



Federal Ministry
of Education
and Research

MARE:N – Coastal, Marine and Polar Research for Sustainability

German Federal Government Research Program

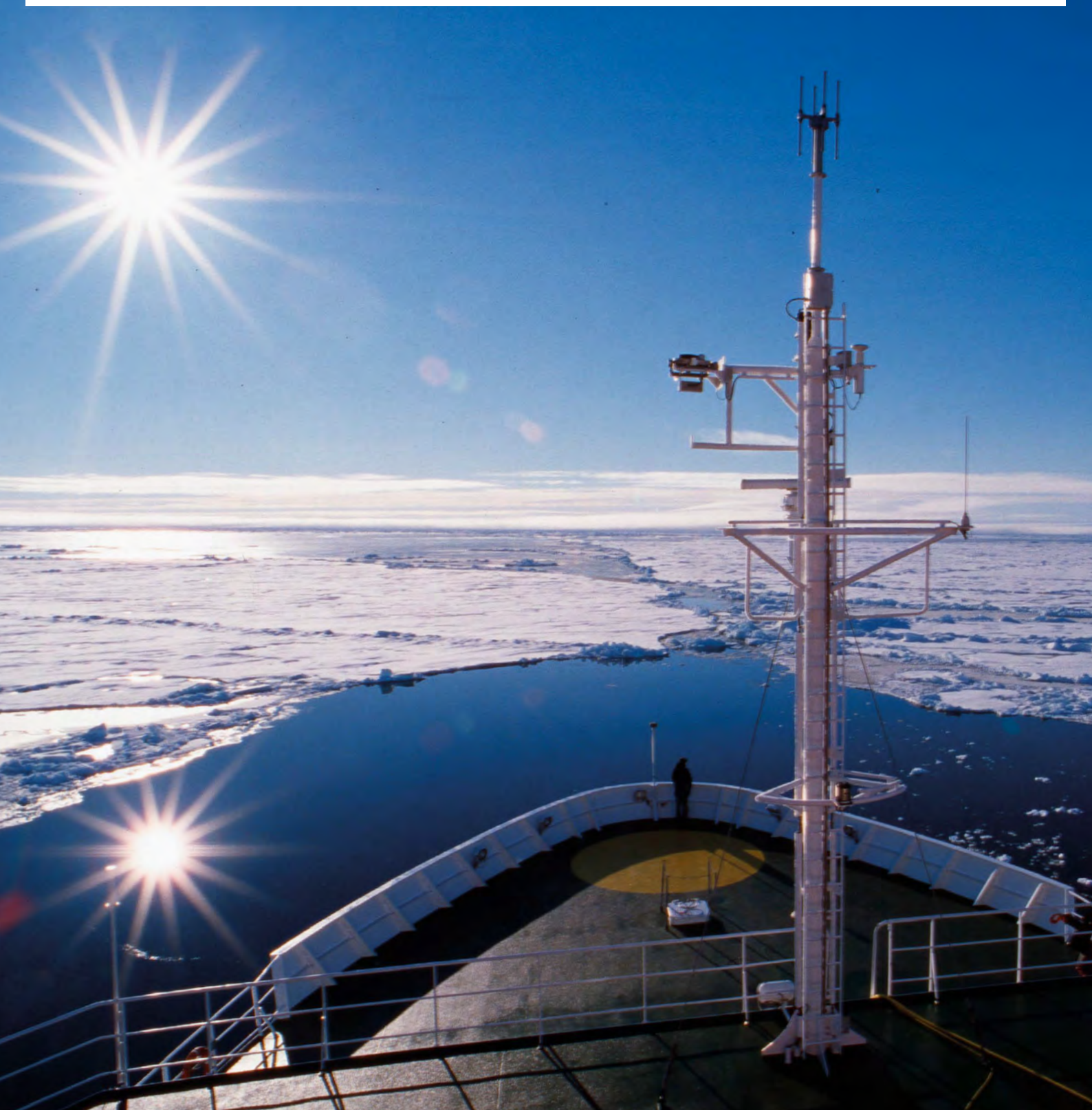


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Foreword

Seas and oceans cover more than two thirds of the Earth's surface. They are the largest continuous ecosystems on our planet and – together with the atmosphere – they play a key role in climate processes and the Earth's substance cycle.

