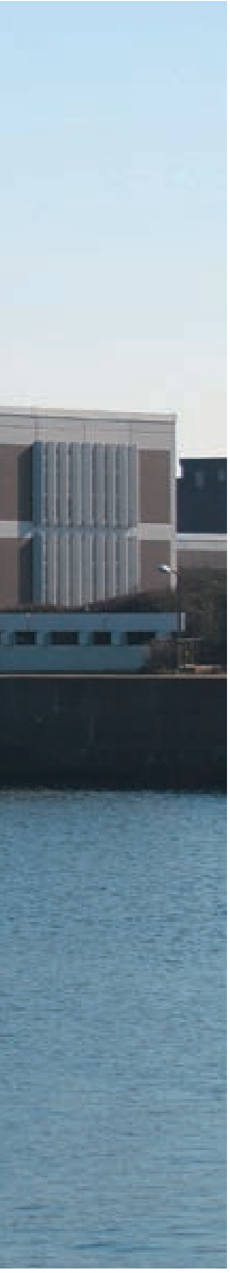


Contents

Photo: H. Lantuit

Preface

Of the global population, approximately twenty per cent live fewer than thirty kilometres from a coast. Eighty percent of all big cities worldwide are located at the coast. Fish and other marine life are vital food sources. The oceans serve both as a means of transportation and as a source of raw materials and their coasts provide vital settlement and recreational areas. The marine organisms (i.e. our submarine neighbours) are rarely encountered despite their proximity to us. With the exception of a few crabs, algae washed up on the beach, a fisherman's catch or an occasional seal, most organisms remain hidden below the surface. That is precisely what makes life in the ocean so fascinating.

As great as our interest in the creatures and goings on in the sea "right at our doorstep" may be, our understanding of coastal ecosystems is no way sufficient to appreciate their diverse and complex interdependencies and interactions. However, sustainability of our use of coastal waters requires the widest possible fundamental level of understanding, as we will only be able to assess the impacts of our actions and reduce negative repercussions if we have a sound basis for doing so. The coastal research scientists at the Alfred Wegener Institute for Polar and Marine Research in the Helmholtz Association (AWI) are ready to tackle this challenge. Closely networked with universities and non-university facilities at the national and international level, they drive scientific progress.

They combine expertise from biology, physics, geology and polar sciences in order to examine, for example, relevant climate issues, how food webs function, new coastal habitats and long-term ecological developments. Via the scientific locations at Helgoland, Sylt, Bremerhaven and Potsdam, many of our coastal researchers have direct access to their specific research area and expertise. Concurrently they also make use of AWI's world-wide infrastructure and decades of logistic experience in carrying out expeditions along the coasts of the polar regions. AWI lays emphasis on application-oriented processing of information for diverse target groups and interested stakeholders. The "Erlebniszentrum Naturgewalten" (Forces of Nature Adventure Centre) on Sylt offers interested visitors first-hand insights into the habitat of the Wadden Sea. AWI's North Sea office develops strategies for sustainable use of the North Sea in conjunction with the political needs and interests of environmental associations.

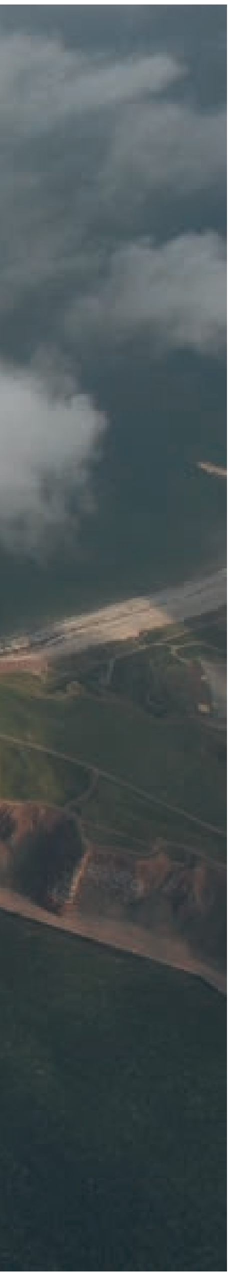
This brochure is intended to provide you with a better idea of our research on the coasts of the North Sea and polar regions. We will take you to the complex communities and ecosystems of the ocean right at our doorstep. I hope you enjoy this read.

Yours,

K. Lochte

Professor Karin Lochte
Director of the Alfred Wegener Institute

Photo: L. Tadday



At the interface between sea and land

The “elements” water and earth meet at the coast. At this interface a huge diversity of structures and habitants exist. This ranges from the unique sand and mud flats of the Wadden Sea through to steep permafrost coasts in the polar regions and glaciers calving into the ocean.

Where water meets land, powerful forces are at work. Here marine organisms have adapted to shifting and diverse conditions over the course of evolution. This includes complex hydrography with the interactions of currents and weather, physical and chemical shifts in water conditions due to varying freshwater input. Seasonality characterises conditions in temperate and polar latitudes, in terms of fluctuating temperature, light and nutrient conditions. As a consequence, coastal zones are among the most productive regions in the world. These environments are currently changing rapidly: Animals migrate into the North Sea from the south – feeling comfortable in the warmer winters and settle in the system. Swarms of jellyfish seem to take on the role of a key predator in the North Sea food web. Pathogenic organisms may thrive better in warmer waters and must be identified and their presence documented. Arctic permafrost is thawing, resulting in the release of the greenhouse gas methane with its feedback effects on global climate processes. We need to understand the amount and implications of such emissions.

Coastal and shelf sea researchers at the Alfred Wegener Institute strive to identify and understand changes, reveal their underlying mechanisms and outline possible future scenarios. Research in coastal seas is both useful and at the same time also fascinating. We are dealing with challenging habitats and the need important for a sustainable coastal human future.

Marine food webs play a major role in our research. The chapter “On eating and being eaten” explains, in the context of current examples, the changes in the availability and quantity of food. This starts with minute microscopic organisms, continues to understanding the development of fish stocks and ultimately involves the effects on human beings.

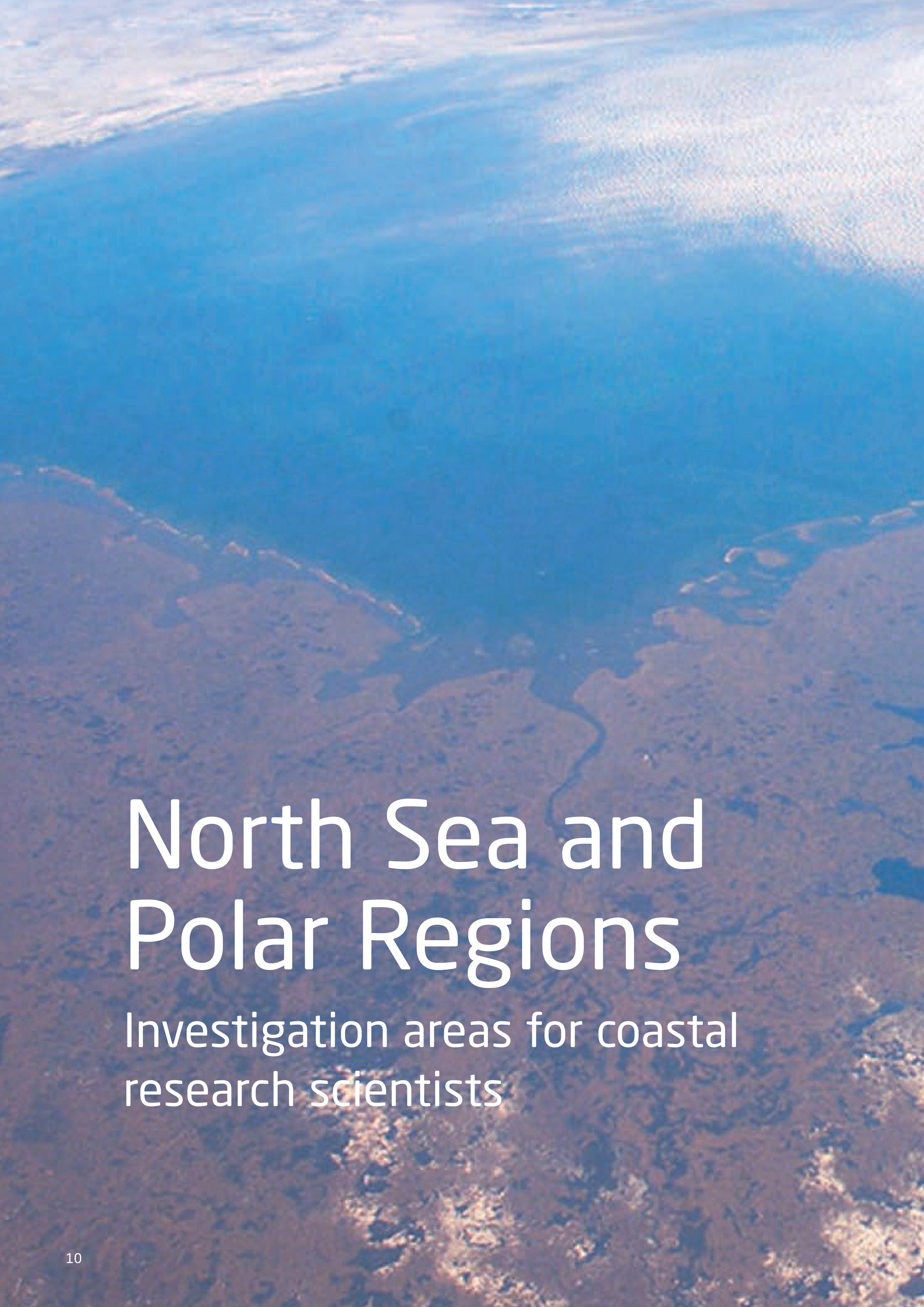
The Chapter “On the Fast Lane of Change” is dedicated to the topic of long-term data series. Differentiating between natural fluctuations and long-term series requires a lot of patience, and that’s exactly what we scientists must have. The long-term data series Helgoland Roads has been running for over 50 years, making it the longest and most detailed phytoplankton data series in the world.

Polar regions can be investigated as “hotspots of climate change,” because they are changing very rapidly and markedly. In this context they can serve as early warning signals for climate change, impacting the “Earth System” via interactions between land, ocean, biosphere, atmosphere and ice masses.
Coastal ecosystems are at least as complex as weather systems and they are full of secrets. It is a challenge to uncover these secrets. Also finding the correct data to do so can be a major undertaking. But it is precisely this which spurs coastal and shelf researchers on.

In this brochure we would like to share our scientific everyday with the reader. We will show you how we try to unravel the mysteries of our coastal ecosystems with the aid of buckets and nets, underwater cameras and countless complex measuring devices in water, mud or air. The great thing about coastal research is that many scientific disciplines are required to carry out research into the big coastal questions.

We invite you to travel with us from pole to pole, join us on our ships and in classrooms, sink into shelf seas and savour the diversity of our research!
Yours,

Professor Karen Wiltshire
Vice Director, Alfred Wegener Institute



North Sea and Polar Regions

Investigation areas for coastal research scientists

Quelle: NASA

Photo: R. Kuhlenkamp

Helgoland – Treasure trove of species

As Germany's only truly marine island, Helgoland is not only the stopover for thousands of migratory birds and site for rare plants. The rocky intertidal flats and rocky subtidal landscapes are home to the most abundant marine animal and plant life of the German coast. It is an ideal site to study changing biotic communities. (Professor Heinz-Dieter Franke)

Situated in the middle of the German Bight, approximately 50 to 60 kilometres off the mainland, the island of Helgoland is an ecological gem that has fascinated marine researchers for nearly two centuries. The scientist Johannes Müller founded the discipline of plankton research on Helgoland in 1846. Evolution scientist Ernst Haeckel carried out his, now famous, taxonomic studies of marine animals on and around the island. With the founding of the "Royal Prussian Biological Institute Helgoland" marine research was formally instated on the island in 1892.

The southeast section of the North Sea is dominated by soft substrates of sand and silt. Contrastingly the bizarre rocky landscape of Helgoland is a geological peculiarity encompassing approx. 40 square kilometres. Only a small part of it sticks out of the water, like the tip of an iceberg. By far the largest portion of the rock is submarine. The transitional zone between the island and the submarine is a rocky intertidal zone (eulittoral), in which water goes in and out according to the tide. Helgoland is special because on the one hand, the living conditions for flora and fauna in the open water and upon the seabed around the island clearly are influenced by the mainland coastal conditions, with fresh water and sediments reaching the North Sea via the rivers. On the other hand, water from the open North Sea and thus also from the Atlantic influences the region so that the living conditions around Helgoland are more marine than at the coast itself.

Macroalgae need a solid base for attachment. The Helgoland rock extends under water and forms the only major natural hard substrate in the German Bight. Photo: I. Bartsch

Habitat for hundreds of species

Divergent habitats are located right next to each other at Helgoland. Consequently a unique and diverse animal and plant world "co-exist" here at very close quarters. Helgoland is therefore an oasis for marine species diversity. Approximately 700 species of visible macrofauna, such as snails, mussels, bristle worms and crabs, live on the rocky intertidal alone. Almost 200 large animal species inhabit the extreme environments of the intertidal zone, in which all major environmental factors change quickly and drastically twice a day as the water moves in and out with the tides.

About 300 species of large marine algae (macroalgae) grow on the hard bottom. Only here do they find the firm substrate on which they can

BLUEHOUSE: Experiencing science on the ground

Who wouldn't jump at the chance to dive into the mysterious depths of the oceans, just like a real scientist? On Helgoland we want to make this happen. The Alfred Wegener Institute would like to convert the research and training aquarium into a public research landscape. In the so-called "BLUEHOUSE" future visitors will be able to discover the ecosystem of the North Sea together with research scientists from the Biological Institute on Helgoland, take part in the evaluation of research data live, or even try doing a scientific experiment. Guests with a diving certificate might in future explore the underwater world of Helgoland with scientific divers as guides.

Photos: U. Nettelmann

anchor their holdfasts. This algal carpet extends from the upper intertidal zone down to a depth of about 15 metres. This is as deep as sunlight penetration of the turbid North Sea water. These macroalgae produce a significant proportion of the total local marine biomass. They also act as a nursery, a feeding ground and as a permanent habitat for many animals and fish.

Depending on the season there is a cycle of growth and dieback of bacteria, miniscule algae, microscopically small animals and the larvae of many benthic animals which populate the open water. We know that the processes governing the growth of these organisms depend on the nutrient supply, light, temperature and currents as well as predator-prey interactions, and although we understand a lot many, if not most of the details have yet to be researched.

Understanding processes and recording trends

Inputs of pollutants and nutrients, climate change, introduction of foreign species "Neobiota" and, other direct human interventions (e.g. the fishing industry) are rapidly changing marine biotic communities in the North Sea. Based on its unique ecology and thanks to the valuable long-term marine data sets, Helgoland is particularly suited for studies and documentation of long-term change. Only when we understand the current physical-chemical status of our coastal waters, the diversity and occurrence of individual species, as well as the inherent natural fluctuations, will it be possible to detect actual trends in long-term series. In order to identify possible causes of such trends and be able to make well-founded evaluations of potential consequences, other processes must first be understood, e.g. the ecological role of the key species, their interactions with each other, as well as their dependencies on various factors. This requires extensive in situ observations and laboratory experiments.

However, not even in an area as thoroughly examined as Helgoland, have all species and their interactions been fully documented. We are most familiar with the biodiversity and spatial distribution of the intertidal biotopes, simply due to the fact that this zone is the most accessible biotope. A similarly comprehensive documentation of the submarine habitats would necessitate deployment of specialized research equipment and a lot of investigative diving. Increasingly methods based on molecular biology have been used to identify previously unrecognised species. Increased use of such methods will make it possible for future classification of the important free-swimming larvae of bottom-dwelling which has been extremely difficult to date. This alone would open up new ecological research as models of the function of the different life stages of organisms in ecosystems can be finally be examined.

Some changes, such as those related to water temperature, the seasonal dynamics of plankton and shifts in the species spectrum have been well documented for the Helgoland area over decades of systematic research. Many questions still remain. We need answers for even simple questions such as: Why does a species disappear? What does it mean for a biotic community when a new species appears?

All in all – the rapid ecological change currently evinced along the coasts combined with their immense diversity and complexity underpins the clear need for basic ecological research on the long term.

