

COASTAL & MARINE



Coastal Climate Change *Biodiversity and nature conservation*



Editorial

Dear Reader,

Climate change is one of the main current and future challenges to humankind and already greatly affects the world's ecosystems, economy and our society. Coastal areas are not only a hotspot of human activities, but are also especially vulnerable to predicted climate change effects such as sea level rise and extreme hydro-meteorological events such as floods and storm surges. Coastline modification as for example the construction of ports and coastal protection measures, but also indirect impacts such as eutrophication and the emission of pollutants have led to drastic changes in ecological conditions. The causes, but also the effects of these changes are reflected across scales, from local to global.

This has direct implications for nature conservation, the management of protected areas and biodiversity. In vast areas habitats have been degraded and biodiversity has declined.

A particular challenge lies in the uncertainty and difficulty to predict future impacts. Potential consequences on the function of ecosystems and biodiversity are only recently in the focus of research. Some examples of this are illustrated in this issue.

Besides efforts to mitigate or reduce further adverse impacts e.g. by reducing the emission of green house gases, it is essential to adapt to these changes. This includes measures to protect our coastal infrastructure, but also the adjustment of nature conservation strategies.



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Coastal & Marine Union (EUCC)

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Climate change impacts on the Baltic Sea ecosystem - consequences for management

The Baltic Sea region is warming faster than the earth as a whole. Since the late 19th century the annual average surface air temperature increased by 0.08 to 0.11°C per decade in the Baltic compared to the global average of 0.05°C. Average sea-surface water temperature has increased by up to 1°C per decade since 1990 and a further increase of 2 to 4°C is projected by the end of this century, with a drastic decrease in the amount of sea-ice cover and the length of the ice season if the warming continues as expected. There has been a tendency for increasing precipitation in winter and spring, and model simulations indicate that winter precipitation could continue to increase, affecting river runoff. Increased river runoff and precipitation in turn contribute to greater inputs of waterborne and airborne pollution, decreases sea-surface salinity and augmentation in sea surface levels.

These are findings of an assessment on climate change in the Baltic Sea area, released in 2013. The report was produced by HELCOM in cooperation with BALTEX, the Baltic Sea Experiment, and is based on the Baltic Assessment of Climate Change II.

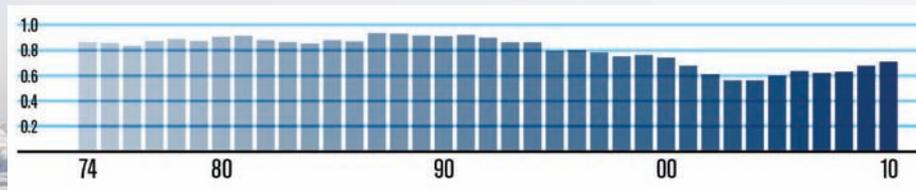
Climate change, warming in particular, is expected to lead to changes in ecosystem structure and functioning, such as shifts in the ranges of species and distribution of habitats, as well as a decrease of oxygen in the water - making benthic communities and habitats more vulnerable. This is not good news for the Baltic Sea biodiversity which is already under significant pressure. Not only do the natural characteristics of the sea, such as variable and low salinity and temperatures, mean that there are few species able to live in it (often at the extreme of their ranges), but also the intensity

of human activities at sea and pollution from land-based activities put stress on the marine environment.

In an effort to mitigate the expected negative effects of climate change, actions have been proposed to buffer the Baltic Sea ecosystem against the changes. The HELCOM nutrient reduction scheme should be implemented so that nutrient inputs are below maximum allowable levels, human pressures stemming from shipping, fisheries and construction activities should be reduced, and the network of marine protected areas should be strengthened to ensure a safe space for species and habitats.

The challenge of mitigation is enhanced by the fact that the changing climate also undermines and/or complicates the implementation of measures to protect the environment. For example, the extension of the growing season and increased demand for crops to produce biofuels are likely to increase nutrient leaching from agriculture (currently the main source of nutrient inputs). Also increased river flow and precipitation, bringing added nutrients to the sea from diffuse and distant sources, make it more difficult to reach the agreed HELCOM nutrient reduction targets. Ultimately, the effects of climate change might render the HELCOM vision of a healthy Baltic Sea more difficult to attain using currently agreed actions and measures.

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Maximum ice cover

There has been a significant decreasing trend in the annual maximum ice extent of the Baltic Sea, amounting to a decrease of 20 % over the past 100 years. Normalised 1-0 (1 = 228,5). Source: HELCOM, 2013



Wadden Sea and estuaries in times of climate change: implications for nature conservation

The unique landscapes of the Wadden Sea and the estuaries of Ems, Weser, Elbe and Eider form parts of the Europe-wide Natura 2000 network. The tides, steep gradients of energy input, sediment composition and salinity create highly dynamic landscapes with high ecological importance for benthic habitats, fish, birds and marine mammals. However, the impacts of climate change are already visible, e.g. by new species entering the area or large scale strengthening of the main dikes due to acceleration of sea level rise.

Direct biocenotic effects of climate change are mainly induced by rising temperatures. As for aquatic species this will lead to a clear increase in species numbers as well as a shift in species composition, to which nature conservation goals must be adapted.

Indirect biocenotic effects result mainly from changes in abiotic environmental properties. An important question is whether the inter- and supratidal areas will be able to morphologically follow the rising sea level, since an erosion of forelands is unfavourable not only with respect to nature conservation, but for coastal protection as well. However, this could lead to options for new alliances e.g. between coastal protection and nature conservation. Further impacts on the abiotic properties of coastal habitats result from interactions of climate change with hydro-morphological changes due to the deepening of the estuaries for large sea shipping.