It is therefore vital that we protect the oceans. The future of mankind will depend on our responsible stewardship of the environment and natural resources.

We still know too little about the biological, chemical and physical processes occurring in the oceans. It needs curiosity to gain knowledge, as Jacques-Yves Cousteau, a pioneer of marine research, once said. We need curious researchers and their multidisciplinary work in order to better understand and evaluate the processes of change in coastal, marine and polar regions. Their scientific findings form the basis of political decisions which concern all of us, including the development of eco-friendly and sustainable strategies for use.

The Federal Ministry of Education and Research is supporting this research with reliable long-term funding. Germany has one of the most modern research fleets in the world as well as excellent research infrastructures. German expertise contributes substantially to international science collaborations. Close intergovernmental cooperation is needed because oceans know no national borders.

The Federal Government's MARE:N programme formulates new objectives for coastal, marine and polar research under the Research for Sustainable Development framework programme (FONA). MARE:N is based on close interdepartmental cooperation and involves stakeholders from science, society, politics and industry. The German Marine Research Alliance (DAM) and the multilateral initiative „Healthy and Productive Seas and Oceans“ (JPI Oceans) provide major impetus for research. MARE:N is also a German contribution to the UN Decade of Ocean Science.

This coordinated funding policy and a transdisciplinary and cross-border approach enable excellent research and generate the knowledge needed to make arrangements for the future. Research findings help us to protect the oceans effectively and ensure greater sustainability in their use.

The Federal Ministry of Education and Research





1. Introduction

The United Nations estimate that more than 40 percent of the world's population, some 2.8 billion people, now live within 100 km of the coast. Ninety-five percent of international trade involves marine transport, and the oceans are important sources of food, raw materials and active substances. For example, saltwater fish provides nearly three billion people throughout the world with more than one-fifth of their daily protein. So that mankind can continue making use of the coastal, marine and polar regions in the future, we must make a lasting contribution to the management of the assets and resources of these ecosystems. In cooperation with society, government and business, research serves the function of establishing the knowledge and decision-making basis needed for drafting potential future scenarios and developing the scientific foundations for sustainable technological and social innovations.

Therefore, the German Federal Government has established the research program, MARE:N - Coastal, Marine and Polar Research for Sustainability, as a component of the „Research for Sustainable Development framework programme“ (FONA). This program is specifically tailored to the topics of coastal, marine and polar regions and serves as an open, adaptive decision-making framework in which funding activities are adapted to current research policy as well as social developments and issues. Stakeholders from society, science, government and business will need to work together closely in order to effectively protect the coastal, marine and polar regions, develop national and international policies and treaties and develop sustainable concepts for exploitation. A coherent research policy and sufficient interlinking of the various funding instruments are crucial to this.

Close coordination and continuous dialogue between the various federal ministries, the federal states, and the scientific community are particularly important for application-oriented research. Participative agenda processes will therefore be integral components in the implementation and updating of the MARE:N research program. The Federal Ministry of Education and Research (BMBF) will establish and foster a council consisting of the following Federal Ministries: the Ministry of Economic Affairs and Energy (BMWi), the Ministry of Food and Agriculture (BMEL), the Ministry of Transport and Digital Infrastructure (BMVI) and the Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Its role will be to coordinate the continuous monitoring and evolution of the program while respecting the responsibilities of the different ministries. The states, the scientific community and other users of the research will participate by means of the „Marine Research Forum“ and the agenda platforms which are to be established.