Whether sieving for organisms in samples from the rocky intertidal in the summer season (above) or pulling a net through the water at autumnal temperatures (below): AWI researchers on Helgoland are delighted to have the advantage of searching for the subjects of their research close at hand.
Photos: U. Nettelmann

Photo: P. Antkowiak

Sylt – Changing tidal flats in a World Heritage Site

Research scientists have been documenting the natural changes in the Wadden Sea for about 150 years. Consequently we now have a solid basis for understanding the interface between land and sea in this unique system. Within the global context of modern research new questions present themselves for Wadden Sea scientists. Deliberating the past and looking forwards. (Professor Karsten Reise)

Long-billed Red Knot are specialised for eating small mussels and snails in the and of the tidal flat sediments. Once they have eaten enough they fly on to Siberia where they breed.

The "newcomer" Pacific oyster increased in numbers in the Wadden Sea. Students collect them. They want to find out if the common mussel has come to terms with this new competitor. – There is still much to understand. –
Photos: K. Reise

The fishermen of Sylt were alarmed. The annual oyster catch had started to yield less and less. So in 1869 they went to Karl Möbius, a zoologist in Kiel, and asked him to conduct a survey. The naturalist revealed that one-sided overexploitation was the reason for the disappearance of the molluscs – a novel revelation for that time. "To keep the oyster stock at a sustainable level," Möbius wrote, "the entire community of life would have to be taken into consideration". This revelation represents the first true scientific milestone for the Sylt tidal flat area and is still accepted as a valid biological concept today.

Fifty years later four other researchers also have set new standards. The biologists Arthur Hagmeier and Rudolf Kändler from the Biological Institute Helgoland (BAH) began a systematic research of the tidal flats. They not only compiled data on which kind of living organisms were crawling around on and under the sediment, but also the actual quantity of each species present. At the same time, Wilhelm Nienburg and Erich Wohlenberg constructed maps on sea grasses presence and sediment organisms. Together they drew up a comprehensive picture of the Sylt tidal flat ecosystem.

This work served as the foundation for current day Wadden Sea research which was given a home. In an oyster laboratory in 1924 which was later developed into the Sylt Wadden Sea Station in 1937. The continuous records from the work at this station provide present-day research with an extensive temporal dimension: in a comparison it serves as a basis for current and future change analysis.

Tidal flats in transition

Not only have the tidal flats changed - human perception of them has also changed. "A miserable wasteland" is how travellers to the region once described them. Merchant shipping avoided the dangerous shallows in the past and people complained about the bleakness of the landscape. Other than oysters, there was nothing of significant value for them to be found there. When in the old times dikes where built separating sand and mud banks and the extensive salt marshes from the sea, thus forming meadows and farmland the hope of land profit was great. However, the dike was repeatedly destroyed by storm tides. Today, our views have changed: we now view the Wadden Sea as a giver of life, e.g. as a nursery for fish and as a stopover site, a place for energy refuelling for migratory birds. International studies show that nowhere else on a global scale do larger flocks of birds stop to rest.

This has had great positive social and political ramifications. The Netherlands, Denmark and Germany started to protect the Wadden Sea area against new dike construction, pollution, overfishing and hunting by means of a joint management plan, a series of national parks and biosphere reserves. This far-sightedness was rewarded, and in 2009 UNESCO declared the Wadden Sea a World Heritage Site. Needless to say this award has spurred on and inspired coastal research.

Before this new declaration research and measurements were more of a regional matter, and predominantly focused on what occurred locally in the Wadden Sea. Topics such as how natural

Photo: V. Frenzel

Powerful natural forces

The wind rages and waves as tall as houses eat away at the land metre by metre.... When we talk about "the force of nature," we usually think of destruction. But this question of scale and dimension is subject to the human point of view. For jellyfish in the water or tiny organisms living in the sand even a gentle wave might be violent. For the common mussel violence is more likely the starfish that feeds on it. AWI research and the "Centre for Natural Forces on Sylt" have a neutral view of the forces: forces should be viewed and studied from different perspectives. People, too, are not only at the mercy of the physical forces of nature, they can be considered a force of "nature" themselves. Human forces are for example fishing the oceans or constructing offshore wind farms.

Storm surges rip at the Wadden Sea shore, toss mussels onto the beach and whip birds around in the air over the sea. After a storm nothing is the same as it was before. These dynamics are important, however, so that the Wadden Sea remains a sustainable system Photo: K. Reise

forces form the tidal flats, how the relationships between waves, soft substrate and salt marshes function, which animal eats what and how and to which extent humans influence all of this.

Now we are in a position to place all this knowledge into a global context. Answering questions such as What makes the Wadden Sea unique? Why aren't there such impressive flocks of birds found anywhere else but in the coastal sky? And can one also find thousands upon thousands of species of microorganisms living between the grains of sand of the beaches elsewhere in the world?

The same old story: nothing ever stays the same

Another challenge of global significance which affects the Wadden Sea is climate change. We have to consider the potential for total disappearance of Wadden Sea tidal flats due to the rising sea level. Within the span of a century the level of the tidal flats currently accretes by just a few centimetres. The sea, however, will rise by as much as a metre by the end of this century. Obviously this is too much for the normal tidal flat growth to keep pace. If this scenario is substantiated, we will need innovative coastal protection solutions that work with, not against, nature. For example, instead of new, rigid dikes, flexible structures of sand imported from the North Sea could be more suited to protection of islands and the coastal landscape and allowing protection of their World Heritage status. Such sand embankments would not be able to exactly preserve the Wadden Sea as it was in the past. But it would be better to work with the changing environment and shifts in nature,in line with the modern notion of nature conservation.

Even with new ways, the scientific tasks for coastal research on Sylt remain the same as they were at the time of the station's founding.

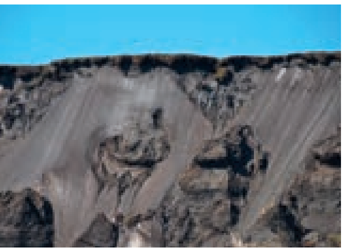
The objectives are still to examine the interactions in the Wadden Sea system. The topic of research can no longer be as specific and contained as was once the case with oyster farming and exploitation of the tidal flats. Future science needs to include the big developments in this sensitive system and advice and support should be given to coastal management with the aim of bringing human desires into harmony with nature.

Photo: M. Fritz

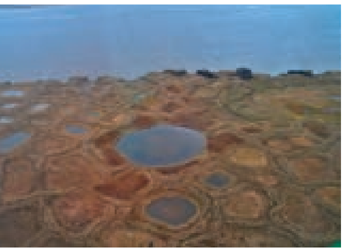
Polar Regions – key areas for climate processes

North of temperate latitudes it is quite inhospitable: snow, ice and freezing cold down to minus 50 degrees Celsius make for extreme living conditions on the Arctic coasts. Conditions in the far North are changing rapidly – the air is getting warmer and sea ice is melting. Is this development positive or negative? AWI researchers want to know how the polar coasts will develop in future.

(Dr Paul Overduin, Dr Ingeborg Bussmann)



Sediment erosion on a permafrost coast.



Melt ponds in the Lena Delta.
Photos: B. Oppermann

The Arctic coasts are home to humans, fauna and flora. Like all coastal areas they are also an increasing economic and trade hub. Tourists are increasingly discovering the cold North as an exciting holiday destination. Arctic coasts are also important for something else – they are a key area for climate processes, and they react more sensitively to global warming than coasts in temperate latitudes. Changes in the Arctic weather can also have a substantial impact on the global climate, not least of all because of the shear expanse of the Arctic coastal region. The northern seaboard encompasses over 400,000 kilometres corresponding to a length ten times that of the equator.

Thawing permafrost

Two-thirds of Arctic coasts are not rock, but rather permanently frozen soft soil – better known as "permafrost". Approximately half of the Earth´s carbon are stored underground, and this is mainly contained in the permafrost soils of the northern hemisphere. When permafrost thaws, also as a result of climate change, carbon dioxide and methane are released into the atmosphere. These gases drive the greenhouse effect, which in turn then feeds back to accelerate the thawing processes further.

In the meantime, the main principles of processes in these remote regions are quite well understood. However, when it comes to quantification – i.e. how much and how gas is emitted from the soils – a lot of research is needed in permafrost regions, for example in the Siberian Lena Delta. This includes a lot basic field work at the outset. On the small island of Samoylov, in the Lena Delta the AWI has been operating a research station jointly with Russian partners since 1998. Scientists use it as a base camp, from which they venture into the field and out onto the coastal water. They measure the ground temperature and depth of the thaw, set up measuring equipment over the ground and in the water and record the quantity of gas emitted per unit area – and they do so repeatedly and as long as possible so that they can track developments and seasonal fluctuations of gases, energy and temperature. Microbiologists and biogeochemists investigate where the high level of methane in the Lena and its delta comes from, and associated with these processes: how quickly bacteria can produce new biomass. Researchers also investigate changes in aquatic organisms and their associations.

In the large-scale PAGE21 EU project the generated data are now increasingly used for global climate models. Field researchers, operators of long-term observatories and modellers from AWI and 17 European partner institutes examine the question as to what exactly occurs when huge quantities of carbon from Arctic soils are released into the atmosphere. Since permafrost with all of its potential climate feedback effects, has scarcely been integrated into the climate models to date, our modelling ability is still imprecise in many of these regions. We do need the most precise models possible, however, if these are to be a basis for the development of avoidance and adaptation strategies in order to ensure sustainability and in order to counter climate change.

Better modelling also requires more knowledge of for example submarine permafrost. Rising water temperatures could also cause this ice mass to thaw. In the western Laptev Sea in Siberia, for instance, the submarine permafrost currently has a temperature of minus one to two degrees Celsius and thus is already relatively "warm". Any further warming would tip it easily out of its current equilibrium. This poses potential risk, as tremendous quantities of methane, estimated at between 2 to 65 billion tons, are embedded underneath the Arctic shelf seas. Currently methane gas is stored in this permafrost as methane hydrate. If the water temperature rises, this may melt with methane thus being released from the sediment into the atmosphere. This scenario would have a huge impact on the climate. The extent to which sediment and water would act as a trap converting the methane has yet to be clarified.

Careful, thawing ice!

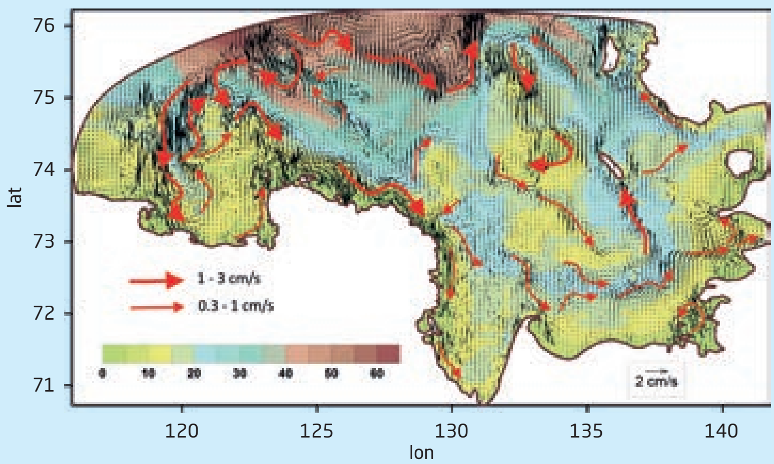
Thawing permafrost, whether submarine or on land, could also induce another process in the Arctic: coastal erosion. The coasts of Siberia, on the Laptev Sea and East Siberian Sea as well as in Alaska and north-western Canada, on the Beaufort Sea, are undergoing dramatic erosion. In these regions the coasts are receding in part by as much as 20 metres a year. The future of these vast coastal regions is very precarious. This naturally also affects the future of the human population, wild animals (e.g. the caribou herds) and many other organisms, also associated with the many freshwater lakes of these coastal regions.

In contrast to the coasts in the temperate latitudes, the coasts of the Arctic are well protected from wave action from November through to May due to the presence of Arctic sea ice. In the summer months, however, waves can "attack" the coasts unhindered. If these collide with thawing permafrost coasts, there is very little resistance. Summer storms are associated with higher sea levels, and correspondingly waves have even greater force. Huge quantities of sediment slide into the sea in vulnerable coastal areas. If sea ice in these regions recedes the risk of erosion increases for exposed Arctic coasts.

The degree of how global climate change influences the rate of Arctic coastal erosion is not yet clear. At present there are few local and regional series of observations for this huge area – and these exist for very different coastal dimensions and time spans. From irregular on-site measurements and air and satellite images it is, however, difficult to reconstruct the temporal sequence of the total coastal events. This is why AWI scientists together with Russian and Canadian colleagues now continuously record erosion rates and sediment transport along the Arctic coasts with the aid of landscape models and high-definition satellite data. Only increased research will allow the evaluation of coastal change better and make consideration of future scenarios better.

Well-planned logistics are essential in Siberia – the nearest supplier and/or repair workshop is hundreds of kilometres away.
Photo: B. Oppermann

The residual circulation of a joint contribution of M2, S2, K1 and O1 tides (cm/s) superimposed on the bathymetry map (m)



Mathematical model: From permafrost to new hydrography

The physical characteristics in the Lena Delta are changing considerably: the water level of the river reaches its maximum point earlier every year in spring, the average water temperature in summer is rising and the ice on the Lena is thinner in winter. Such observations must be incorporated into global oceanographic climate models. Mathematician Vera Fofonova has developed a special model for this region. Among other things, it shows the interrelationships between the dynamics of atmospheric forcing, temperature, salt concentration and water level and takes into consideration how the tide in the Laptev Sea influences the mixing of the river water. In this context the Lena Delta region of the Laptev Sea can be theoretically subdivided into different depth layers with 250,000 data points each. From the differences between the points the model is programmed to calculate which parameters have changed where and in which manner. Currently Dr Fofonova is feeding the model with all available data on grid points. The resulting calculations help to better understand the role of each individual parameter as well as the ramifications of changes in hydrology of the region for productivity.

On eating and being eaten:

Marine food webs

Photo: U. Nettelmann

Microscopic image of dinoflagellates of the genus *Diplopsalis*.
Photo: M. Loeder

Plankton à la carte

The menu of the sea appears simple at first glance: the big eat the small, the small eat the smaller animals and these in turn eat phytoplankton. However, research on this basic food web is actually highly complicated – and new questions constantly arise.

Biologically speaking, those who like to eat fish are positioned as top predator at the uppermost level of the marine food web.

"Yes, one could put it that way," laughs Professor Maarten Boersma, ecologist at the AWI on Helgoland. Together with his team, he conducts research on how individual links in the North Sea food web are inter-woven in the "Helgoland Food Web Project".

The project concentrates on the miniscule: fish larvae, tiny crabs, microalgae and bacteria. This tiny plankton forms the basis for all higher marine life. The goal is to work out the interplay in the system – above and beyond the food chain at the point where "who eats whom". The model of a food web also takes into account the feedback between the individual consumers. Nutrient cycles and bacterial activity also play an important role. "We don't stop at: 'zooplankton consumes algae', rather, we pose the question 'what effect does zooplankton have on algae?'," Boersma explains. In order to fill these and other gaps in knowledge, zoologists, algal specialists, bacterial experts, ecologists and oceanographers work together in an interdisciplinary process to unravel the secrets of the marine food web on the Coastal Food Web Project at AWI.

Nitrogen and phosphorus "taste" different

Often, in the course of their investigations, questions arise on matters which scientists thought they had already answered – such as issues concerning young fish. As has been known for many years, these live off animal plankton. We also know how much the mini-fish need to eat in order to survive. But where and how exactly do they eat it? "When you calculate how much plankton is contained in the water passing through their mouths, the quantities don't match up with their growth." The plankton in the water is much too diluted for the fish to take in sufficient food. The fish probably "harvest" local groups of zooplankton. Such accumulations occur for example, on the edges of currents, between masses of water with slightly different densities and/or patterns of movement. This again immediately leads to new questions: How do fish larvae and other organisms find these places, and what role does food quality play? How do animals recognise which algae are the best food while they are swimming in a patch of algae where everything is in constant motion? All we know is that they do it.

You have to be careful with the concept of "food quality". Based on the food web, "good" and "bad" are not useful characteristics of the prey –

algae food, in this case. Quality is defined more by how much the consuming animal actually grows. In this case it not only depends on the energy content based on carbon. For the marine food web, nitrogen and phosphorus also are criteria as to how valuable algae are as food for zooplankton. While carbon is present in coastal waters in practically unlimited quantities, nutrients such as nitrate or phosphate are only available in limited quantities, depending on the chemical conditions in the sea. Flagellates und copepods, which live on algae, need more of these substances, comparatively speaking. "Consuming only carbon is comparable to us only eating sweets. We then put on weight while lacking important substances like vitamins and minerals."