Accelerated sea level rise demands new and creative adaptation measures in coastal protection, since strengthening the existing

line will come to its limits in the medium and long term (>50 years). Therefore additional coastal protection strategies will have to be implemented. This may comprise the construction of second dike lines within a new concept of spatial flood protection, the construction of flood barriers in the lower estuaries or backward relocation of dikes. However, any future measures must aim at increasing the adaptation capacity of coastal habitats. The opening of summer dikes may well be a step into this direction allowing for the reestablishment of tidal habitats and sediment accretion (see pp. 14/15).

These examples show, that the future strategic orientation of nature conservation must not only take the direct impact of climate change into consideration, but has to take changes induced by social and economic shifts and climate change adaptation measures into account as well. Within nature conservation, conflicts of objectives may occur since the EU Habitats Directive aims at fostering the natural, dynamic estuarine functions and habitats, whereas the EU Birds Directive aims more at conserving actual landscape properties. On a long-term scale nature conservation will have to explicitly include climate change into its strategy, e.g. by an appropriate and more flexible definition of development goals, including the conservation objectives of the EU Birds Directive.

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North Sea animal life mirrors changes of maritime climate

Water temperature is one of the most important features shaping the distribution of marine species. Biogeographic areas follow temperature gradients so that distributional patterns can be used as indicators for water bodies. Furthermore organisms integrate such conditions at least through their whole life span and therefore can be used as steady “measuring instruments”. The occurrence of certain species in an area confirms that the environmental conditions have been stable for a certain time in that area. Long term observation of biodiversity, therefore, allows monitoring of local environmental change.

The North Sea belongs to the boreal system, predominantly characterised by cold waters from the North Atlantic. Warmer water influx comes mainly through the British Channel, but also oceanic waters from the north are warmer in winter than the continental water bodies in the southeastern North Sea. The different water bodies meet in the Doggerbank area, which therefore used to be quite diverse in species composition. Long term studies of the benthic fauna started in 1991 and sampled 37 stations yearly. The results show that warm water species are consistently spreading farther south and east so that the fauna is changing its character by getting more and more temperate. This resulted in a decrease in species numbers in this area, as the fauna became more homogeneous than it was before. A clear regime shift can be seen around the year 2000 with a decrease in biodiversity.

The regime shift around the onset of the new millennium observed in the Doggerbank area is also visible in the coastal areas of the German Bight. 35 years of sampling decapod crustaceans in the Helgoland Trench (a depression of >50 m depth south of the Island of Helgoland) showed the same features around the year 2000. This confirms that these shifts are not local phenomena, but follow a general trend in response to climate warming and an increase of East-Atlantic species from regions with milder water temperatures in winter.

Not only has the composition of the fauna changed through time, but also the distribution of individual species. This applies especially to warm water species that were in the past, besides their more southern occurrence, restricted to the southwestern North Sea and that have steadily spread farther north along the coast. A prominent example is that of the small hermit crab *Diogenes pugilator*. Until 1984 this species did not occur beyond the coast of south Holland. In 1995 it was recorded from the Western Frisian Islands. The first record from Helgoland was in the year 2002 and since 2005 it is constantly found in the inner German Bight, both offshore and on the beaches of the Eastern Frisian Islands, where it has established stable populations.

Another example is the swimming crab *Liocarcinus depurator* that used to be present in the oceanic waters of the northern and central North Sea, as well as in the southwestern part before the 1990ies. In 2000 its populations increased in the Helgoland Trench and dominance was reached in 2002, resulting in a dramatic decrease of the formerly common *Liocarcinus holsatus*. Presently this last species is still dominant in shallower areas of the German Bight, while in the deep water of the Helgoland Trench *L. holsatus* is outcompeted by *L. depurator*. The reason for this might be that the shallower, non-stratified waters of the German Bight cool down near to freezing temperatures in winter, while the deeper waters still keep a slightly higher temperature. This means that this faunal signal might also be triggered by the temperature regime.

These examples show that long term observations of the marine fauna can help to understand the effects of environmental change towards the biosphere and therefore give more information about biodiversity shifts than single parameter measurements.

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Hermit crab Diogenes pugilator from an offshore sand bank off the Eastern Frisian Island of Wangerooge captured in 2005.
© Michael Türkay



Swimming crab Liocarcinus depurator from the Helgoland Trench, captured in 2010.
© Sven Tränkner



Climate change impacts on Mediterranean Marine Protected Areas

The Mediterranean Sea is considered one of the biodiversity hotspots on earth with nearly one fifth of the total known number of marine species world-wide. Today only 4.6 % of the Mediterranean Sea is covered by marine protected area (MPA) status and just 0.1 % is designated as no-take reserves. Some MPAs are breeding areas for rare and endangered species like the critically endangered Mediterranean monk seal *Monachus monachus*, the sea turtles *Caretta caretta* and *Chelonia mydas* or the dusky grouper *Epinephelus marginatus*. Other MPAs hold an unusual rich biodiversity, are the main spawning grounds of big pelagic fish like the eastern Atlantic bluefin tuna *Thunnus thynnus* or preserve important marine habitats that support many diverse species. These habitats and the resources they sustain provide the public with a valuable and diverse set of goods and services, including seafood, recreational enjoyment, carbon sequestration, storm protection, and opportunities for pharmaceutical discoveries among many others.