2. Challenges in Coastal, Marine and Polar Research

Approximately 70 percent of the earth's surface is covered by oceans, making them the largest ecosystem on earth. Microscopic algae and bacteria in the upper layers of our oceans produce just as much oxygen and bind as much carbon as all terrestrial plants. The oceans have absorbed some 30 percent of all the carbon dioxide released into the atmosphere by human activities since the beginning of the Industrial Revolution. At the same time, the oceans act globally as thermal buffers which prevent extreme temperature fluctuations and ensure a thermal balance between the high and low latitudes by means of ocean currents and atmospheric circulation.

Humanity is having an increasing adverse effect on the mechanics of the earth system at crucial points. The effects of human activity, which were barely perceptible at first, are now clearly measurable and visible in the world's oceans.

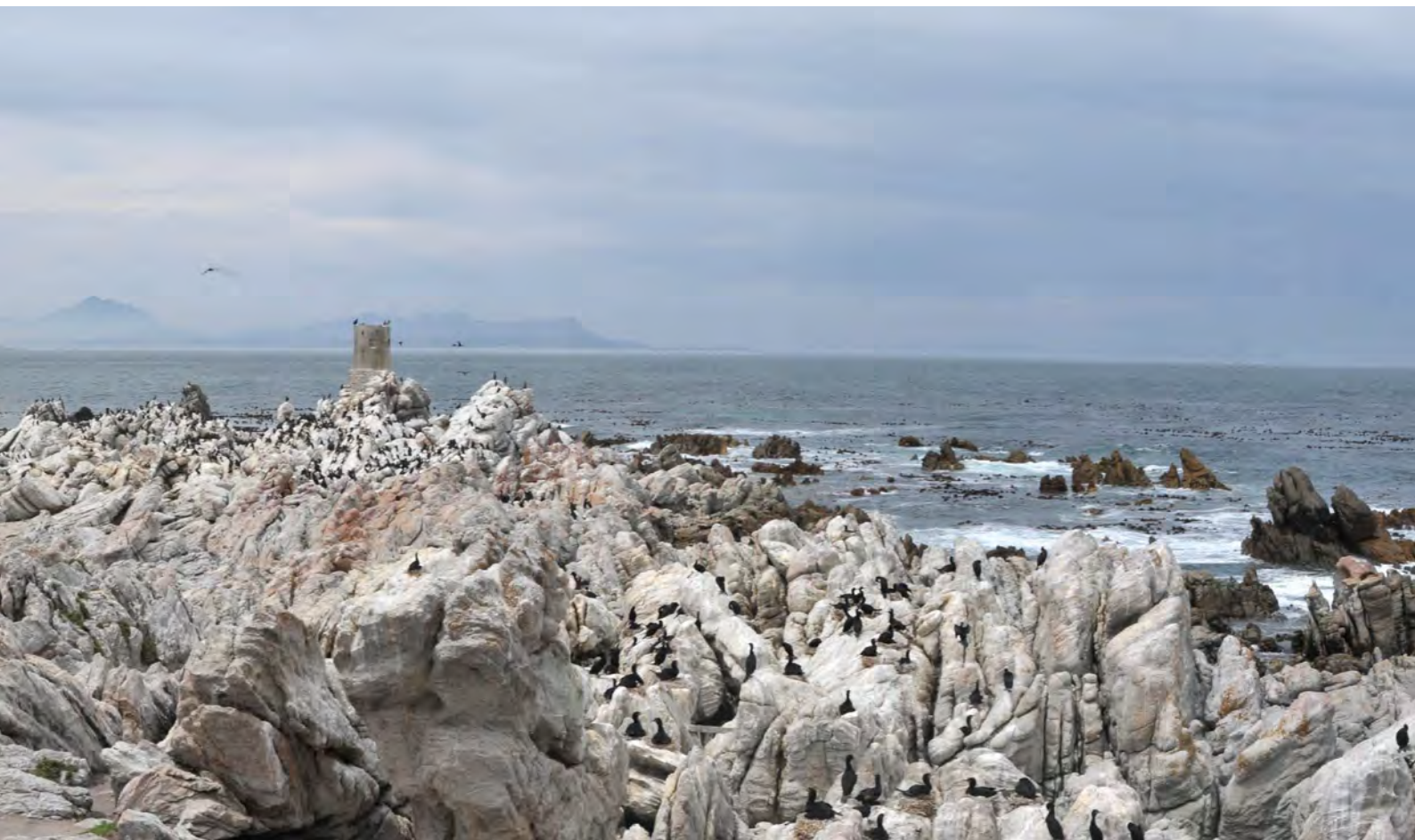
The anthropogenic emission of carbon dioxide and its consequences, such as climate change, ocean warming, rising sea levels, the acidification of the oceans, low oxygen levels and the decline of polar sea ice, poses a threat to ecosystems, as does the uncontrolled exploitation of biological and geological resources and the increasing incidence of contaminations, pollutants and nutrients.