Faulty links in the food web

If based on low quality food, the links in the food web no longer fit together; less nutritious algae result in fewer copepods so that, in turn, fewer fish and lobster larvae get their fill. "This has obvious consequences. Cod, for example, is disappearing from the southern North Sea mainly because its larvae are not getting the proper food," explains Boersma.

The food web can get out of sync (in the temporal sense) – triggered for example by climate change and resultant warmer water. Because most marine animals are cold-blooded their metabolism accelerates as the water becomes warmer – but at different rates depending on the species. Fish which originally mated and spawned in the summer may do that in late winter in the future. At that time, however, there is no real algal bloom providing the necessary food for the larva.

Maarten Boersma is optimistic, however, that even if change occurs, loose ends in the food web will ultimately link up again into a new tight weave.

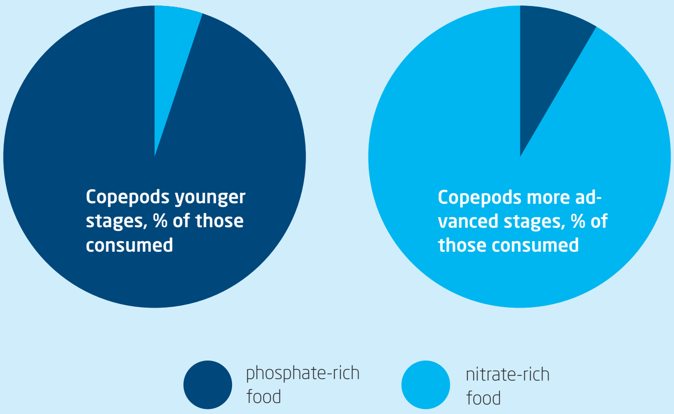
Food webs of a new weave?

"We have to understand that we cannot influence the food web directly. Plankton simply does not lend itself to being managed on a large scale." There have been experiments on fertilisation of the sea with phosphorous for example to boost primary production with the idea that more fish would end up in the net. But do we really want that? Do we want to actively take part in weaving the food web or should the sea find its own steady state? Or does the solution lie somewhere in between? "This is an issue which must be politically and socially re-negotiated again and again. We scientists can only provide the basic knowledge to make educated decisions in this regard."

For himself and in his personal role at the top level of the food web, Professor Boersma has clearly decided that one thing will never happen: Helgoland lobster will never land on his plate. "There are simply no longer enough of these animals around Helgoland to justify further consumption." This is an example of something where each of us can make a difference to the state of the marine food web.

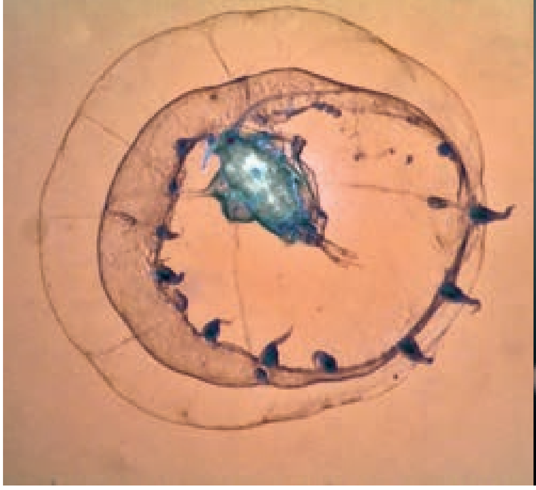
Photo: M. Loeder

Übersetzung:
Unterschiede im Fressverhalten jüngerer und älterer Ruderfußkrebse



Food quality – plenty of it, but little of substance

In comparison to the 1970s seawater`now contains more carbon although less nitrate and phosphate. This substance ratio is reflected in the quality of algal plankton – plenty of biomass, but of poor substance. Does the algae-eating plankton even notice this? A definite Yes! is the answer. Dinoflagellates and copepods, for example, can target "good" food, as has been revealed in feeding experiments. Both of these model organisms were fed with a mixture of algae with more or less nitrogen in comparison to phosphorus or carbon. After a defined feeding period, the portions of the two algae species remaining in the water differed. Dinoflagellates and the younger stages of copepods predominantly ate algae with little nitrogen and relatively more phosphorus – presumably because phosphorus is important for growth. The older copepod larvae, in contrast, preferred nitrogen-rich algae because they need this element to build up body structures. How exactly zooplankton and dinofalgellates differentiate between the algae of different nutrient status is something that will be subject of future experiments.




Many enemies: The copepod on the left is being eaten by a Anthomedusa. The image on the right shows an anthozoan attacking a copepod, of which only its red eye and the transparent antennae are visible. Photos: R. Schüller

Plankton and the "extra portion"

In the food web of tiny marine creatures things could proceed in an orderly manner if it weren't for the fact that some species of plankton occasionally indulge in an "extra portion". Once an algal bloom begins, particular plankters become greedy opportunists. Autotrophs can become hunters of prey, vegetarians can become carnivores and hunters and their actual prey can suddenly compete for the same meal.

A copepod taking a nap in a surplus of food. The small dots are micro-algae, food for crabs. Photo: R. Schüller

Unicellular animals eat "vegetable" plankton and bacteria. Multicellular creatures eat unicellular organisms. Small zooplankton ends up in the stomachs of larger zooplankton and these in turn end up in the stomachs of fish larvae. So far, so good, one might think. During an algal bloom, however, nothing is constant. The food supply varies – first there is an abundance of nutrients and few algae (phytoplankton) in the water. Then the algae start to grow and flourish. They use up the nutrients and in turn they themselves become food for others. At the end of a phytoplankton bloom the water is depleted of nutrients and the algal number shrinks. "The battle at the marine buffet is correspondingly turbulent," jokes Dr Nicole Aberle-Malzahn.

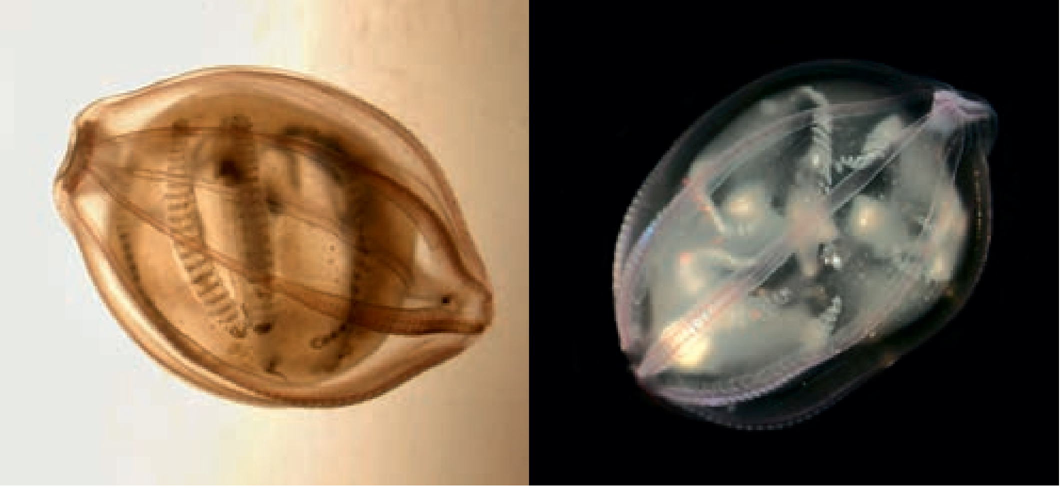
Dr Löder and Dr Aberle-Malzahn have examined the gourmet menu on offer during a spring-bloom in the North Sea. Research scientists more or less constructed an artificial North Sea in 750-litre tanks in the laboratory. Using a cleverly designed light-control system, they succeeded in simulating the sun and the increasing day length at the Helgoland latitude. The scientists took water samples every day for a month and examined the species composition and the feeding behaviour of the zooplankton. They found they were in for surprise: "Certain plankton species adjust their feeding habits to the respective supply and what is available. We knew that this could happen but the actual magnitude of this was new to us," says Löder.

A few dinoflagellates get their energy via photosynthesis as plants. During the peak of the algal bloom, however, when the nutrients for plant growth are in short supply, they behave more like animals and eat different things. They avail themselves of the single-celled tiny algae and thus create considerable competition for copepods which also eat these microalgae. Dinoflagellates can grow in number very quickly via simple cell division and thus react much faster than the slow growing copepods to available food.

Copepods being vegetarians, on the other hand, are dependent on algae. Some algae can form colonies and thus becoming too big for small crustaceans to be able to eat them. Instead, the latter re-orient themselves and increasingly hunt for unicellular animals. "They thus get food that has already been enriched via one step more up the food web. This corresponds to a person who eats schnitzel from an animal that has eaten potatoes and root vegetables," Löder explains.

And things can get even more complicated – fish larvae that normally go after copepods also eat unicellular algae, thus grabbing the prey from their actual prey. And these are only three examples of planktonic organisms "consuming an extra portion" from the gourmet menu.

"All of these cross relationships in feeding obviously have an important function in the system which to date have hardly been studied," says Aberle-Malzahn. "For calculating the carbon balance in the sea, such supplementary feeding levels should however also be taken into consideration in future. Previously this has been underestimated – overall it represents a work-intensive but exciting job."



Jelly eating jelly: the comb jellyfish Beroe sp. preying on another comb jellyfish – the sea gooseberry Pleurobrachia pileus (microscopic images in transmitted light on the left, in reflected light on the right). Photos: U. Nettelmann

Forwards, but backwards into the past

There have always been jellyfish in the North Sea. They even eat their own kind, thus, keeping the population in check. But what happens when a new jellyfish appears in the system? How does for example the newly arrived "sea walnut" interfere in the food web and how do it and its relatives shape the future of the North Sea habitat?

Transparent and fairy-like, *Mnemiopsis leidyi*, also known as the "sea walnut", looks harmless. When this comb jellyfish appeared in the North Sea for the first time a few years ago, it initially caused a storm among scientists. In the 1980s these creatures decimated fish stocks in the Black Sea since they can eat fish larvae and eggs. How justified was this related to the North Sea?

In food experiments Dr Arne Malzahn wanted to work out what the sea walnut prefers to eat and what position it assumes in the food web. "To accomplish this goal, we had to observe them live," says Malzahn. But how can one capture an animal that is so delicate that it doesn't survive the fishing nets? "Luckily, jellyfish have the habit of gathering together at the boundaries of water masses with different characteristics. We can then scoop them up from the surface of the water." Tissue samples indicated what the animals had eaten before capture, because since jellyfish incorporate the isotope signature of their food in their bodies. Animals were also fed while monitored in the laboratory in order to be able to observe their feeding behaviour directly.

The results: The sea walnut does feed on fish larvae and eggs, but rather infrequently. Only a few percent of the body weight stems from fish. The sea walnut is actually a minimal eater. Even when it does not get enough other food, it hardly ever touches fish. It does not "consciously" forgo fish, there seem to be natural inhibitions to this. It is difficult for it to capture fish larvae because it does not have tentacles, thus allowing the larvae to easily escape. And fish eggs simply do not activate a capture reflex. "The sea walnut will therefore probably not deplete the North Sea of its fish stock," says the marine biologist. "But one should still continue to observe them and their habits closely."

Newcomers like the sea walnut are clearly new food competitors. The simple food chain was previously seen to be dominated by a great deal of fish at the upper end. Algal plankton ends up in the stomachs of copepods and the latter, in turn, in the stomachs of fish. However, the system tends to move little by little towards a big food web. Additional and new tiny animal plankton in a system creates competition for the copepods which can also eat one another until it ends up in the stomachs of jellyfish rather than fish.

The sea walnut and its relatives evidently cope with change in the seas better than others. For instance, there are more and more areas in which the water is oxygen deficient. "How exactly jellyfish come to terms with a shortage of oxygen is an interesting question. It seems that they have few problems while fish really have to struggle."

Such observations indicate that marine life may be of an extremely gelatinous nature in the future.

"Such a scenario is actually not all that new," says Malzahn. "The food web in the Earth's distant past actually looked like this before fish began their conquest." We are talking of over 400 million years ago and beyond our comprehension. "Overexploitation contributes much more to this tendency for the system to revert to this sort of scenario than the natural processes do. It is basically quite simple: we need more targeted fisheries management."

The North Sea in the fast lane of change

Long-term measurements confirm change in the ecosystem

Photo: S. Zankl

Plankton nets are used to sieve many cubic metres of North Sea water in situ. In this manner biologists on Helgoland find new species, such as the Japanese ghost crab *Caprella mutica*.
Photos: S. Zankl, U. Nettelmann

North Sea in the fast lane of change?

Long-term investigations off Helgoland provide proof: the North Sea has become warmer, the spring bloom is changing and many a new species from the south are arriving and staying. The climate change is "rumbling" the North Sea.

Every weekday since 1962, a research vessel from the Biological Institute Helgoland (BAH) has sampled at the same location between Helgoland and Düne, known as the "Kabeltonne". Temperatures and water clarity are measured, plankton nets are towed and water samples are taken. Back in the laboratory the scientists determine the salt and nutrient concentrations and examine the plankton. The small vessel only stays in the harbour when storms whip up the water of the North Sea or if there is ice. Captain Klings has not seen ice here for a long time. Things have changed in the North Sea: "The average water temperature has risen by approximately 1.7 degrees Celsius in the last 50 years," says Professor Karen Wiltshire.

When the Station's director came to Helgoland more than 10 years ago, she had no idea what kind of data treasure trove she would uncover. The hydrobiologist painstakingly sorted and evaluated the data from decades of measurements at "Kabeltonne" and continued and expanded the measurements that are officially designated as "Helgoland Roads Time Series". "This time series is now so unique that scientists from all over the world ask us for data and information on a weekly basis. With the help of our data, models for ecosystems are developed and climate models are verified. Public agencies use the data to develop strategies for management of the seas."

What makes the "Helgoland Roads" so valuable? With these data scientists are able to pursue a plethora of questions, particularly when it comes to long-term trends. How is the species composition changing? Who is eating whom? How do ecosystems react to changing environmental conditions?

Algae are winners

Wiltshire and her colleagues have verified how global climatic warming can affect an entire system by changing the timing of the spring bloom of unicellular algae in the North Sea. For the last 20 years or so the water here has been warm in winter. This initially created an advantage for zooplankton, the microscopically small animals in the sea. Throughout the winter they grazed the complete phytoplankton, causing the algal bloom to begin later. However, now things have changed – in the meantime the water has probably become too warm for the zooplankton in winter whereas the algae have adapted and the spring bloom tends to begin earlier. "At the moment," explains Wiltshire, "algae are the winners". Their metabolism is dependent on light rather than temperature so they are not so sensitive to fluctuations in temperature."

Examination and experiments with plankton are a task for the patient.

The plankton content of a 1 litre water sample just barely covers the bottom of a coffee cup. However, at the same time a hundred different species can easily be found in this "sediment" in the summer – and these all have to be classified and counted under the microscope daily. “This keeps our technicians busy for a few hours every day. Our technicians and their knowledge are irreplaceable – there is no device that can work as precisely as they can – we have checked this numerous times,” Karen Wiltshire emphasises.

Life in Helgoland’s waters is becoming increasingly diverse. Over the last fifty years at least sixty new animal and plant species have settled here – the actual number is probably three times as high. On the one hand, we have the “aliens” that have “travelled” great distances on the hulls and in the ballast water of ships or have been introduced as by-products from aquaculture. The latter being how the Pacific oyster and the Sargasso weed arrived in the North Sea. On the other hand, many heat-loving species from southern climes have gradually moved up along the Atlantic coast on climate change. Professor Heinz-Dieter Franke is quite familiar with the newcomers. The biologist has conducted an in-depth study of amphipods, for example.

“For a long time now approximately fifty different species of amphipods have been known here in the area around Helgoland. And in the last 20 years at least nine species for sure have been added to that list – two newcomers were brought in from Japan and New Zealand, and seven species have simply settled here from southern regions with mild winters,” Franke reports.