However, the Mediterranean Sea seems an especially vulnerable region to global change and recent scientific reports show alarming signs of its impact. Marine sea surface temperatures have been rising at a similar rate to land air temperature, increasing on average by 1°C since the 1980s and are expected to be approximately 2.5°C warmer over the next 86 years. Sea level around the Mediterranean rose by about 1-3 mm/year during the 20th century with a sharp increase since the mid-1990s. In the forthcoming years sea level changes, even though considerable regional variation is forecasted, could be up to 60 cm depending on land movements, temperature and salinity at different localities. Similarly, the acidification of marine waters caused by the absorption of excess carbon dioxide released in the atmosphere has produced abrupt changes in the

oceans with an overall increase in acidity (by the equivalent of a 0.1 unit reduction in the pH) of surface sea water since the beginning of the industrial era. Current estimations project a further drop of 0.5 units or more by 2100, lower than it has been for more than 50 million years.

The impacts of these changes on the marine biodiversity of Mediterranean MPAs are already visible. During the heat waves of 1999 and 2003 marine habitats around some western Mediterranean MPAs lost a substantial amount of benthic fauna due to massive die-offs following anomalous high temperature conditions. These massive events have been repeated continuously on different scales and have particularly affected the coralligenous populations, one of the richest habitats in the Mediterranean. An illustration of this was the loss of 50 % of the gorgonian *Paramuricea clavata* communities in Cabrera National Park in 2007 in Spain. Similar observations have been recorded since then during the summers of 2008 and 2009 with the first recorded large sponge die-offs in several MPAs (including Cabrera National Park and Scandola Nature Reserve in Corsica).

The colonies of *Cladocora caespitosa*, the only coral native to the Mediterranean that form reef-like structures similar to tropical corals, has suffered similar recurrent mass mortalities over the past 10 years due to seawater warming. MPAs such as Columbretes Islands Marine Reserve (Spain) and Strunjan Nature Park (Slovenia) that hold some of the largest colonies of this endemic coral have both witnessed these effects. Since 2003, up to 50 % of *Cladocora* colonies in Columbretes islands have died in repeated events in response to higher summer water temperatures.

Meanwhile on the eastern side of the Mediterranean Sea, warmer conditions are facilitating the invasion of many Indo-Pacific species that enter through the Suez Canal. A noteworthy example is the rapid spread of the rabbitfishes *Siganus luridus* and *S. rivulatus* that now have become very abundant in shallow coastal areas of Turkish MPAs. The intensive grazing of algae by these species has left Kaş-Kekova and Fethiye's rocky reefs almost empty of benthic life. Another example comes from the highly toxic pufferfish *Lagocephalus sceleratus*. Its voracious predation and rapid spread can decimate local stocks of commercially important species for local communities. Nowadays, large numbers are being caught by local fishermen proving also a hazard for human health. The species has recently been spotted all the way to Zakynthos Marine Reserve in the Ionian Islands off of the west coast of Greece, home to the endangered loggerhead sea turtle *Caretta caretta* (www.iucn-medmis.org).

Climate change will continue to have further impacts on species from changes in distribution and abundance in and outside the reserves, habitat use and timing of seasonal events like nesting and spawning. These changes will consequently affect the composition of communities in different MPAs. Rising sea levels and increased storminess will affect shallow coastal habitats. Increases in sea temperature may result in more frequent and severe mass mortalities of shallow water communities. Acidification will severely compromise the ability of intertidal bioconstructions, such as reefs built by vermetid molluscs and coralline algae as well as coralligenous formations such as gorgonian forests, to maintain their structures and communities.

Impacts will differ among regions and within local MPAs in the same region according to the degree of climate change interactions with

the hydrological situations and the vulnerability of the species. MPAs located in the more northerly Mediterranean areas could have an important role to play in preserving endemic and native cold-adapted species.

Although MPAs cannot do anything to alter the temperature or the salinity of the seawater, it is possible that well protected and managed MPAs can mitigate temperature or salinity driven effects on some marine communities. The importance to understand these early signs will help to prove management actions that can increase the ability of populations to resist climate disturbances or mitigate its effects. Research and monitoring programmes need to be put in place to look at mitigation alternatives and potential adaptation measures for the unforeseen and predicted effects of climate change on MPAs. A set of the most appropriate parameters for monitoring climate change impacts on biodiversity in these MPAs at a Mediterranean scale have been developed by IUCN and the Regional Activity Centre for Specially Protected Areas (RAC/SPA). Their implementation will enhance our understanding of how marine communities respond and help managers assess the condition of their sites and the environmental changes that are occurring there. Mediterranean countries still need to further develop policies and strategies for dealing with the impacts of climate change in the marine environment including MPAs if we want these sites to help us safeguard Mediterranean biodiversity.

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A bird's-eye view of marine wildlife - Digital aerial imagery for monitoring birds and mammals at sea

Assessing the impacts of human activities on the marine environment requires increasingly reliable and accurate data. Seabirds and marine mammals that are highly reactive to environmental change have traditionally been counted by observers on ships and airplanes. Recent developments in digital imagery allow more accurate census of marine wildlife, thereby solving major problems with previous survey methods.

The marine environment is subject to many anthropogenic influences, and exact data on the frequency distributions of marine organisms are becoming increasingly important to effectively address current conservation issues. The anticipated growth of offshore wind farm installations over the next decade could lead to a significant loss of undisturbed habitats for seabirds and marine mammals. Standard environmental assessment studies in Germany have so far included aerial visual surveys to assess the potential impacts of offshore wind farms on the spatial distribution of birds and mammals. However, observer-based aerial surveys have methodological disadvantages: Low flight altitudes, necessary for the classification of bird species, and high flight speed in combination with large numbers of individuals allow only rough quantitative estimates. Aircrafts flying at low altitudes also disturb sensitive bird species, such as common scoters and divers. In addition, observational data need to be corrected for distance-related observer-bias, lowering the explanatory power of the resulting geo-ecological information.