But man is dependent on the ecosystem services provided by the seas and coasts; therefore, the cross-generational conservation of marine services and resources serves both economic and social interests. Exploitation by humans must not be allowed to endanger the natural basis of life for flora and fauna in the seas. Finding a balance between ecological, economic and social aspects is therefore one of the major challenges that we are facing.

The climate-regulating effects of the oceans and the biogeochemical processes occurring in them, which are often regenerated through the global flow of substances and energy, are even more fundamental to our livelihood. The predicted rise in sea levels, the increase in extreme storm surges and coastal erosion already endanger about a third of the world's population. Therefore, strategies for adapting to the consequences of climate change and for the sustainable use of coastal regions are imperative.

Research plays an indispensable role in the process of transformation to an environmentally compatible and sustainable society: It provides basic decision-making information for society, government and business, describes possible development and action scenarios, and develops technological innovations for sustainable

coastal and marine exploitation. Its future success is dependent on objectives which are oriented toward global challenges and the meeting of societal needs as well as cross-ministerial and international coordination. Due to its global importance as well as its scientific and social complexity, coastal, marine and polar research must be implemented in a broad regional, national and international context. Its success will depend on close cooperation between the disciplines, the sharing of capacities between institutional, ministerial and university research and project funding, and the collaboration of science, civil society, government and business. As a research program of the Federal Government, MARE:N offers a framework for future coastal, marine and polar research.



The nutrient-rich waters of the Benguela Current (Southern Africa) are rich in fish. Numerous bird species such as cormorants, pelicans and flamingos feed here.



3. Administrative and Programmatic Framework

Coastal, marine and polar research is a universal trans-disciplinary and interdisciplinary topic. Future challenges will require the immensely broad participation of social, administrative and economic stakeholders. This applies to the careful use of biological and geological resources, as well as to the sustainable exploitation of marine energy sources, the protection of the marine environment and the reduction of pollutant emissions. Other socio-political challenges include adaptation to climate change and the securing of social prosperity, quality of life and economic development. The diversity of the tasks associated with meeting these challenges is reflected in the participation of various federal ministries in the implementation of national and international policies and agreements. Apart from the respective foci of the ministries, science provides one of the most important foundations for administrative and social decision-making (Figure 1).

German coastal, marine and polar research is well positioned in comparison to other countries throughout the world. Its indispensable basis consists of the institutional and ministry-based research facilities with their large-scale equipment, complex infrastructures, and outstanding national and international networking. Programmatic project funding is a flexible strategic management tool laid upon this foundation.

MARE:N, a research program coordinated by the Federal Government, is aimed at closely interlinking various funding instruments and all stakeholders from science, society, government and business. The resulting synergy effects will be used to meet the requirements of forward-looking coastal, marine and polar research.