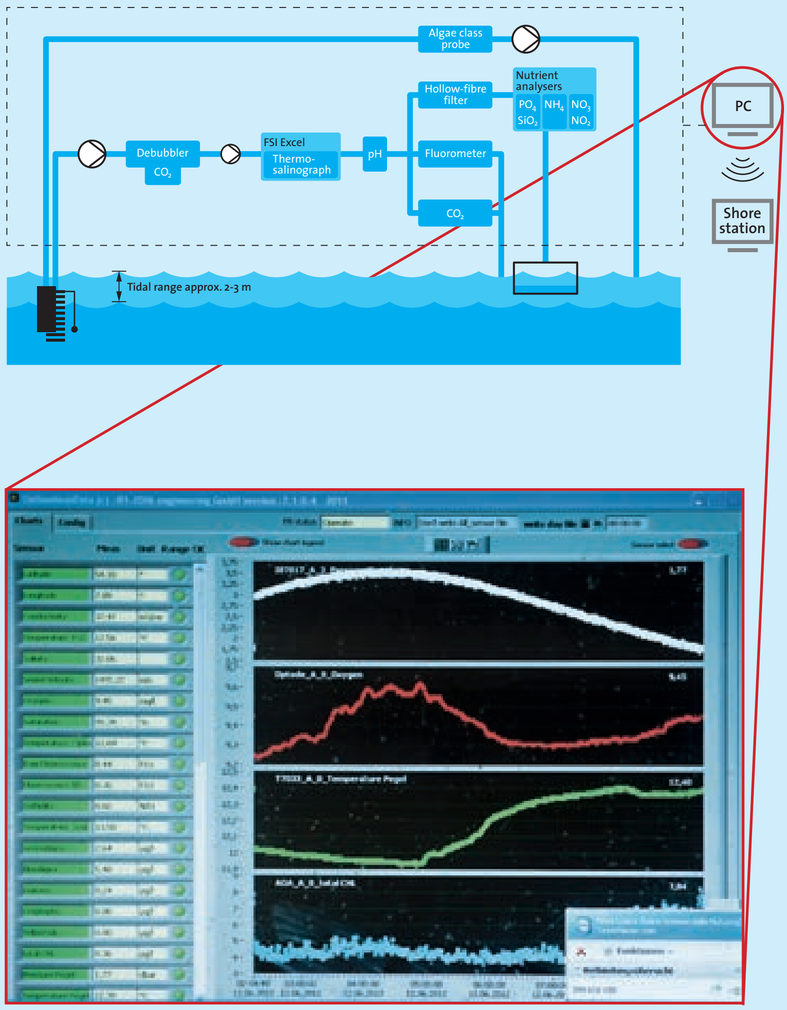
Does this result in new competition for species that have been here a long time? So far, it seems that no newcomer has been able to force out a native species. It is actually more often the case that they live in peaceful coexistence with each other. Franke explains why: “The German Bight is a very young and incompletely developed ecosystem. There are many niches in which new species can settle – as opposed to old, species-rich ecosystems, such as the tropical rainforests where competitive pressure is much higher.” As regards species diversity, the North Sea is thus clearly a climate change winner. This is no reason to sit back and relax, however, since every species reacts differently to the warming of the seas. Development phases of individual species may shift in time so that predator-prey relations get out of balance – even in the North Sea *(see “On Eating and Being Eaten,” page 18)*.

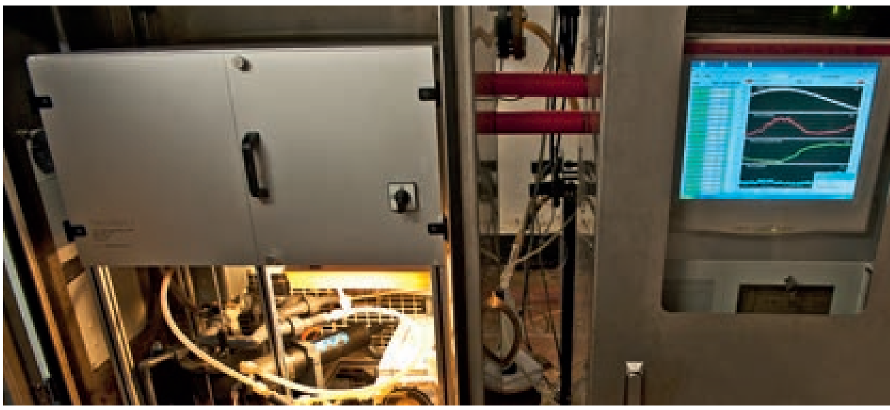
Reliable predictions for the North Sea are one of the objectives of coastal research. For this reason, the Helgoland scientists seek to cooperate more intensively with climate researchers. “Their models can be very useful for ecology,” says Karen Wiltshire.

Nonstop operation

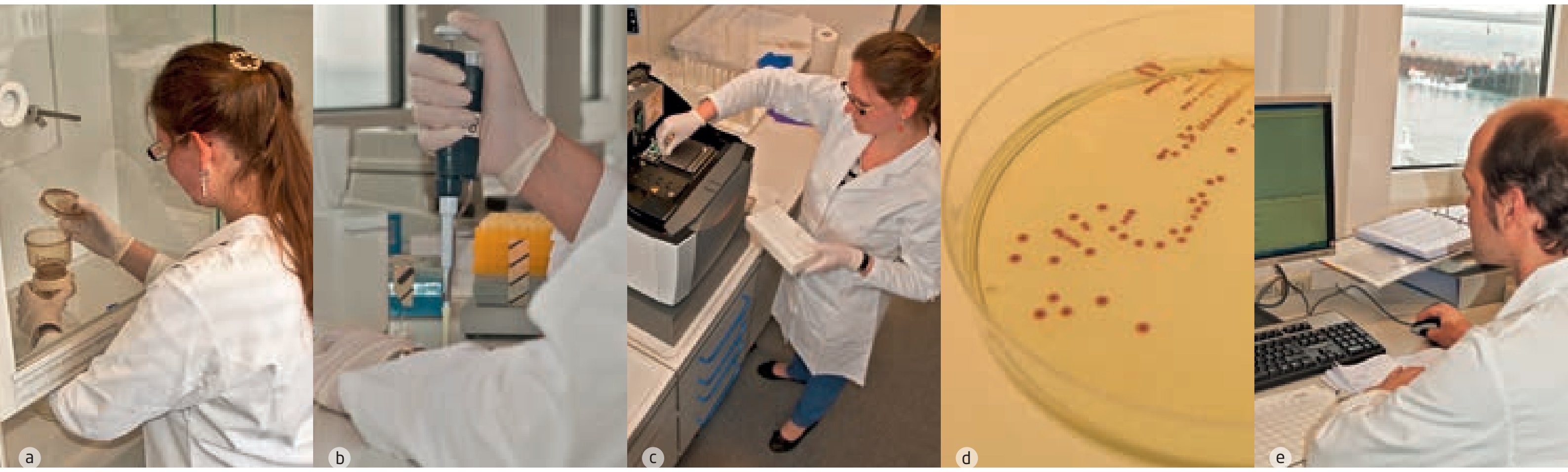
Originally developed for deployment on ferries, the FerryBox supplements the “Helgoland Roads” data series with valuable additional data. Pumps continuously feed seawater into an automatic measuring system. In nonstop operation their sensors and analytical equipment record key biological and chemical parameters: temperature, salt concentration, turbidity, oxygen and carbon dioxide concentration, pH value, fluorescence, chlorophyll and nutrient salts such as silicate, phosphate, ammonium, nitrite and nitrate. A computer controls the system, records data and transmits them to the BAH where scientists then evaluate them. The continuous measurements show long-term trends as well as the day-night rhythms of individual parameters.

Schematic of the FerryBox





Packed full with measuring devices and sensors, the FerryBox provides live data on condition of the sea via a direct line to the researchers.
Photo: U. Nettelmann



Vibrios from the North and Baltic Seas are identified and described by means of various methods. This includes conventional microbiological culture (a, d) as well as detection of genetic markers (b, c) or MALDI-TOF, a chemical procedure for the determination of certain vibrio cell components with the aid of mass spectroscopic analysis (e).
Photos: U. Nettelmann, R. Erler

Vibrios like it hot

Vibrio infections acquired on German beaches have recently become a great cause for concern, particularly in hot summers. Risk assessment versus risk containment? An interview with microbiologists Dr Gunnar Gerdts and Dr Antje Wichels from the Biological Station of Helgoland regarding diarrhoea illness, wound infection, fast diagnostics and areas of high risk.

What are vibrios?

Gerdts: These are bacteria that live primarily in warm and nutrient-rich coastal waters. We currently can identify 70 to 80 species. Three of them are categorised as dangerous for humans: the cholera pathogen *Vibrio cholerae*, another vibrio diarrhoea pathogen and a vibrio species that leads to wound infectio. There are also numerous species of vibrio that are dangerous for fish and other marine animals. But we don't know exactly how many species actually have at least an infectious potential – for humans as well.

In fact, the really dangerous vibrios are those at home in Southeast Asia and countries with a great deal of aquaculture. So how is it that they also may pose a risk on German coasts?

Wichels: They find their way into our boreal waters via the ballast water of ships, and in fish and mussels. Climate warming and over-fertilisation of the sea result in improved living conditions for these bacteria in the Baltic and North Seas so they are better able to establish themselves.

Are there indications for this scenario?

Wichels: By continuous measurements off Helgoland, we have shown temperatures between 10 °C and 14 °C. But something else might also happen – previously harmless strains might become pathogens through genetic shifts. This is currently the case with cholera pathogens, whereby bacteriophages – these are viruses that can infiltrate the genetic compliment of bacteria-initiate the production of the cholera toxin.

Gerdts: We probably don't need to worry about cholera here. But older individuals or people with a weaker immune system could develop serious wound infections from small cuts due to the wound infecting vibrios. This could prove to be fatal if not treated quickly.

This requires rapid diagnostics?

Gerdts: Precisely, and that's why we want to develop a reliable method in preparation for a potential infection increase. We are setting up a vibrio database called "VibrioNet" in a joint project with Federal institutes and State authorities. Using mass spectrometry, an analytical procedure used in clinical microbiology, we are currently examining vibrios from about 1,000 samples and characterising the various strains. Moreover, we are looking for genetic factors that determine pathogenic potential.
Wichels: When coupled with environmental data such as temperature, salt and nutrient concentrations as well as oceanic currents, this approach will also enable identification of high-risk areas for future management.

Vibrio infections are still quite rare in our country. How have the countries that are more affected benefited from your research?

Gerdts: In particular emerging countries such as India, Bangladesh and Chile, can only afford limited research in this regard. In this joint project we work closely with them and support them with our technology and methods. Our current project partner is Chile.

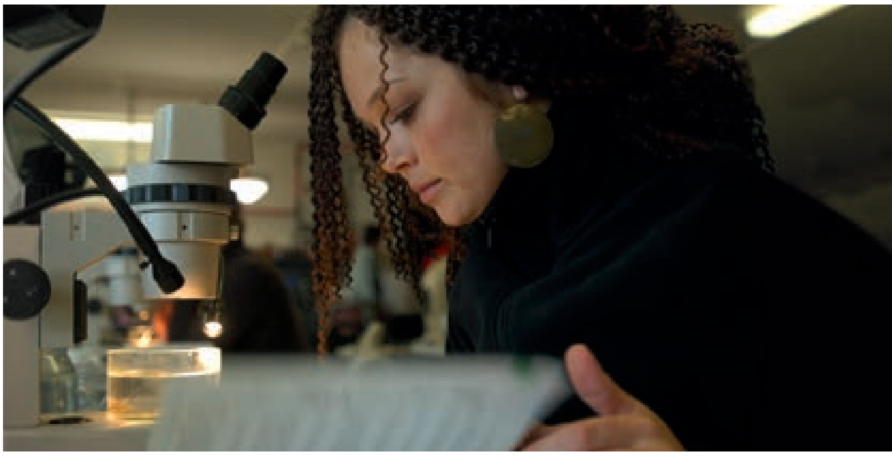
Detective work in the microcosm

Biodiversity on a small scale: tiny plants and animals do not simply live next to one another. They interact with and compete with one another, in dimensions that are not visible to us. In order to identify these and understand the inter-relationships, a quick look at the sea is hardly enough. These have to be studied continuously.

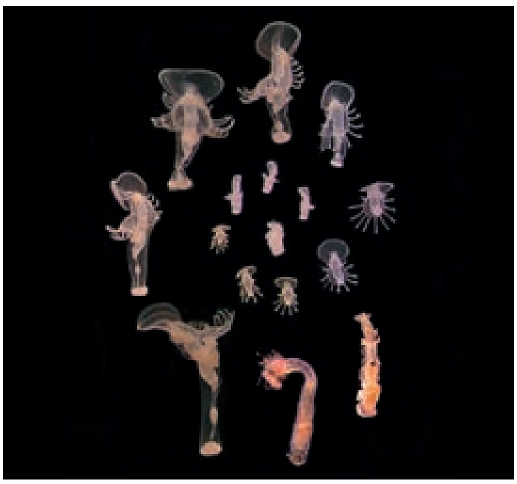
A series of sample vials, a microscope and lots of expert literature – that's what goes to make up the centre for constant assessment of the situation in the sea. From her Helgoland office at the BAH Dr Alexandra Kraberg coordinates such long-term observations of the Alfred Wegener Institute. "From species inventory to atmospheric values right through to metabolism, we have the whole gamut here at the AWI – there is virtually no parameter that is not evaluated on a regular basis."

She herself works on microscopically-small algae – always a technical challenge. To classify the species precisely, the tiny creatures have to be examined under the microscope. This may even involve some tinkering: by gluing an eyelash to a fine needle, it is possible to push the examined object back and forth under the microscope in order to observe it from all angles. Even with such time-consuming method you still often see nothing. "The typical features that characterise a species are often missing – miniature appendages that have fallen off, for example. Or an appendage is visible, but not suitable for distinguishing one species from another," Kraberg describes the idiosyncrasies of such investigations. "This is real detective work!" In the framework of routine counts of large numbers of samples, this is not possible for time-related reasons. And also because such samples are chemically fixed samples, in which the cells frequently have only limited similarity to their living counterparts. If something cannot be classified despite all efforts, the cells are simply grouped and counted in large size classes – a problem existing in many time series.

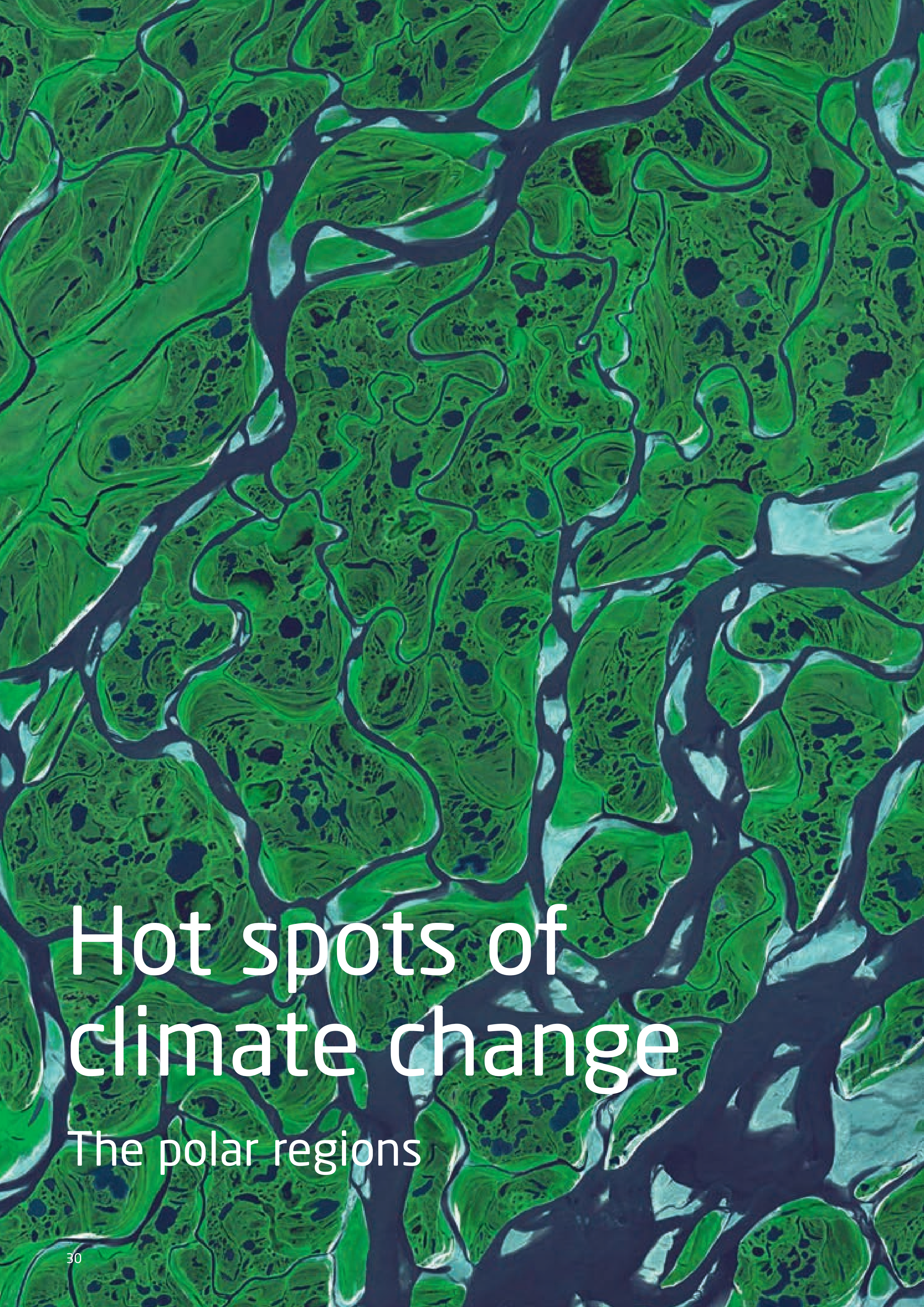
All results flow into PLANKTON*NET (http://planktonnet.awi.de). All plankton types registered at AWI are stored with an image in this database, from Spitsbergen (Norway) to the Galapagos. It is often not a perfect image, but an overall image composite that helps in classifying species. Together with two colleagues, Kraberg has compiled a classification book. It "does not only depict aesthetic super-photos, but actual plankton as you see it – unadorned – under the microscope in everyday life, or algae dyed or fixed with various substances. For scientists faced with a sample involving umpteen species, this approach is more beneficial."