Flying at low altitude through wind farms is also risky for the human observer. Consequently, digital aerial surveys, which take place at far higher and safer altitudes, i.e. away from the rotor-swept zone of the wind turbines, have become a mandatory requirement.

There are currently two established digital aerial techniques: (1) high resolution digital stills using either transect- or grid-based sampling

schemes, (2) high definition videographic methods that collect continuous series of images along linear transects. Statistical power is predicted to be generally lower for continuous sampling along line transects due to the lower number of spatially independent "samples" per survey.

Aerial digital photography of the marine environment is challenged by the low contrast between target objects and their surrounding. Grey harbour porpoises, for example, often merge with the environment, and even white seabirds are hard to distinguish from glare/reflections. Nevertheless, most seabirds and marine mammals can be identified down to species level (see example images).

The switch from analogue to digital methods has led to a significant rise in survey costs, because image acquisition, data processing and archiving require expensive equipment and experienced staff, which potentially limits the affordable number of surveys per year. At the same time, the current governmental standard in Germany (StUK 4) entails coverage of at least 2000 km² by 10 %, which leads to excessively large sets of images with long processing times. Consequently, there is an urgent need to consider trade-offs between image quality (precision) and quantity (coverage) in order to inform public policy decisions about cost efficient survey designs that generate significant, interpretable data.

Following a classic transect design (continuous sampling along equidistant lines) often means that a wind farm area or a nature reserve is chronically under-sampled. An even distribution of images on a smaller scale, on the other hand, would allow for proportional sampling of relevant areas, which may significantly increase the explanatory power of the survey results.

Seabirds inhabit spatially and temporally heterogeneous, or "patchy", environments across a wide range of scales. Most theoretical models



applied to visual sea bird surveys, i.e. models correcting for distance-related observer bias, assume evenly distributed individuals, through which the underlying patchiness of bird species and their habitats is averaged out. Through concentrating digital sampling effort to specific areas of interest (habitat patches), the quantity of images, survey time and costs could be reduced, while the statistical and biological significance of the surveys would increase.

The minimum technical and methodological requirements for carrying out digital aerial surveys are subject to ongoing basic research. Based on research results gathered over the past 3 years, a ground resolution of at least 2 cm in combination with forward-motion compensation (FMC) is required to recognise relevant bird species down to a body size of approximately 30 cm. Depending on the level of sensitivity of species towards disturbance through aircrafts, a minimum flight altitude of 425 m is advisable. This flight altitude also represents a good compromise with respect to the low cloud level which frequently occurs during the staging season of seabirds. To compensate glare effects, which significantly reduce the signal quality, an over-sampling approach is generally recommended. A technically limited sampling rate of 1.5 seconds at a flight speed of 100 knots produces sets of images that overlap by 30 to 50 %. Using a state-of-the-art tandem camera system, a swath width of around 400 m can be achieved. A new purpose-assembled stabilised camera system provided by IfAÖ is one of the platforms that bring these parameters together. It has been successfully tested during surveys in the North and Baltic Sea over the last months. The Baltic Sea with its many biodiversity hotspots is the ideal testing ground for further refining these new and exciting census techniques!

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Aerial photographs of common eider (*Somateria mollissima*), European herring gull (*Larus argentatus*), harbour porpoise (*Phocoena phocoena*) and long-tailed duck (*Clangula hyemalis*), © IfAÖ GmbH



Blue algae on the rise? - Modelling results for the Baltic Sea

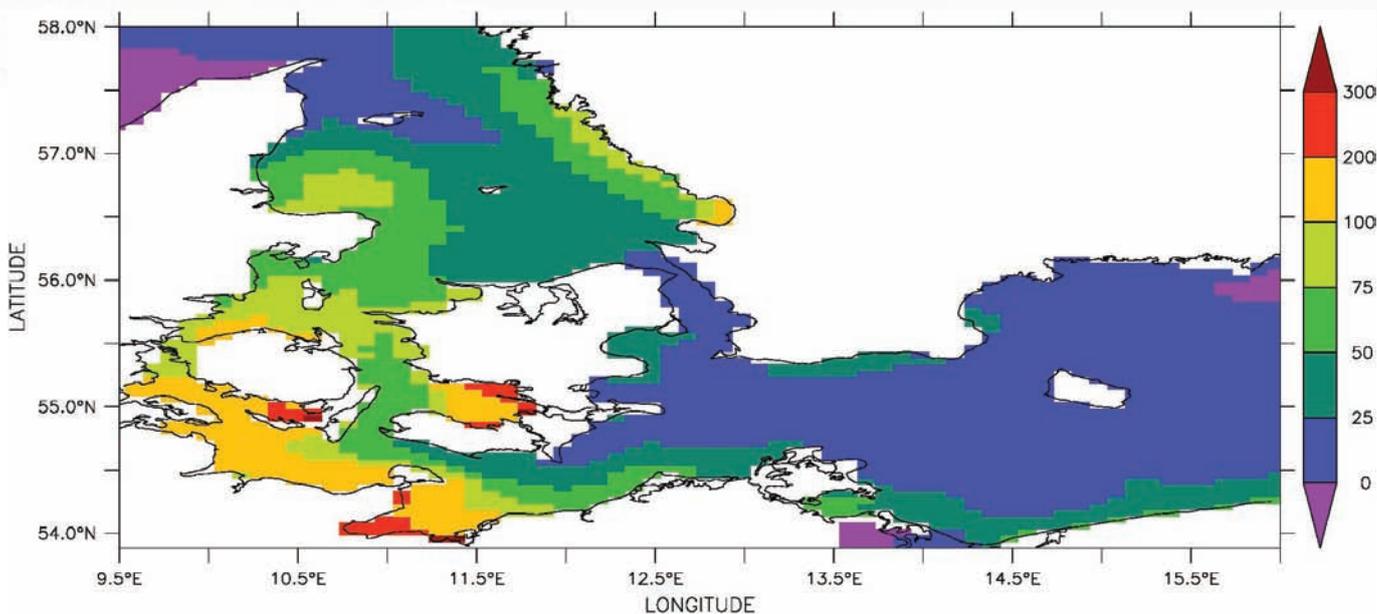
The Baltic Sea's ecosystem has changed dramatically since the start of the industrialisation in the mid 19th century. Nutrient loads to the Baltic Sea have grown strongly due to a large increase in the human population, the use of fertilisers, and phosphate containing detergents. This man-made eutrophication caused by an excessive supply of phosphorus has resulted in a nitrogen-limited ecosystem (especially during summer). The main group benefiting from this are nitrogen-fixers, who use atmospheric di-nitrogen for their growth (these organisms are often better known for producing large summer algal blooms which can be seen from orbit by satellites). Since most of them produce toxins, they are not eaten by zooplankton, but instead sink to the bottom, where they are degraded by oxygen-consuming bacteria. This process is one of the reasons why the anoxic zones in the Baltic Sea have drastically increased in the last century.