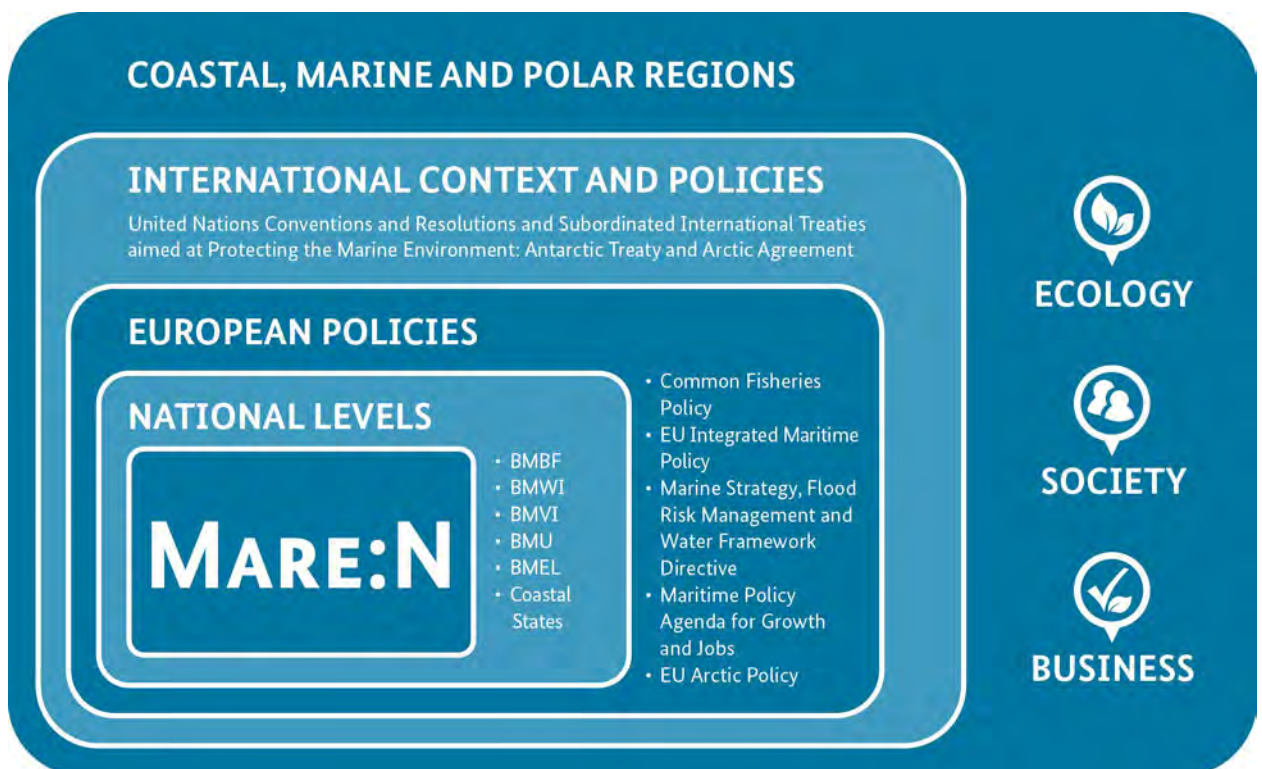


Fig. 1: Administrative and Programmatic Framework for German Coastal, Marine and Polar Research.



4. International Integration of Coastal, Marine and Polar Research

Complex relationships and feedback mechanisms influence the Earth system on a global scale and, at the same time, can trigger regional and local chain reactions. Coastal, marine and polar research must take the global context into account; accordingly, Germany has been conducting its national activities in cooperation with international programs for decades. The Federal Government is committed to the existing multilateral agreements and treaties for the protection of coasts, seas and polar regions. Of particular relevance among these are the UN Convention on the Law of the Sea, the UN Convention on Biological Diversity, the UN Framework Convention on Climate Change (UNFCCC), international agreements on the prevention of marine pollution (e.g. MARPOL and the London Protocol) and the Antarctic Treaty System. There are also regional conventions, such as the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), the Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM) and the Trilateral Wadden Sea Cooperation.

The research activities within MARE:N are integrated into the international programs of the UN and the EU. They contribute to the development of international strategies for the protection and sustainable development of the coastal, marine and polar regions, which can support the implementation of both European directives (see Figure 1) and the UN's 2030 Agenda for Sustainable Development (particularly Development Goal 14: „Conserve and sustainably use the oceans, seas and marine resources“).