Even expert eyes are not always immediately sure of what they see. In 2009 a 'new' form of the marine diatom *Mediopyxis helysia* appeared in the long-term "Helgoland Roads" data series. Kraberg was fascinated. "About 100 micrometres in diameter, making it as thick as a human hair, which means *Mediopyxis* is a relatively large marine diatom." If it had appeared earlier off the coast of Helgoland, it should have been easy enough to identify. "One must consider that it is similar to another species that can be found in the North Sea. It is possible that it might have previously been observed, but was only recorded as a size class. This algae was actually only first described as a separate species in 2006. Thus, this is why we cannot be absolutely sure that it was not there previously. However, now we have *Mediopyxis* in our line of sight." Such results underpin the need for repeated sampling at the same site and long-term observations.



Anyone wishing to analyse changes in the ecosystem needs a lot of patience. Whatever cannot be directly classified or determined in the field ends up under binoculars or a microscope in the laboratory. Classification books help to identify species wherein typical identification characteristics are recorded. Photos: S. Zankl (top) , PLANKTON*NET (middle), R. Schüller (bottom)



Hot spots of climate change

The polar regions

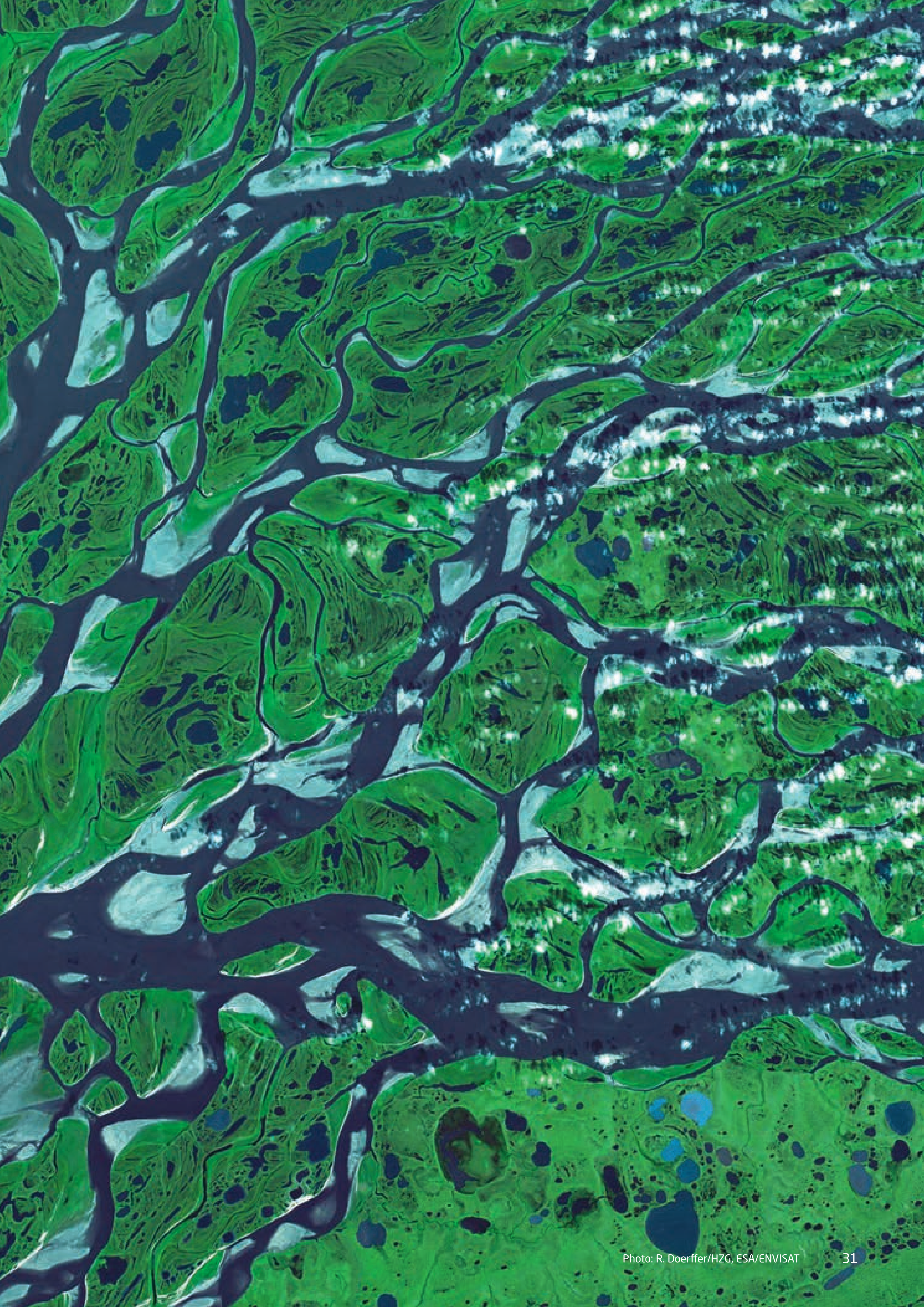
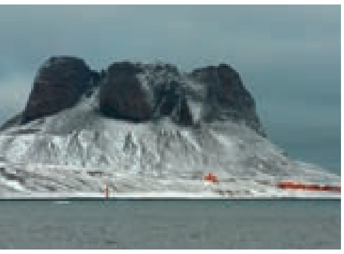


Photo: R. Doerffer/HZG, ESA/ENVISAT

Melting glaciers and turbid waters

The Antarctic Peninsula juts out into the Antarctic Circumpolar Current as a meteorological divide. This makes it a particularly climate-sensitive region. The perpetual ice is no longer permanent, the sediment transported in melt-water sinks down to the ccean floor and animals that are thoroughly adapted to the cold temperatures are in danger of experiencing thermal shock. AWI researchers have been tracking the signs of global warming in this northwest corner of the southern continent for almost two centuries.



Research on our doorstep: researchers at the Carlini Station can go to their field experiment areas on foot. Photos: H. Poigner, D. Abele, E. Philipp

62° 14′ S, 58° 40′ E, King George Island, Antarctic Peninsula. When the boat turns into the small bay, Potter Cove, a huge glacier dramatically comes into view. Approximately 70 metres high, it forms the western edge of the 400-metre thick ice cap of the island. The ice extends far out into the bay. Except for a small area, King George Island is completely white. This is how AWI scientists described their arrival at the research station some twenty years ago. Today one is confronted with a completely different scene; a large volcano, rising into the sky, towers over the island. The whole coast is practically free of ice. And it is green. Lichens have spread, algae grow up the rocky cliffs and Antarctic grass sprouts everywhere. "It makes you think you are in Scotland," says Dr Doris Abele. The biologist from the Alfred Wegener Institute in Bremerhaven has been researching the southern end of the world since 1995. Jointly with an Argentinean Antarctic institute, Instituto Antártico Argentino, the AWI runs the Dallmann Laboratory there as part of the Carlini Station.

What has happened in Potter Cove? Climate change has distinctly left its mark there. The glacier is melting and persistently receding inland. From 2000 to 2008 alone, the Antarctic ice sheet got thinner by about thirty metres. Moreover, the permafrost on the island is slowly thawing. "Glacial streams gurgle away in many places. At times during the Antarctic summer actual waterfalls splash down into the bay. Sometimes the water is red – an indication that large quantities of iron, magnesium and aluminium are washed out of the thawing ground," explains Abele.

The West Antarctic Peninsula is the region experiencing the most pronounced warming in all of Antarctica. In the last fifty years the average air temperature has risen by more than three degrees Celsius. The water has become one degree warmer in the last 25 years. "That is a big difference for some marine organisms," says the animal physiologist. "Their tolerance level regarding such a rise in temperature is quite low. Over a period of millions of years, many cold-blooded animals have made their home in the stable cold temperatures – they have lowered their metabolism and live quite comfortably. Some fish and snails, for example, have temporarily set their heat-resistance gene to "cold" as they don't actually need it." Together with colleagues, Doris Abele has demonstrated in field and laboratory experiments with closely related snails that species from Patagonia and Tierra del Fuego with functional heat-resistant genes can handle temperature increases better than their Antarctic relatives.

But it is not only the increasingly warm water that creates stress for many marine organisms. The sediment transported in melt-water flows sinks down onto the seafloor inhabitants. Many organisms cannot deal with this change. An example of a consequence: "Our Argentinean colleagues have shown in dive studies that there are now more flat sea cucumbers present and many sea pens that can coexist better with the sediment cover than the bottle-like, upright sea cucumbers," says Abeles' colleague Dr Valeria Bers. Antarctic krill has almost completely disappeared from these coastal waters. This crustacean has an extravagant energy requirement, it needs plenty of food. If its

stomach is however filled with more sediment than plankton, the krill starve.

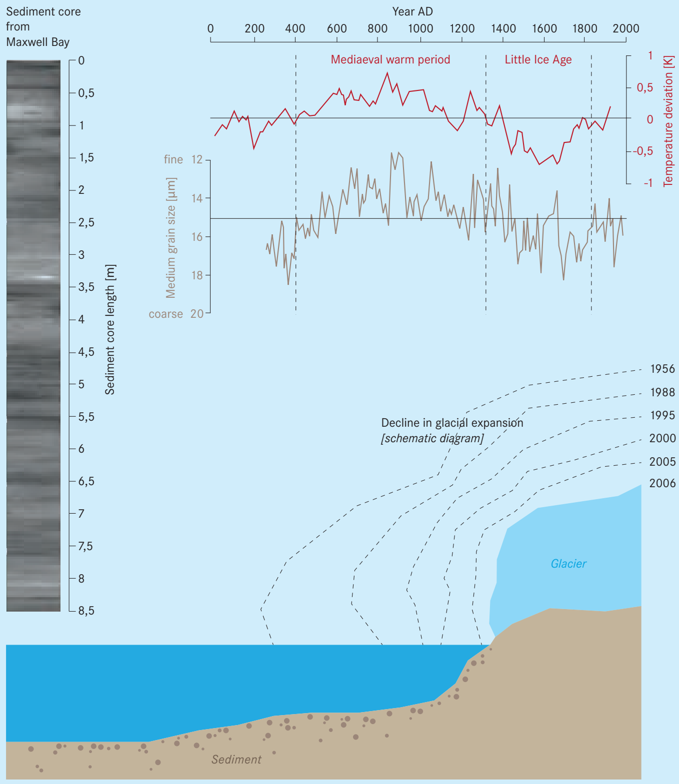
Suspended sediment in the water makes the ocean water turbid. For algae this means less light, less photosynthesis, less biomass – and this means less food for snails, small crabs and other algae eaters in habitats near the coast. Penguins now have to roam farther away from their breeding grounds in order to find sufficient food for themselves and their chicks.

All of these processes are merely small parts of a very large puzzle that can only be solved internationally with an interdisciplinary approach. In the joint project IMCOAST AWI scientists have been working together with European and Argentinean colleagues since 2010. Biologists, glaciologists, biogeochemists, oceanographers and microbiologists endeavour to aquire greater insights regarding glacial melt and its ecological impacts.

Another international project is on the block – the network project IMCONet. Started in 2013, scientists will work at partner institutes worldwide and with the colleagues to analyse samples, evaluate data and further develop models. The model that Bers has just developed with colleagues from Buenos Aires is a good example. It focuses on analysis of long-term data records concerning changes in water like temperature and salt concentration. “But we still have so much data,” says the sea biologist, “that we will have to work at least three more years to get an idea of what has shifted.” This will include the analyses to the more southerly areas of the peninsula. Scientists from the British Rothera Station and the American Palmer Station were equally diligent in collecting data there.

“To put it colloquially, we first have to lump all our long-term results together for the whole area, so as to get a general picture for West Antarctica. This cooperation among the research stations is a huge step forward,” says Bers. The Carlini Station is located way up north on the peninsula. Due to the proximity to the South American continent, other environmental conditions prevail there and presumably the changes in the north differ considerably from those in the south. By analysing the collected data, the research scientists want to obtain an understanding of the climate-related changes along the north-south axis of the Antarctic Peninsula and assess their impact on the polar ecosystems.

Research scientists at the Dallmann Laboratory have a spectacular view of the majestic Antarctic glacial landscape.
Photo: G. Aguirre



Climate history from glacial outwash

The melting glaciers in western Antarctica wash more and more fine sediment into the sea. The ice in the past scraped it off of the underlying rock and crushed it. Potter Cove and the connecting Maxwell Bay thus qualify as unique areas for the investigation: particle size analyses and surveys of the seabed with the help of underwater acoustics reveal how much sediment is transported into the sea and where exactly it is deposited. At the same time sediment cores provide a high-resolution climate archive. Over the past two thousand years several metres of dense sediment were deposited in Maxwell Bay – half a centimetre per year, which is unusually high. Based on this and in the light of observation of current patterns, scientists are now able to reconstruct past climate change in the icy South.

Photos: J. Boike (left), K. Piel (top)

Thawing permafrost comes alive

At one time on Herschel Island in north western Canada there were five large ice cellars. Whalers deposited their catch in the permafrost there. Today only one of these "refrigerators" remains – it is used by AWI research scientists to store their provisions and samples. The other four have caved in. In the following interview you can read about why this happened, according to geoscientist Professor Hugues Lantuit from the Potsdam Research Unit of the Alfred Wegener Institute.

Expedition to Siberia: impressive landscapes, the combination of a tent camp and modern measurement technology and providing a "hands on" experience for all-regardless of whether one is technician or professor.
Photos: K. Wischnewski, N. Bornemann, M. Gräber

Approximately a quarter of the northern hemisphere is permanently frozen. What significance do permafrost soils have?

Lantuit: First, they are habitats, the Arctic coasts and river deltas in particular. People in Siberia, Canada and Alaska build apartment blocks, schools, villages, whole cities, railroad tracks and airports on them. Second, permafrost is a huge carbon sink. In the upper three metres there is about twice as much carbon in the dead plants, dating back thousands of years, as is contained in the entire atmosphere.

What is currently happening in the permafrost?

Lantuit: Due to global warming, the soil in a few regions tends to thaw to deeper and deeper depths every summer and at the same time freezes in the autumn and winter later each year, or even does not completely at all anymore. We observe great variability from year to year. On the basis of long time series, which we have started in the framework of an international measurement campaign, we will be able to assess this development better in the future.

What determines how deep the soil thaws?

Lantuit: The most important factor is the air temperature. If more heat energy penetrates into the soil, it thaws deeper. The conditions in the ground are additional factors: which sediment makes up the soil, how much water or ice does it contain, do trees grow there and does tundra cover the soil? Sediment-rich permafrost thaws out faster than ice-rich permafrost. Vegetation close to the ground has an insulating effect. The same is the case with snow, which additionally protects the soil even more from the cold. The warmer the permafrost is, the quicker it can thaw.

What are the consequences?