Nitrogen-fixers consist mainly of cyanobacteria (blue-green algae), and the growth of the main species present in the Baltic Sea is limited to salinities below 10 ‰ and water temperatures above 12°C. All recent climate change simulations for the Baltic Sea agree that there will be substantial warming, increasing the growth period of nitrogen fixing bacteria. Many simulations also show strengthening of rainfalls in the Baltic catchment, resulting in an additional increase of the nitrogen-fixers' potential growth region. Taken this effects together, climate change will lead to an increase of nitrogen-fixers, especially in the western Baltic Sea (shown in

the figure is their increase compared to the present situation). This will be accompanied by growth of the anoxic zones. The only way out is to strongly reduce nutrient inputs to the Baltic Sea, whereas not only the absolute amount of nutrients, but also the nitrogen to phosphorus ratio matters. Reducing both nutrients by the same amount would have no influence on the summer blooms: stronger reductions in phosphorus are needed. Using the reduction targets of the Baltic Sea Action Plan from 2007, our simulations resulted in a phosphorus-limited ecosystem with more or less vanishing nitrogen-fixers, while the BSAP-simulations of other modelling groups (e.g. of the Swedish Meteorological and Hydrological Institute) did not show this.

But be aware that ecosystem models are only simplifications of today's knowledge, e.g. adaption strategies to a changing environment are not included. Additionally, the group of nitrogen-fixers is much more variable in reality, which means that regardless of the nutrient inputs to the Baltic Sea, further harmful blooms of blue-green algae cannot be excluded. However, with the right management strategies we can diminish their occurrence and severity.

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Percentual increase of N-fixers (annual mean) at end of 21st century compared to end of 20th century, © René Friedland



How will Baltic microbial communities react to climate change?

Climatic changes are a major societal concern affecting ecosystems across the world. These changes may accentuate current anthropogenic effects such as eutrophication, thereby destabilising the ecological balance of marine ecosystems. For the Baltic Proper, the major part of the Baltic Sea, annual precipitation, surface water temperature, and atmospheric partial pressure of CO₂ ($p\text{CO}_2$) levels are expected to increase. By 2100, salinity may decrease from current levels of 7 to 4‰, while the mid-summer water temperature may increase from 12°C to 16°C, and $p\text{CO}_2$ levels may increase from 380 ppm to 960 ppm. A recent review of the effects of ocean acidification on Baltic ecosystems concluded that the effects on the Baltic spring and summer blooms will likely be small, and perhaps positive. Nevertheless, the expected effects of climate change may compromise the Baltic Sea as a recreational and economical resource: there are strong indications that an increased frequency or duration of summer cyanobacteria blooms, will result in serious harm to, for example, tourism industries. However, there is scant evidence how these changes will affect Baltic primary producers, which are the foundation of the food web.

Increased CO₂ levels will probably not affect heterotrophic bacteria directly, but increased phytoplankton biomass may stimulate growth of particle-associated bacteria. The increased competition for nutrients may also hamper bacterial degradation of dissolved organic carbon. For heterotrophic bacteria, temperature seems to be the strongest driver for structuring bacterioplankton communities. Moreover, bacterial assemblages in surface waters of the central

Baltic Sea harbour members of typical freshwater bacterial groups and lack several typical marine taxa. Hence, the estuarine/brackish local conditions have created a uniquely adapted bacterioplankton community. Since some bacterial populations are sensitive to or require salt, decreased local salinity will likely lead to increased dominance of freshwater bacterial species. The effect on Baltic phytoplankton seems to be species specific, where cyanobacteria like the toxic *N. spumigena* grows well in a salinity range of 4 to 24‰ with an optimum growth rate at around 7 to 8, while *Aphanizomenon sp.* seems more sensitive to salinity changes.

As currently predicted, climate change will affect all trophic levels of the planktonic food web, and thereby nutrient and carbon cycling, in a complex and possibly synergistic manner. Hence, identifying the ecological consequences of climate change requires multi-factor approaches rather than single-factor experiments (www.bioacid.de).

It is still unclear what effects on Baltic microbial communities we should expect. Laboratory experiments should be complemented by large-scale outdoor mesocosm studies to provide more ecologically relevant data for modellers and, thus, to be able to make more reliable predictions about future scenarios.