Lantuit: The ground loses stability so that buildings begin to tilt and streets subside. Also: thawing permafrost basically comes alive. Bacteria transform the stored carbon into carbon dioxide and methane and release greenhouse gases into the atmosphere. Thus, the latter continues to warm up even more, which leads to deeper thawing of the soil and emission of even more greenhouse gases – a positive feedback results so the process reinforces itself.

Due to climate change, taiga bogs or forests could develop where once there was tundra, with more resultant vegetation. Could this serve as compensation for soil emissions?

Lantuit: Such effects are conceivable. More vegetation can store more carbon – the same carbon that was previously released into the atmosphere from the thawing soil. But the carbon cycle is very complex and encompasses the land to the seabed which actually includes also the "submarine permafrost" under the Arctic shelf seas.

Photos: K. Piel (top), H. Lantuit (right)

Arctic coasts in retreat

A number of things are happening at the same time in the Arctic: sea ice is melting, permafrost is thawing, storms are getting more violent and the ocean water warmer. This results in the increased risk of erosion for the coastal regions, concern about the homes of people living there, and a lot of work for polar researchers. Scientists take a closer look both above and below the water to see exactly what is happening on the Arctic coasts.

Every summer, and sometimes in spring, the Inuvialuit People host guests from the AWI. These research scientists travel to the Canadian Arctic to study the land of this native ethnic community. In the Mackenzie Delta and on Herschel Island in the outermost northwestern section of Canada, the scientists set up their tents for a few weeks – even in April at – 20° Celsius. What exactly is so interesting about this inhospitable corner of our planet?

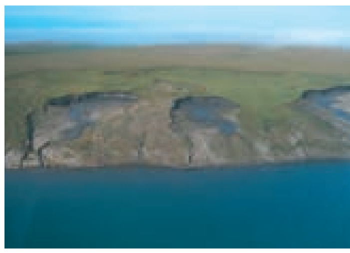
"The coasts in the Arctic are losing ground. In many places they are receding by one to two metres per year, in others by as much as 30 metres," says Dr Hugues Lantuit of the Potsdam Research Unit of the Alfred Wegener Institute. This coastal erosion is in fact a normal process – wind, waves, rain and snow eat away at the seashore. Sediment is washed into the sea, leading sooner or later to landslides or erosion. "The only problem is that the coasts in the Arctic are less robust than in other places. They do not consist of solid rock, but rather of sand, clay, silt and ice – a relatively stable structure as long as the ground remains frozen," explains Lantuit. But if the permafrost soil thaws, the ice turns into water and the ground begins to slide. And this not only occurs above water. "When a coast erodes, it happens under water as well," says Lantuit.

The geographer will travel by rubber dinghy along the coastal waters with his colleagues. They want to map the water depths and examine the underwater profile of the coast. "The way waves strike a coast and the damage they cause depends on how steep the particular coastline is, what material it is composed of and how powerful the waves are."

The force of the waves could very well increase if more powerful storms hit the coasts due to climate change. Additionally, the protective shield of sea ice is disappearing. Many Arctic coastlines are already completely free of ice in summer and thus at the unprotected mercy of waves. In the meantime the first ice forms in mid-October at the earliest, when the autumn storms are already raging. If and how all of this accelerates coastal erosion is what Lantuit and his colleagues want to find out.

Using sediment cores from the seabed, the scientists also follow the tracks of the carbon. How much of the coastline has been eroded away in past millennia? Does the eroded carbon sediment remain on the seabed or is it transported away? How much permafrost is in the seabed? Climate data can also be obtained from the sediment cores. And last but not least, the sediment deposits also change the living conditions for marine fauna. "What the consequences are – this we don't know," states Hugues Lantuit.

This information is interesting for the Inuvialuit People because in summer they fish here. Scientists and the local population work closely together: "With the experience of the Inuvialuit People we can organise and understand our findings more accurately. Our scientific results are a basis for on-site coastal management."



Along the Arctic Ocean fringe permafrost coasts are eroding, in some regions are losing up to 30 metres of coastline a year.
Photos: H. Lantuit

From the air, on land and under water:

Methods of modern oceanography

Photo: M. Molis

Photo: S. Domisch

A stroll through the underwater forest

Huge brown kelp and other large marine algae provide a habitat for many fish and invertebrates. However, climate change is making life difficult for these hospitable algae – for some species more than others. Field observations, laboratory experiments and remote sensing technology are helpful to scientists in research on these seemingly simple organisms and their importance.

The fruit of brown algae can take on bizarre forms.
Photo: C. Buschbaum

Brown algae of the class *Fucus* on the Helgoland bedrock.
Photo: U.Schilling

The slender yellow-brown leaf of a macroalga that Dr Inka Bartsch has pinned to her office door in Bremerhaven is about two metres long. In the past the sea washed up tons of sugar kelp from the nearby rocky flats onto the beaches of Helgoland. Those times are over however. "The stocks of these brown algae are now changing dramatically all over Europe," the biologist reports. "Off the coast of Helgoland the sugar kelp has retreated to deeper water. In southern Norway for example after two warm summers it has also become very reduced."

Large species of brown kelp, so-called "laminaria", can form underwater forests with their long, leathery leaves. Scientists refer to these habitats as "kelp forests". They serve as a living room, safe haven, nursery and feeding ground for crabs, worms, other invertebrates and many fish. Moreover, small algae attach themselves to the larger plants. Brown kelp and other large algae grow in waters on rocky coasts with clearer water, mostly in the boreal and polar regions.

To be or not to be dependent on temperature and light

However, living conditions are changing concurrent with warming in some places. Inka Bartsch has been researching the large varieties of algae for 27 years and is still fascinated. "These seemingly primitive organisms are actually very complex. Some species can react quite sensitively to changes in their habitat."

Certain death is a consequence for many brown kelp forests, when the water temperature remains above 20 degrees Celsius for longer periods. The depths at which large algae settle and where they start to grow, depends on how clear the water is – in other words, how much light reaches the seabed. Since the coastal waters near Helgoland are comparatively turbid, large algae grow at depths of only 10 to 13 metres there. As a comparison, in the clear polar water off Spitsbergen Bartsch's colleague Professor Christian Wiencke found red algae at depths of 60 metres.

The water along Helgoland's coast is changing, because it is less influenced by the turbid coastal waters. The Long Term Data sets at Helgoland Roads have shown that water is becoming clearer and some algae can move farther down into the depths. Their habitat has thus become larger. On the other hand, the North Sea has also become warmer (see North Sea in the Fast Lane of Change? page 24). Does this have repercussions for the species diversity of large algae? Bartsch has gone through the entire historical literature back to 1845. Based on this old information the botanist can deduce tends in habitats: "Nowadays we find fewer brown algae and more green algae." No one knows for sure why certain spe-

Automatic mapping from above

In order to analyse more closely the distribution of the algae on Helgoland's coasts, AWI researchers in collaboration with the University of Kiel and FIELAX AG, Bremerhaven are carrying out airborne remote sensing. An aircraft with a so-called hyper-spectral sensor is flown over the coastal sea and the reflection signal of the algae on the rocky intertidal is recorded. Each pixel represents the colour spectrum of visible light up to the infrared range. With the help of the characteristic reflection of the individual algal varieties, it is possible to map their distribution roughly. Since 99 percent of the macro-algae never are exposed, the sensors are also designed to record what grows under the water. In this context research scientists are also currently developing an application for the hyper-spectral satellite EnMAP, which will supply ground images from its orbit.

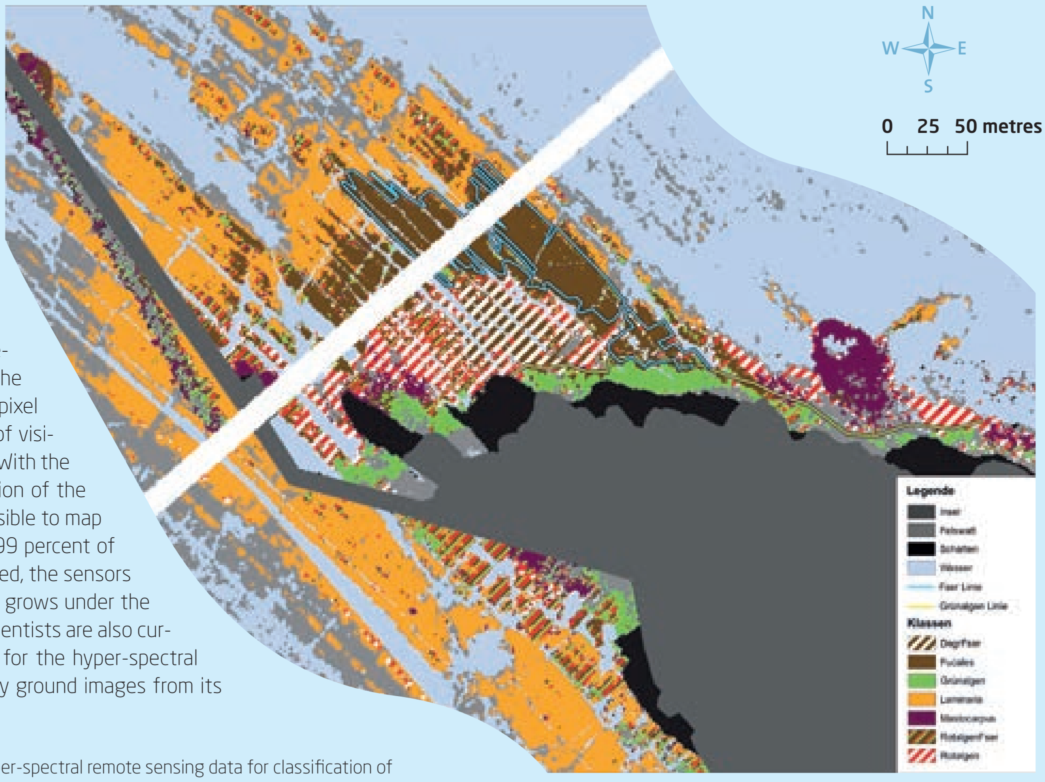


Fig.: Inga Eisenhardt 2011. Use of hyper-spectral remote sensing data for classification of macrophytes in the rocky intertidal flats of Helgoland. Diploma thesis, University of Kiel.

cies have disappeared. "Temperature changes always play a role, but other factors such as diseases also need to be seriously considered."

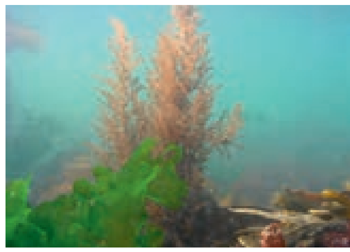
Inka Bartsch has been concentrating on large algae near Helgoland for the past seven years. In cooperation with the State Agency for Agriculture, Environment and Rural Areas in Schleswig-Holstein, every summer and winter she and her colleagues identify and quantify which algal species grow on a defined patch of the intertidal. "Even in this short period of time, we have been able to document clear fluctuations," says Bartsch. After the hurricane "Kyrill" was instrumental in razing the complete Fucus brown algal cover in January 2007, it took three years for the algae to recover. "If in the course of climate change severe storms sweep over the North Sea more frequently, there might be not enough time in between for some species to rebound." Scientists have also discovered newcomers. Among the red algae two species have emigrated from southern areas and have acclimated well to the new warmer waters of the North Sea.

Take for example also the Sargasso seaweed, *Sargassum muticum*. It arrived in the North Sea around 1980 probably as flotsam. In the meantime this has adapted and forms large underwater forests – preferentially in submerged spots protected from the waves. The Sargasso weed frequently shares these habitats with the native "sea oak" *Halidrys siliquosa*. In some places, however, it seems that this newcomer might be pushing the native species out of this habitat.

How much is too much?

In the laboratory Inka Bartsch also determines where exactly the pain threshold regarding environmental changes is for large marine algae. How much ocean acidification can a species tolerate? How well can it cope with rising water temperatures? How much do light and the length of day influence growth? Frequently the interaction of more than one factor shows how a species will react. The biologist explains this using the example of red algae from the North Atlantic: "In warmer waters the algae show poorer growth, but with an increased supply of carbon dioxide (CO_2) at the same time, as in the case of ocean acidification, this can be compensated."

The biologist is now examining how sensitive the kelp forests are along polar coasts in Kongsfjord at Spitsbergen. The Gulf Stream increasingly pushes warm Atlantic water to the north. Furthermore, freshwater and sediments from the melting glaciers make their way into the ocean. Together with Christian Wiencke and other colleagues, Inka Bartsch will conduct a stock assessment and compare the results with similar data from 1998. In addition, she wants to meticulously study the reproduction of large polar algae – where a number of secrets remain to be revealed.



Sargasso weed *Sargassum muticum* has arrived in the North Sea.
Photo: M. Molis

Brown algae of the class *Laminaria* form submerged kelp forests.
Photo: H. Krumbeck

Photo: B. Hussel

Mathematical evaluation of the tidal flat menu

Which animal eats which plant in the plankton and under which conditions? This can be examined quite readily in the laboratory. AWI experts on Helgoland have collected a lot of information on how a reduced food web might look like. But what does the large-scale food web look like? AWI researchers on Sylt are assessing this by investigation of tidal flat communities combined with mathematical evaluations.

Rubber boots, raincoats, nets – always equipped for mud and weather. Research scientists from the Sylt Wadden Sea Station head out to the tidal flats every day. They monitor the populations of crabs, mussels and snails and observe which animal hunts which. Furthermore, they sail out in the catamaran "Mya" once a month to examine the fish stocks at seven different sites in Sylt Rømø Bay. Overall, the trips provide "numerous indications that the marine life menus in the tidal flats are changing considerably," says Dr Harald Asmus. The zoologist and his colleagues want to map the water depth and examine the shallow underwater profile of the coast in a rubber dinghy. "How the waves strike the coast and what impact they have there depends on how steep the coast is, what material it is composed of and how powerful the waves are."

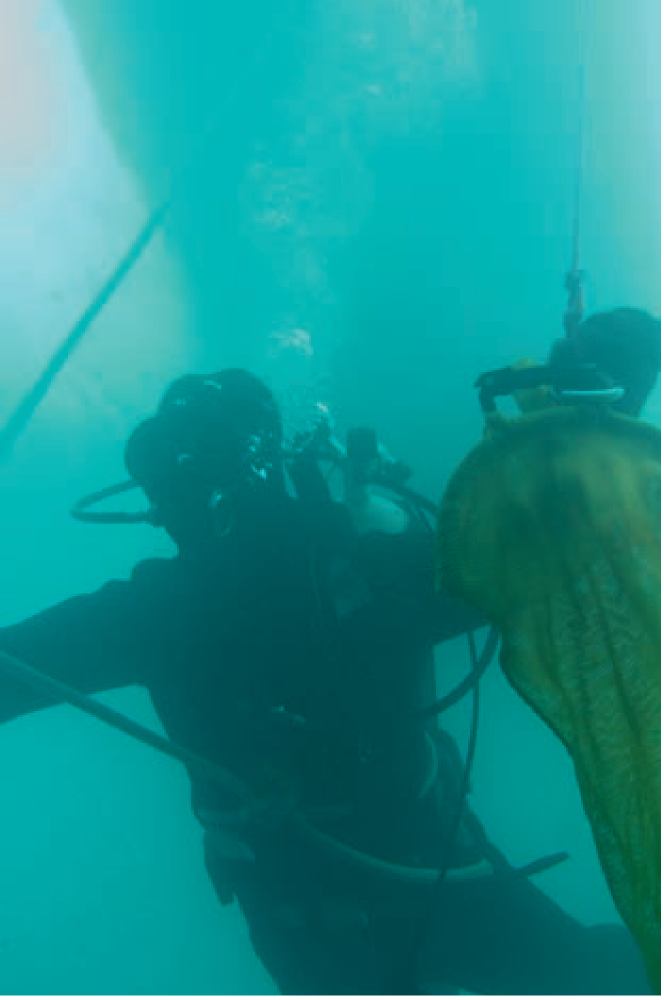
To find out more about this, Asmus and his colleagues are investigating the energy flow in the system. "This is similar to studies of money flow in financial questions. The various 'currencies' in this ecological case are carbon, nitrogen and phosphorus and the question is simply: How much 'currency' flows from one level to the other?" This ranges from primary production to the level of crabs, mussels and snails to birds, seals and finally humankind.

This so-called "network analysis", a food web model, provides us with the overall picture. In a mathematical matrix, nutrient providers are compared with the nutrient consumers, linked by the consumption quantities and material flows. "In this manner biological processes can be expressed in numbers that characterise the current status of the food web in the Sylt tidal flats. If certain values change, the matrix provides a new scenario on this basis."