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Networking for dunes and beaches

Coastal dunes are one of the most threatened habitats in Europe according to recent reports required by the EU Habitats Directive. They have suffered significant decline in both their extent and quality due to the impacts of urban development, pine plantations, invasion by alien species, stabilisation trends and the impacts of coastal change, amongst many other things. Despite these facts, it is recognised that dunes have a high biodiversity value and provide a range of important ecosystem services including flood protection, water supply, and recreation. The dynamic nature of dune landscapes creates and sustains these values and services. As a consequence it is clear that the conservation of geomorphological processes and the importance of the beach-dune relationship are priorities for conservation managers. Dunes are in urgent need of more effective conservation action across the whole of their European range.

The establishment of a European Dune Network (EDN) was first proposed at the 1987 European Dune Symposium in Leiden, leading to the launch of the European Union for Dune Conservation and Coastal Management (EUCC). This was followed by three international dune conferences between 1989 and 1991, through which an informal network of academics and practitioners interested in dunes developed.

In 1993 the interests of the EUCC were broadened to consider a wider agenda based on Integrated Coastal Zone Management (ICZM), which led to the present day Coastal and Marine Union (EUCC). This meant that there was no longer a dedicated European networking resource for sand dunes and the capabilities of the informal network was therefore not fully utilised nor exploited. In response to this networking gap the UK 'Sand Dune and Shingle Network' was established in 2006.

The UK Network makes sustained efforts to communicate and collaborate with other European dune colleagues. It gained formal support for the establishment of an EDN from the EUCC

Council in 2010 and has published a set of over-arching aims and objectives. Soon after this the German 'Beach and Dune Network' was established through EUCC Germany and is a growing one. Additional national dune networks are now emerging across Europe. A EDN newsletter is now published three times a year and is coordinated through the UK Sand Dune and Shingle Network.

The established German, UK and European dune networks all share a set of complementary aims to conserve sand dunes as dynamic landscapes. They work to achieve this by enthusing and encouraging people to value and understand the habitats more thoroughly, by 'championing' the habitats, facilitating an exchange of knowledge and supporting actions that are good for the habitats. The networks promote and support the formulation of policies, implementation of wise management and sustainable uses that maintain the intrinsic values of dunes. The intention is to develop a vibrant European network of national communities concerned with coastal dunes and their management to develop knowledge and understanding of coastal beaches and dunes and to provide an international platform dedicated to coastal dunes.

Dune networks comprise active communities of participants, and are a recognised source of expertise and authority at a global level. The members include site managers, national policy makers, students, researchers, ecologists, geomorphologists, hydrologists, foresters, coastal engineers and tourism managers. Events are organised by the networks that engage a cross-section of interests. The intention of this is to bridge the gap between disciplines and to encourage lively debates. The common interest is the natural resource of dunes and beaches and the desire to find sustainable solutions to conservation issues.

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Are you concerned about the future of dunes in your country and across Europe? If you are then we encourage you to join the relevant dune networks in either Germany or the UK. They are free to join and you will receive three newsletters a year and have the chance to join in activities with like-minded members concerned with dune conservation. If you are based in a country without an active dune network please contact dunes@hope.ac.uk for advice and guidance.

European Dune Network: www.eucc.net/en/european_dune_network/index.htm

German Beach and Dune Network: www.eucc-d.de/dune-network.html

UK Sand Dune and Shingle Network: coast.hope.ac.uk



Shipping safety as contribution for nature conservation

The southern North Sea with its Wadden Sea is characterised by international and short-distance sea shipping, recreational yachting, fisheries, ferry traffic, and off-shore services. The traffic lanes directly north of the Wadden Sea, designated as Particularly Sensitive Sea Areas (PSSA) and partly as World Heritage Site, are one of the busiest shipping areas worldwide.

In the recent past, shipping safety measures like Vessel Traffic Service (VTS) and Vessel Traffic Management (VTM) came into focus as options to increase safety standards. There is a growing concern about the intensity of shipping, in particular how the traffic separation schemes adjacent to the Wadden Sea area may impact safety and the environment.

Recent incidents such as accidents, near collisions, loss of cargo (deck cargo and containers), and the fast developing offshore wind farms require a re-evaluation of VTM and an assessment of what vessel traffic monitoring in the southern North Sea can provide with regard to shipping safety in order to contribute to nature conservation and a healthy biodiversity in the Wadden Sea.

The shipping intensity in the German Bight to neighbour ports amounted to some 50.000 movements in 2010. According to the report of the policy document "North Sea 2009-2015", the number



Shipping density, © WSF/EUCC Germany

of ship movements will increase by 14 % to 31 % in the near future. The capacity of shipping lanes in the estuaries will grow to its limit without a sound VTM in outer waters.

Recognising the present and future developments with envisaged increasing risks to the Wadden Sea and its natural values, the Wadden Sea Forum recommends developing a trilateral system for vessel traffic monitoring and management in the German Bight with the aims to ensure strict compliance to existing rules, to prevent dangerous situations, and to intervene immediately when a dangerous situation develops. This system will be built on best practises applying VTM in estuaries and harbour approaches for further voluntary use in the main shipping routes to support a smooth vessel handling. A close cooperation between shipping and port authorities, the coast guard and ship owners will contribute to an enhancement of the system.

In particular, it is recommended:

- More comprehensive monitoring and a sound control of an area-covering Automatic Identification System (AIS) and VTS from Northern Denmark to the south of the Netherlands;
- Management and monitoring of the tidal windows in the Wadden Sea area and agreement on a protocol between the relevant authorities for the admittance of approaching vessels;
- Expansion of emergency towing capacity in the Wadden Sea Region;
- Introduction of a trilateral VTM system in the Wadden Sea Region as pilot for regional seas;
- Establishment of a transnational maritime operation centre for monitoring and controlling.

A VTM system for the entire area could improve safety for both man and the environment. Guidance for shipping in the area should be carried out on a multidisciplinary level between the coastguards and port authorities. It will have a positive influence on shipping and industry, will enhance safety standards and will acknowledge the protection of the vulnerable Wadden Sea nature reserve and World Heritage Site.

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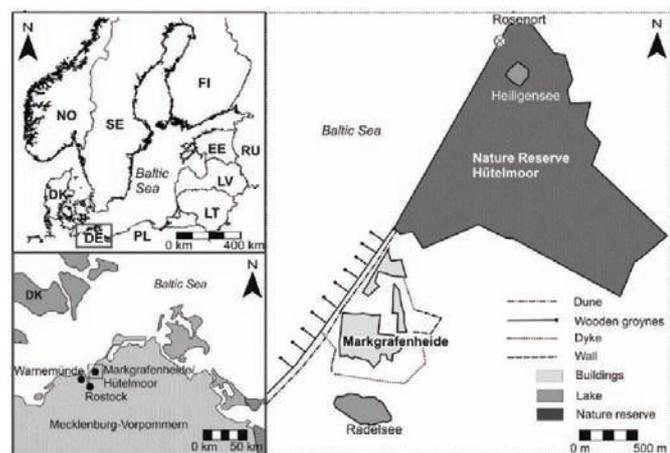


Combining coastal and environmental protection – the example of the realignment area Hütelmoor

Climate change and rising sea levels are a growing threat to the South Baltic Sea coast. 70 % of the 377 km long outer coastline of the German federal state of Mecklenburg-Western Pomerania are subject to erosion. Altogether, 135 km are protected by wooden groynes, seawalls, breakwaters, and beach and dune nourishment at an annual maintenance cost of around 15.5 million Euros. Rising sea levels combined with shorelines covered by coastal protection structures cause adjacent areas to suffer from an intensified pressure. These areas are often economically important, such as touristic beaches. This *coastal squeeze* increases the need for beach nourishment. However, several off-shore sources for sand dredging have been exhausted, and alternatives are protected by nature conservation regulations. Thus, the high investment costs and the lack of sand sources make new, flexible climate change adaptation strategies necessary.

As a part of a comprehensive coastal protection scheme for the seaside resort Markgrafenheide, a realignment plan was implemented in the adjacent coastal fen and nature conservation area 'Hütelmoor and Heiliger See' as a compensation measure. This area had been drained and used agriculturally for many decades. The traditional protection strategy was abandoned and a ground-sill was installed, allowing for rising groundwater levels and a reflooding of the coastal fen. Within the next few decades the restoration of dynamic coastal processes will lead to a narrowing of the adjacent beach in the northern Hütelmoor region, eventually creating a breach in the dunes towards the coastal fen with temporary brackish water intrusions. The forces of erosion are clearly visible today and have created cliffs in the dunes.

Within the project, different nature conservation aims could be combined both on land and within adjacent coastal waters. Reflooding the area will contribute to the revitalisation of the coastal fen and thus the restoration of an important biotope with its unique and diverse flora and fauna that is dependent on aperiodic saltwater influxes. Moreover, pressure on declining off-shore sand sources would be reduced, benefiting areas which are often valuable marine habitats. Furthermore, this coastal realignment process allows for a more natural and dynamic development of the coastline and serves as a buffer zone for neighbouring areas. This will not only reduce the impacts of storms on the coastline by providing areas for temporary flooding, but will also serve as a natural sand source for the nearby seaside resort Graal-Müritz. The resort will benefit from the restored longshore drift, which will increase sand deposition and thus reduce costs for protection through beach nourishment.



Location of the Hütelmoor area in the Baltic region, © Eva Weisner

A coastal realignment measure can be a more natural and sustainable alternative to conventional coastal protection measures. They allow the removal of protection structures, the restoration of dynamic coastal processes, and the flooding of certain designated coastal areas of extensive use.

In general, coastal realignment measures can reduce erosion in target areas, create new habitats and decrease the pressure on existing habitats. Depending on the local conditions, coastal realignment measures can therefore be a sustainable and natural solution that can meet both aims of climate change adaptation and nature conservation in coastal areas.

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Public acceptance of wetland restoration – the example of the Geltinger Birk

The nature reserve Geltinger Birk is located at the entrance of the Flensburg fjord in the German state of Schleswig-Holstein. Since 1890 the area was continually drained and used for intensive agriculture. To reverse these changes, in 1993 the cabinet of Schleswig-Holstein decided to build a new land protection dyke, stop the drainage and reflood the area. These measures do not only provide natural flood protection, they also respond to a rising sea level. Today 733 ha of the Geltinger Birk are protected, with 260 ha below sea level (SL ±0). Parts of the territory were flooded by an inlet built in 2013. Since the lagoon was originally open to the Baltic Sea, one goal is to restore these water dynamics. Therefore, the inland water level has been raised from SL -3 m up to SL -1 m. It is also planned to temporarily flood the area up to SL -0,5 m during winter and to dry it out again during the summer.

The area is now managed by the principle of a semi-open field landscape. This is a traditional year-round grazing system with large herbivores such as wild Konik horses and Galloway cattle that has positive effects on the local habitat types, because the grazing prevents development of forest.