Moreover, the matrix provides indices that theoretically describe the system of the food web in the tidal flats. Such as: How many individual cycles exist in a system? An example of this: phytoplankton grows, mussels eat the phytoplankton, the oystercatcher eats the mussels, the metabolism of the oystercatcher produces nutrients, nutrients end up in the ocean and are eaten in turn by phytoplankton. "The matrix provides 1,100 different cycles like this for the Sylt tidal flats. We have verified most of them already in the field."

Now Dr Asmus and his team want to systematically incorporate invasive species. "We are currently evaluating the corresponding raw data and extrapolating it in order to adapt it to the matrix." Seals are also to be included in the future. "In Sylt Rømø Bay alone we have 365 seals that certainly have an impact. We also know what they eat and how much, but not where they eat since they move around a lot." A new doctoral candidate has just started working here and will record data on these migrations.

And Asmus has yet another idea for research. "In America the network analysis is being applied to human systems, such as villages. I can imagine doing something similar here. How we behave with regard to the sea is, after all, part of the system." A team study between biology and sociology – it is still merely an idea and not a specific project. However, such interdisciplinary knowledge will be increasingly valuable for sustainable coastal zone management in the future.



Let's dive in!

Many experiments in the ocean can be conducted either in the laboratory or by means of technical sensors from the ship. However, some things can only be examined on site but under water. For this we need the skills of ocean scientific divers combined with an ocean scientist.

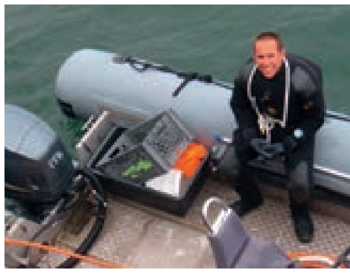
Anyone who wants to get up really examine the medium and its underwater organisms as an oceanographer needs to dive into the world of his research objects. That is why the AWI has established the Centre for Scientific Diving on Helgoland, headed by fisheries ecologist Professor Philipp Fischer. "As a diver, you get first-hand experience of how an underwater ecosystem like the kelp forests around Helgoland presumably works, for example how functions are structured. Of course, I have also conducted a lot of experiments in the laboratory. But that is always merely simulation," Fischer declares.

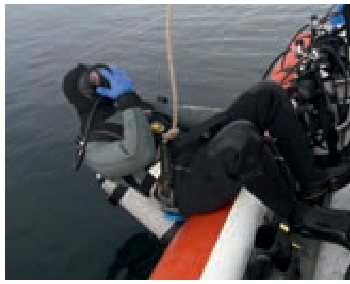
The ability to combine laboratory and underwater studies is one of the major strengths of the AWI. Examinations that are completely normal on land (ornithologists studying through the forest, grass experts examining a meadow) are only limitedly possible under water. Deep-sea diving in capsules is possible and salt-water-resistant and almost autonomous underwater equipment do exist. "But divers are more efficient ... and cheaper!" laughs Fischer." All joking aside – whenever possible, we use technology, but this too has its limits."

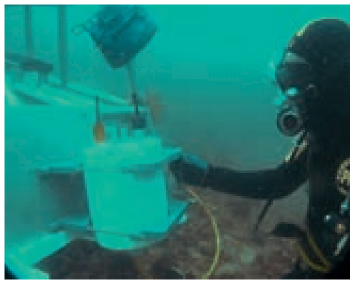
There was, for instance, the question of how fast certain species of mussels grow in a Chilean cold-water fjord. These animals grow on the seafloor. In order to examine them in the laboratory, you have to take them out of the water – but then they would either die or no longer display natural growth. Thus, the investigation was only possible under water. For this purpose the divers marked the mussels, contained them in plastic bags and injected a dye solution into the bag. The animals imbibe water, metabolize the contents in it and thereby incorporate the dye into a calcium ring in the shell. In this way the growth rate per unit of time can be precisely determined later. All this effort to understand organisms that are only a few centimetres in size? Without divers – not likely!

The assignment of Fischer's team is generally two-fold. "On the one hand, we are service providers and conduct experiments for non-diving colleagues and on the other hand, we are researchers ourselves." Fischer's working group is currently studying how fish react to "hard" shore structures such as tetrapods, a type of breakwater made of concrete. "There have only been two scientific studies so far concerning Helgoland fish stocks. So we in fact have no idea about how the animals are faring, either with or without tetrapods." This information gap is now being filled, but diving studies can only supply "snap-shot" data. "The best thing would be long-term underwater observations." This is what the COSYNA project (Coastal Observing System for Northern and Arctic Seas) offers. It involves several fixed underwater nodes in the North Sea and polar regions equipped with glass fibre cables. These supply power to sensors and cameras and deliver data and images in real time via the Internet for direct analysis in the laboratory. Research scientists worldwide can access it and link their own instruments to the distribution nodes. The first node was recently installed off the coast of Helgoland – actually: this is the first true German underwater observatory ever.

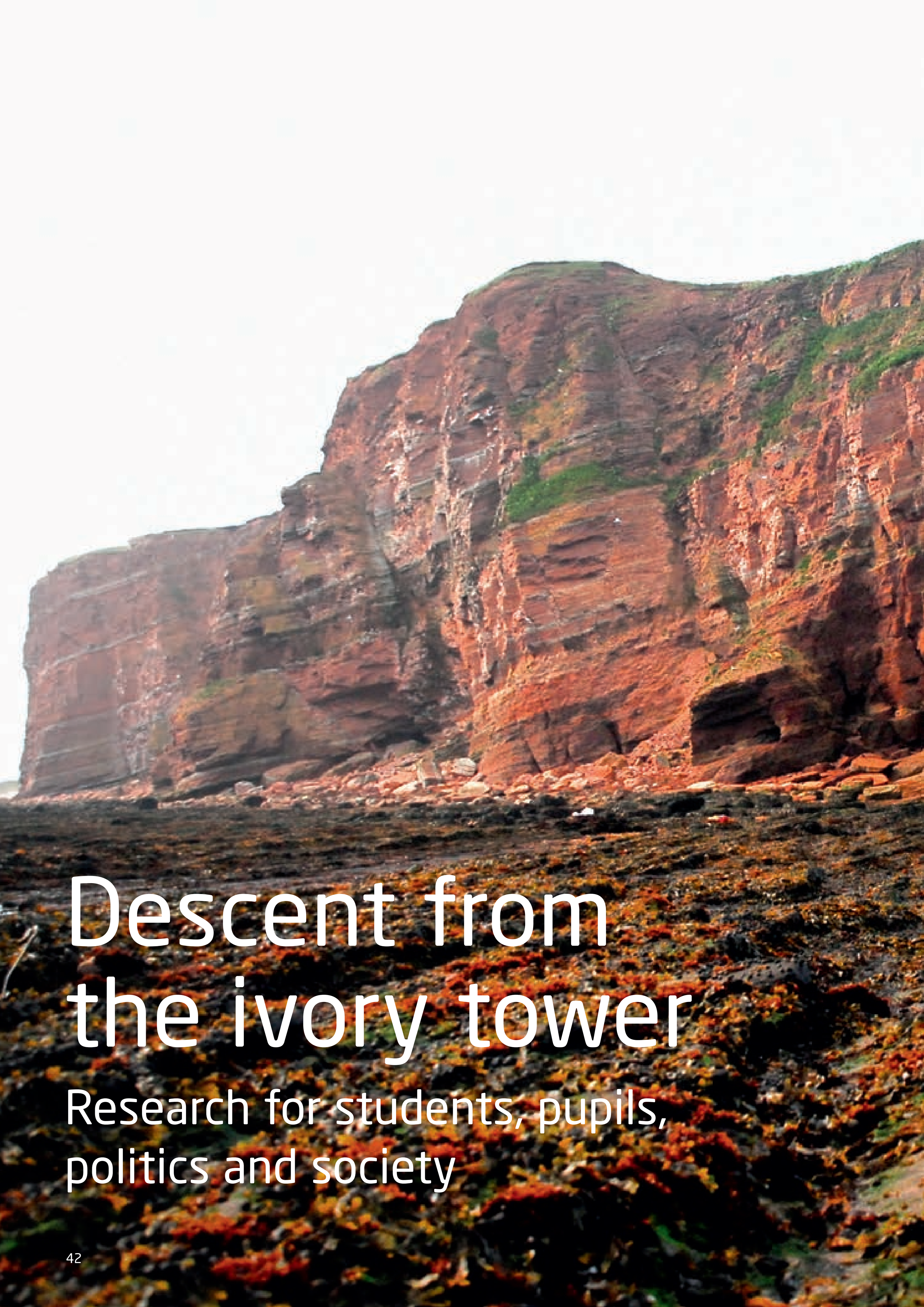
Will this automatic underwater station now do all the work for scientists and make the dive team obsolete? "Certainly not. Large-scale patterns of development can be deduced from the permanent information on temperature, pressure or salt concentration. But at the end of the day only humans have the specialist capabilities needed to carry out the work. It boils down to small details and these are underwater the work we often do, research cannot do without diving."







Rubber dinghy is frequently the basis for dives. The diver communicates with his colleagues above water by means of a safety line. If he / she, for example, has completed an underwater installation, he / she gives a signal by pulling on the line and his / her colleagues know that he / she will soon surface shortly.
Photos: J. Haschek (left), P. Fischer (top right), J. Haschek (centre right), P. Fischer (down right)



Descent from the ivory tower

Research for students, pupils, politics and society

Photo: U. Nettelmann

Research scientists pay a visit

The AWI is lucky. Its research stations are often situated directly in the research environment being studied. This attracts researchers from all over the world.

Things never get boring on Helgoland for guest researcher Otto Larink: in 2012 he was on the island for the 50th time. His research interests: adaptations of microorganisms to the marine ecosystem.
Photos: U. Nettelmann

The leaf feels smooth and a bit rubbery. And it is quite strong. Two people can give it a good tug and it will still not tear. It leaves a sticky feeling on one's fingers. "That's the sugar the algae form," says Professor Kai Bischof from the University of Bremen as he lets the brown algae leaf slide back into the pool.

The one-metre-long algae have been floating in a pool of seawater for two days – they were taken fresh from the sea off the coast of Helgoland. "We are examining how large algae react to changes in the sea," Bischof explains. "Helgoland is unique in this regard because there is no other place in Germany where you can find such ample stocks with so many different species."

New species are regularly discovered adding to the indigenous diversity. These are often "shipped" from their original home to the North Sea. Making comparisons between ways of life, between original and new species, is particularly interesting: How do the original North Sea inhabitants and the newcomers react to particular environmental stress? How do they deal with more or less solar radiation, with warmer or colder water? Why is the new species perhaps stronger and does it push out the native species? "Based on such questions, we can deduce what the species community at Helgoland could look like in the future."

For this reason Bischof and his doctoral candidates regularly travel to the island and examine the underwater plants on site while they are emerged during low tide. Or they may order samples from the AWI diving team. "We basically give them a 'shopping list' for samples. We need 60 samples of "this and that" or "these or those" algae. The divers then bring them up for us from deeper waters."

Same work, different location

Bischof has also worked in polar regions and in the tropics. "The tropics are really attractive, not only for scientific reasons." But finding a well-equipped laboratory to carry out such detailed analyses as required for his experiments "is often a challenge elsewhere".

Thus, since his graduate degree and PhD dissertation at AWI, Bischof has been returning to Helgoland on a regular basis – at least twice a year for two weeks with student courses. The advantage is that AWI provides very-well equipped laboratories to him at minimal charge. "That's very valuable, especially for training junior scientists."

Otto Larink agrees with this. The now-retired zoologist from Braunschweig is also a regular guest on Helgoland. He has been coming to the island every year since 1963, initially as a student and from 1969 to 2004 as a course instructor teaching junior scientists the fauna and flora of the coasts. "The North Sea off the coast of Helgoland offers an excellent overview of zoological systematics." To this day he is still fascinated by the diversity at Helgoland.

Like Bischof, Larink emphasises the significance of the AWI infrastructure in his teaching. "The lecture room provides all necessary equipment. And it makes it possible for us guests to keep and observe plants and animals in running sea water in the laboratory. That's an enormous advantage. Though you can also observe the organisms well in the outside with the sample material, you still don't know how exactly the environment has developed over time up to that point. Thus the lab is useful. Moreover, the AWI offers excellent sleeping accommodation – in short, everything you need to make a course successful."

Evidently these factors have been successful because the students are also very enthusiastic. One in particular came back to work at AWI – the Helgoland biologist Professor Heinz-Dieter Franke was a Larink student in his day.

Curious about life both above and below water

Larink himself originally had fewer research interests under water compared to those on land. His doctoral thesis was written on the jumping bristletail, a primeval insect without wings that lives in rocky areas. Helgoland was thus ideal for studies on this animal. "I collected several samples, let them lay eggs in the laboratory and conducted research on how the embryos developed. And I had lots of time until the larvae hatched..."

Larink used this time to peek into the water – and so discovered his passion for marine plankton. On all his visits he made observations under the microscope and took photos, even though this was quite expensive back then. "When I was on the island for ten days as a student, I was only able to afford maximally three rolls of slide film." Today Larink's database comprises at least 3,000 analog and more than 10,000 digital photos.

A few hundred of them are published in a book edited by colleagues at the AWI to facilitate other research scientists to determine and classify species correctly. Larink's untiring microscope work in collaboration with Wilfried Westheide, who also used to do research on Helgoland himself, resulted in this classification book (field guide) for marine plankton. You can also find his pictures in the AWI PLANKTON*NET database (http://planktonnet.awi.de). Although Otto Larink is now very familiar with many species and varieties, he is still fascinated. "Even after throwing in a plankton net for 50 years, you still constantly discover something new!" Bischof, also, "repeatedly rediscovers Helgoland". Not only because Helgoland is right at his doorstep. "Of course, the travel time is short and the ticket is affordable. But that's not the point. What draws me here is the fascination of the immense scientific relevance of our own coasts and particularly Helgoland. The island is really an exciting place."

And what if it is difficult to conduct research there on occasion? Such as when the laboratory is closed for renovation? No reason to give up. Larink just moves his work over to the guest house. "What do I need then? Only a Petri dish and a microscope! And I've always got those in my suitcase." Bischof, on the other hand, continues to collect sticky, slippery leaves in more pools in his local experimental realm. And he just might make another trip with his student group – to the AWI on Sylt with equally good facilities- for a change in scenery.

Pupils from Helgoland's own James Krüß School conduct research both outdoors and in the laboratory in the framework of projects with AWI on Helgoland.
Photos: K. Herrig, G. Engel, B. Köhn, U. Nettelmann

OPEN SEA: School children investigate the North Sea

How does climate change affect the plants and animals of the ocean? Do imported species affect the ecosystem? Or how does plastic refuse end up in marine organisms? Young scientists will investigate questions like these on Helgoland in the future. In collaboration with the association "Helgoland children are our future" and the Helgoland youth hostel, the Ministry and BINGO funding the BAH has founded the OPEN-SEA research laboratory. This is initially for secondary school pupils, thus expanding the educational activities offered on the island. In the three to five day courses the pupils receive basic knowledge of rocky intertidal flats, phytoplankton, etc. They can conduct research in their own small projects – with generous scientific and educational support. And there certainly is a lot of natural science potential that can be fostered in many of these young guest researchers.

A newspaper article described how the "knight of the North Sea" courts a "damsel". Such terminology takes some getting used to for research scientists whose daily routine is characterised by more sober language based on facts.
Photos: I. Schmalenbach

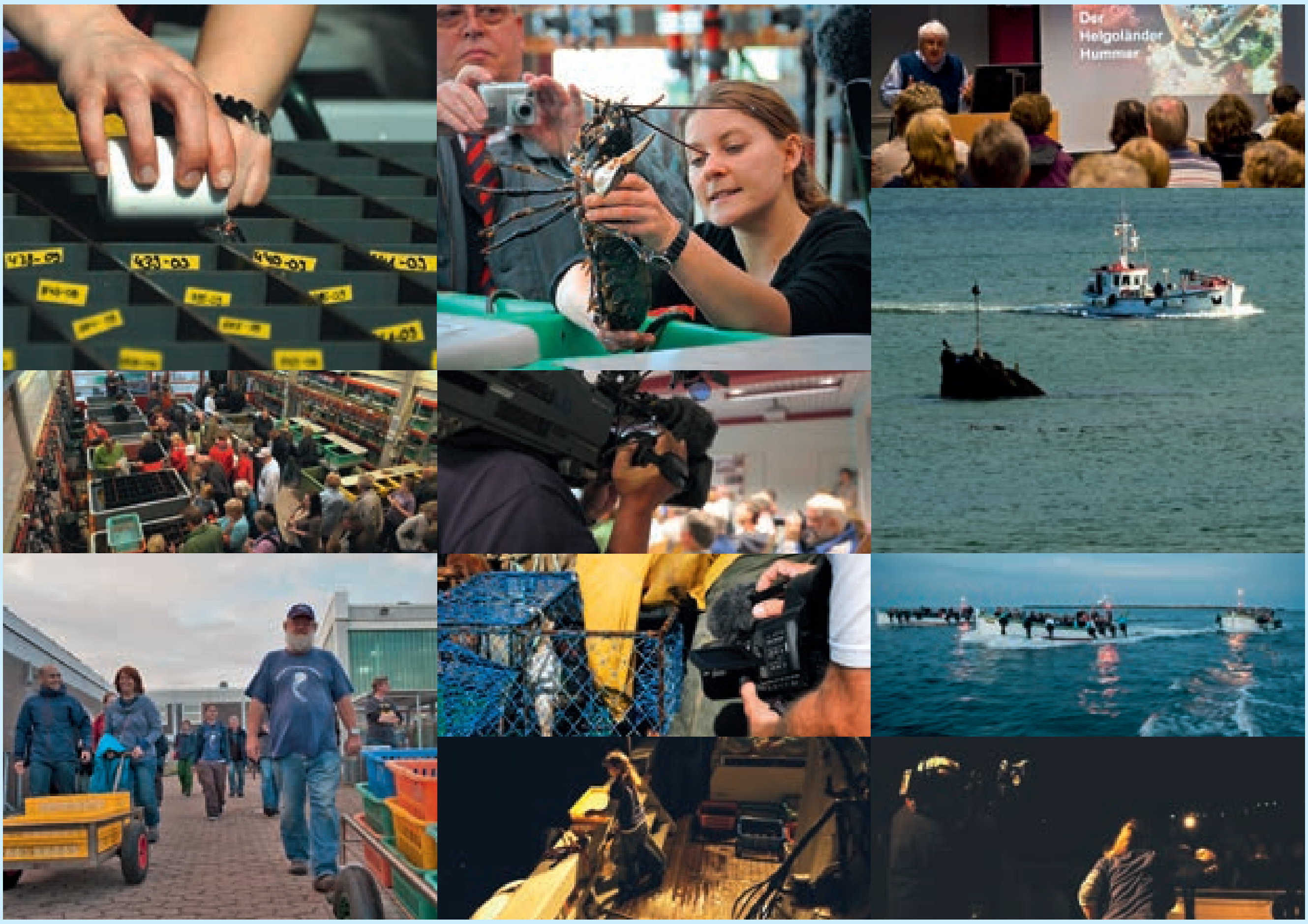
Marine research goes on TV

The AWI has the goal to communicate and share its research and the results with the public. The AWI website and blogs offer up-to-date information on AWI science. The scientists support TV and media crews on a regular basis, the public can take part in new and exciting aspects of marine and polar research.

It is late in the evening, the water is already black. In the glow of the flickering lights from the island, in the shelter of Helgoland's sea-stack "Tall Anna", BAH environmental scientist Isabel Schmalenbach is tipping the contents of hundreds of small beakers over the railing of the "Aade" into the sea: hundreds of small lobsters which were raised in the laboratory. The onlookers in the unique Helgoland passenger transfer boats "Börte Boote" applaud. Their lobster 'foster children' have just been given freedom. This is done after sundown so that the little crustaceans have time to find a safe place before their daytime enemies come looking for food.

A camera team records the annual spectacle. As the film director would like "atmospheric pictures" and Captain Dieter Klings accordingly steers the BAH ship "Aade" into the red glow of the sunset. "The people in the "Börte Boote" look on interestedly and applaud when "their" little foster animals are put into the water. As part of a restocking programme the public can foster a lobster larva which is released after sundown. Even the media are always interested in something this spectacular – "big cinema," says Klings.

He is used to having journalists and film crews looking over his shoulder. The research vessel captain takes about twenty filmmakers on board every year, and even more radio and newspaper people. They want to capture AWI's research activities on the island for viewers, listeners and readers. The daily excursions taken by Klings and his colleagues to the Helgoland Roads are the heart of the institute's long-term time-series of world renown.



Photos: AWI, U. Nettelmann

Foster a lobster

The Helgoland lobster has become quite rare. The stocks of the noble crustacean have shrunk considerably since World War II – perhaps due to habitat destruction, an increase in environmental toxins, excessive fishing or probably due to a mixture of all of these. Moreover, the increasingly warm winters due to warming of the North Sea may have a negative effect on the animal's reproduction. Despite protective measures, the population is so small that it is no longer able to sustain itself. BAH scientists work to understand and stabilise the stocks. In the laboratory they in future hope to raise hundreds of thousands of young lobster and release them to their natural habitat when they grow to about four centimetres. This large-scale project requires external support, however. Interested persons have been able to sponsor lobster larvae since 2007. Now over one thousand sponsors are acquiring valuable knowledge about this endangered species and its habitats. They can even visit "their" lobster baby and accompany it when it is released to the underwater world of the Helgoland's rocky base.

AWI takes its responsibility of informing the public very seriously – it is important, for example, to show what is done with research monies. Direct questions and needs from journalists are sent to the Public Relations Office in Bremerhaven, which coordinates the timing and experts. Then it's the "Aade" team's turn.

Meanwhile, the three seamen have become semi-professional actors. "Tow the plankton net again, please. We didn't get a good picture of the sampling." Sometimes umpteen takes are required until science is staged properly. "It takes a while until it really 'sticks'."

Klings is relaxed. He supports the teams in every respect: he talks about his work, gives tips on the right time of day for proper lighting or steers the vessel to the appropriate position when the filmmakers are looking for certain organisms for their shot. "Marine sciences is incredibly exciting for someone from the mainland. And to make sure it comes across properly, I'm happy to do my part. I feel that's part of the job."

There was only one time when the captain did not play along. "A presenter was wearing a uniform jacket and a captain's cap for the shot. They wanted me to put on the same thing." That was too much for him. "A film is supposed to reflect reality. And I simply don't look like that when I'm at work!"

Today, every thing worked out great. The fostered lobsters are freed and the film is 'in the can' – and millions of TV viewers can share in it.

"Meeting public needs: Advice and support."

The Wadden Sea and the North Sea are unique natural areas, while also being pivotal economic regions. Conflicts of interests between the various interested parties can easily occur. To find sustainable solutions to these it is important to incorporate scientific findings into social and political decision-making processes. Biologist Dr Christian Buschbaum talks about work at the AWI North Sea Office, which received an award from the German "Country of Ideas" initiative in 2012.

Research in the Wadden Sea and North Sea is real manual labour. Sampling on a regular basis provides insight into changes in biotic communities and their possible environmental causes. Photos: C. Buschbaum

Dr Buschbaum, you head the AWI North Sea office. What does this office do?

Buschbaum: We act as the bridge between applied marine research, the public and politics. Anyone wishing to know what is going on in the south-eastern section of the North Sea can obtain comprehensive information and advice from us. The AWI provides a broad database and many experts for this purpose. We bundle this knowledge and thus support social decision-making processes.

In connection with which issues, for example?

Buschbaum: For example, the question of how to deal with the large number of non-native species that are increasingly introduced into the Wadden Sea and the North Sea. We investigate which impacts these organisms have on local biotic communities. Or in the recently identified micro-plastic problem: tiny, finely dispersed plastic particles in the sea represent a whole new form of waste pollution. In such contexts we constantly provide information to the public and stakeholders in general.

For whom is this information primarily collated?

Buschbaum: Primarily for decision-makers, i.e. politicians or government agencies like the Federal Agency for Nature Conservation or the State Offices of the Environment and Nature Conservation. Often they come to us with specific questions. We then advise on what should be examined, define research focal points and also supply the data.

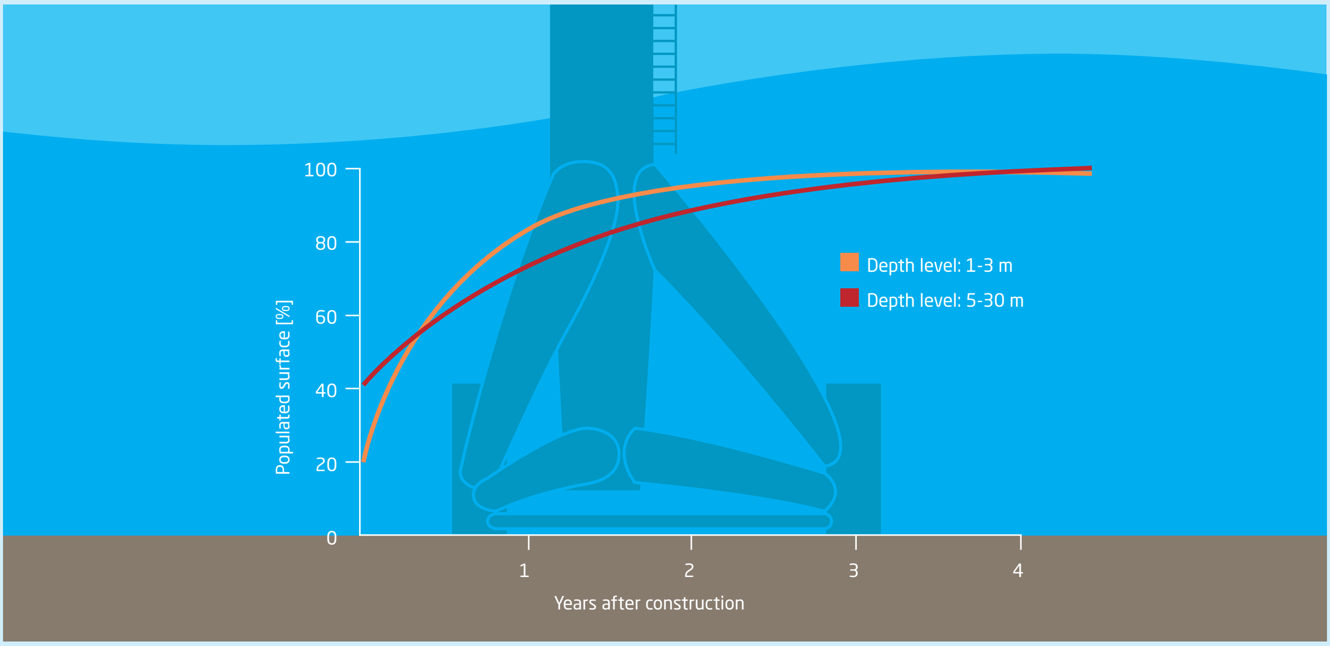
So you work closely together with the authorities. How unbiased are the results?

Buschbaum: We have a dual role. On the one hand, we provide data from our basic research. On the other hand, we also examine specific questions as research assignments. What we find out is always absolutely free of any external influence. We always convey the result clearly and in a factual manner – combined with recommendations for further action.

What is your personal motivation?

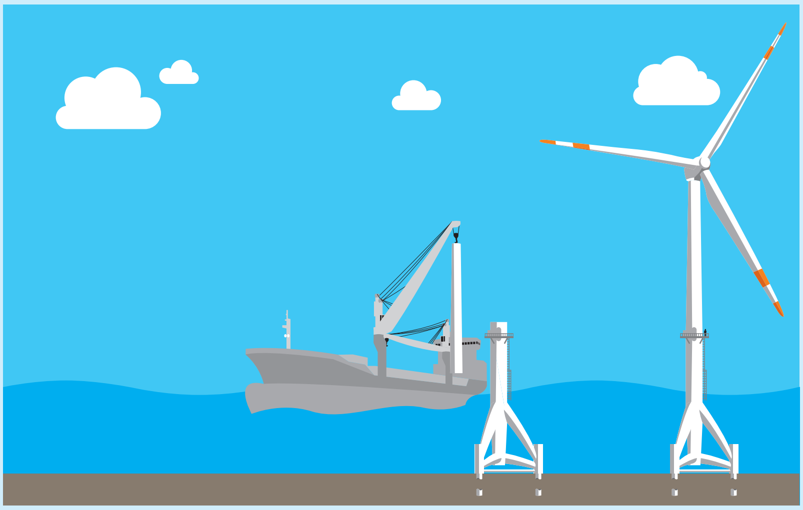
Buschbaum: Many people only perceive what our environment is like online. A computer, however, cannot convey the smells of feeling of the beach and ocean, for example. You have to immerse yourself in nature in order to experience it in its entirety. If we are able to sensitise people to this and at the same time communicate information and enthusiasm, people will understand the importance of our coastal habitats. And then willingness will grow to protect them and perhaps to invest in them, as well.

Depth-related settlement dynamics at the underwater structure of an offshore wind turbine.

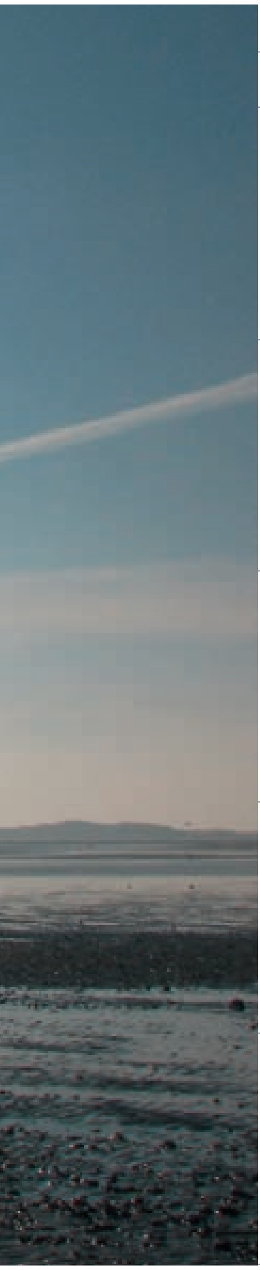


Energy transition on the seabed

The offshore wind industry leaves its footprint in the sea. AWI research scientists led by Dr Lars Gutow found this out in a study on behalf of the Federal Ministry of the Environment. The enormous fundaments of the wind turbines represent a new habitat for all kinds of sea inhabitants, such as mussels, sea anemones and worms. The excretions of these organisms, their larvae and also the changes in the currents around the underwater structures alter the seabed and the animal communities living there. However, wind farms also indirectly protect as there is no fishing in the farms so that the animal populations on the seabed can have a refuge from the destructive trawl nets. With the aid of models scientists now want to forecast whether and how the effects of numerous offshore wind farms all add up.

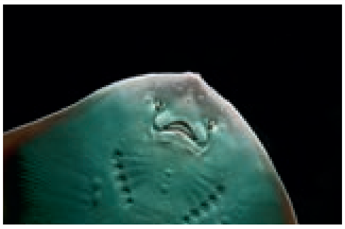


Contacts at AWI



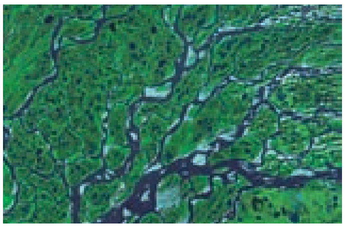
North Sea and Polar Regions
Investigation areas for coastal research scientists

On eating and being eaten:
Marine food webs



The North Sea in the fast lane of change
Long-term measurements confirm change in the ecosystem

Hot spots of climate change
The polar regions



From the air, on land and under water:
Methods of modern oceanography

Descent from the ivory tower
Research for students, pupils, politics and society

Legal notice

Alfred Wegener Institute
Helmholtz Centre for Polar
and Marine Research
Am Handelshafen 12
D-27570 Bremerhaven
Telefon +49(0)471/48 31-0
Telefax +49(0)471/48 31-11 49
E-Mail: info@awi.de
www.awi.de/en

Editing and design:

Responsible for content:
Professor Karen Wiltshire,
Vice-Director Alfred Wegener Institute

Claudia Pichler, Communications & Media
Dr. Folke Mehrtens, Communications & Media

Layout: Yves Nowak, Communications & Media
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ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

Am Handelshafen 12
27570 Bremerhaven / Germany
Tel.: +49 (0)471/48 31 - 0
Fax: +49 (0)471/48 31-11 49
www.awi.de/en

HELMHOLTZ
GEMEINSCHAFT