The primary halophile flora and fauna on the former seabed were displaced by new species as a result of the altered natural conditions. The native primary vegetation will be restored by, for example controlling non-native rose hedgerow by covering them with geotextile and using sheep grazing to control their growth. Specific water management will establish salt meadows, which will support the emergence of wet meadow and salt meadow vegetation. Furthermore, this will increase the habitat potential for water birds and wading birds, resulting in a restored close-to-nature lagoon landscape. Additionally, pools of standing water were created as habitat for amphibians and birds. The resettlement of the natterjack toad is one project which will be especially

strengthened by the restoration of those small biotopes, as well as the settlement and spread of primary and halophile species. The results of the monitoring report not only showed positive development of the protected natural area in 2013, but also expect this trend to continue in the future.

However, the decision to rewet the area caused a strong public opposition and fear of decrease in tourism and usability. Results of tourist surveys show that these fears were unfounded, in fact most tourists appreciate the changes to restore the original state of the lagoon.

87 % of the tourists surveyed thought the measures had a favourable impact, 30 % liked the landscape or usability of the area better after the changes, 28 % reported noticing no difference. 41 % of the tourists visit the Geltinger Birk for walking or cycling, 28 % like to observe birds. When asked to list positive and negative factors about the Geltinger Birk 80 % of the given answers were positive and only 20 % were negative. Many tourists mentioned the natural, open landscape, flora and fauna and the quite location as very positive aspects of the Geltinger Birk.

Overall, the controlled restoration of the Geltinger Birk is a positive example of how expected changes can be determined in the landscape, flora, and fauna. It also shows that such measures do not inevitably create problems for tourism, as tourists largely appreciate the effects of such restoration measures.

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REGIONAL PROJECTS INVOLVED

RADOST (2009 – 2014)

Regional Adaptation Strategies for the German Baltic Sea Coast

Climate change is confronting the German Baltic Sea coast with the challenge to develop suitable adaptation strategies. RADOST aims at developing these strategies in cooperation with science, economy, administration and the public. The project is equally about minimising damage to business, society and nature as well as about making use of the development opportunities provided by the change. It further strives for the permanent establishment of stakeholder networks and communication structures in the region and beyond. Regional implementation projects in cooperation with partners will demonstrate exemplary adaptation measures, comprising amongst others the following topics: Innovative coastal protection, adaptation measures for tourism and ports, aquaculture, optimisation of ship hulls, combination of coastal protection and use of geothermal energy. RADOST is one of seven projects funded by the German Ministry of Education and Research within the ministry's initiative KLIMZUG ("Regions adapt to climate change"), which supports selected regions in Germany in the development of innovative approaches to climate adaptation. A central goal is the creation of long-term, sustainable cooperative networks for regional stakeholders. www.klimzug-radost.de



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BIOACID (2012-2015)

Biological Impacts of Ocean Acidification

The growing evidence of potential biological impacts of ocean acidification affirms that this global change phenomenon may pose a serious threat to marine organisms and ecosystems. Despite a wealth of knowledge on specific effects of acidification and the related changes in seawater chemistry on the physiology of individual marine taxa, many uncertainties still remain. Because the majority of studies are based on single species experiments, little is presently known about possible impacts on natural communities, food webs and ecosystems. Moreover, few studies have addressed possible interacting effects of environmental changes occurring in parallel, such as ocean acidification, warming, and deoxygenation and changes in surface layer stratification and nutrient supply. The overarching focus of BIOACID II is to address and better understand the chain from biological mechanisms, through individual organism responses, through food web and ecosystem effects, to economic impacts. www.bioacid.de



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Development of a concept for a sustainable management of Baltic Sea beaches (2011-2015)

Population growth, industrial economy, coastal defense and climate change threaten Baltic Sea beaches. In order to implement sustainable nature conservation at intensively used beaches a concept to reconcile habitat and species preservation with tourism will be developed. In the project, field experiments help to determine the home-range of animals to find their area of demand. In particular, the impact of trampling by tourists on individual plants and vegetation communities are investigated to identify sensitive beach zones. By interviewing decision makers and regional stakeholders, their interests and issues towards beach conservation are involved into the process to develop a concept to integrate nature conservation and tourism. www.ecosystems.uni-kiel.de/projekt_straende.shtml



Wadden Sea Forum

The Wadden Sea Forum (WSF) is an independent platform of stakeholders from Denmark, Germany and The Netherlands contributing to an advanced and sustainable development of the trilateral Wadden Sea Region. In particular, this means integrating specific cross-sectoral and transboundary strategies, actions and techniques which are environmentally sound, economically viable and socially acceptable. The WSF consists of representatives of the sectors agriculture, energy, fisheries, industry and harbour, nature protection, tourism, as well as local and regional governments. National governments are represented as observers.

The focus of work is on the recently developed ICZM strategy, climate mitigation and adaptation measures, shipping safety in the North Sea and partnership in risk management. The WSF also serves as a consultation body for governments and forwards stakeholder knowledge and advice to the political level. www.waddensea-forum.org



EUCC - The Coastal Union Germany (EUCC-D)

EUCC-D was established as a non-governmental association in 2002, forming the German branch of the Coastal & Marine Union (EUCC), the largest European coastal and marine organisation. The main objective of EUCC-D is to strengthen German activities within the field of Integrated Coastal Zone Management (ICZM) by bridging the gap between coastal science and practice. EUCC-D provides relevant information, consults and educates coastal practitioners, hosts workshops and conferences and runs demonstration projects in the field of coastal and marine management. We develop information systems, create tools (e.g. databases, learning modules) for international networks and disseminate coastal and marine information via our German Küsten Newsletter or in shared media with our international colleagues. EUCC-D offers memberships for professional and private individuals, and other non-profit organisations. The German membership also includes membership with EUCC International. Please visit www.eucc-d.de/membership.html for more details.