The Federal Government seeks strong international coordination of research activities in order to generate global knowledge on the conservation of common resources in the area of preventive research. Various international partnerships, which are to be expanded further in line with the requirements of future research, have already been successfully established in the field of marine research in coordination with other ministries. For example, the Federal Ministry of Education and Research represents the Federal Republic of Germany

in the joint program initiative, „Healthy and Productive Seas and Oceans“ (JPI Oceans). This is a multilateral initiative aimed at harmonizing national activities in the field of marine and maritime research. The BMBF (Federal Ministry of Education and Research) also participates in funding instruments which create a common European research space and support the direct transfer of knowledge for the implementation of common marine policies (for example, Article 185, EraNet, CSA).

German marine research also provides significant contributions to the UN’s World Climate Report (Intergovernmental Panel on Climate Change, IPCC) and is closely involved in international research programs on global change, such as Future Earth Research for Global Sustainability and the World Climate Re-

search Programme (WCRP) Moreover, as a member of UNESCO’s Intergovernmental Oceanographic Commission (IOC) and the International Council for the Exploration of the Sea (ICES), Germany will continue to play an important role in the coordination and promotion of oceanic research and observation.

Under the umbrella of MARE:N, the coordination of the funding strategy will be further intensified both at the national level between ministries and at the international level. As one of the leading economic nations, Germany is aware of its international responsibilities in the field of marine research and marine policy and is providing the necessary infrastructure and basis for research with MARE:N



Panel Discussions on the Challenges of Modern Climate Research at the 21st Climate Change Conference (COP21) in Paris.



5. Agenda Processes in Coastal, Marine and Polar Research

Coastal, marine and polar research integrates numerous scientific disciplines and particularly addresses the issue of the major societal challenges presented by climate change. The various disciplines must work even more closely together in the coming years in order to acquire the necessary decision-making knowledge regarding the function of the seas in the Earth system, the influence of human activity on marine ecosystems and the repercussions of marine and global changes on human society. It will be necessary to establish a dialogue between experts from science, society, government and business in order to determine needs-based research focal points. To ensure that marine research in Germany meets

these requirements, we must develop a coherent, complementary and internationally coordinated research policy for the coastal, marine and polar regions in order to make efficient use of all available capacities and resources. The Federal Government's MARE:N research program forms the basis for this strategy under the umbrella of the Research Program for Sustainable Development (FONA). A council made up of the participating ministries monitors its implementation in order to ensure that its research results are integrated into social and administrative decision-making processes.

The German “Länder” have also established the „Marine Research Forum“ in cooperation with the BMBF and the German Research Foundation in order to better coordinate future research activities. The agenda platforms (Fig. 2) ensure the participation of the scientific community and future users of the research results.

The MARE:N research program is an open, adaptive operational framework based on these structures. It is the task of the Agenda processes to identify the continually evolving challenges as well as the research topics in coastal, marine and polar research which are determined as a result of these challenges. To this end, three transdisciplinary and interdisciplinary platforms, in which the funding measures are adapted to the actual needs and development levels, will be set up with experts from science, government and society. The topics identified for project funding in this way will generally be published in the form of coordinated notices and the funding will be awarded by means of a competitive process. This will allow the program to react flexibly to current societal developments as well as developments

in research policy and serve as a strategic control instrument designed especially for short-to medium-term research issues.

The MARE:N program will play a special role in the cooperation between university and extra-university researchers. Competencies will be further developed and resources bundled, so that the specific strengths of the respective organizations and their programmatic research become closely interwoven. The interplay between preventive research and application-oriented research is also expected to improve. University research is particularly important both for the training of junior scientists and for the structural implementation of interdisciplinary research approaches.

Research will be carried out primarily in transdisciplinary and interdisciplinary networks in order to accelerate the application of the results. The inclusion of future user groups for the duration of the project and modern scientific communication are, therefore, of crucial importance.

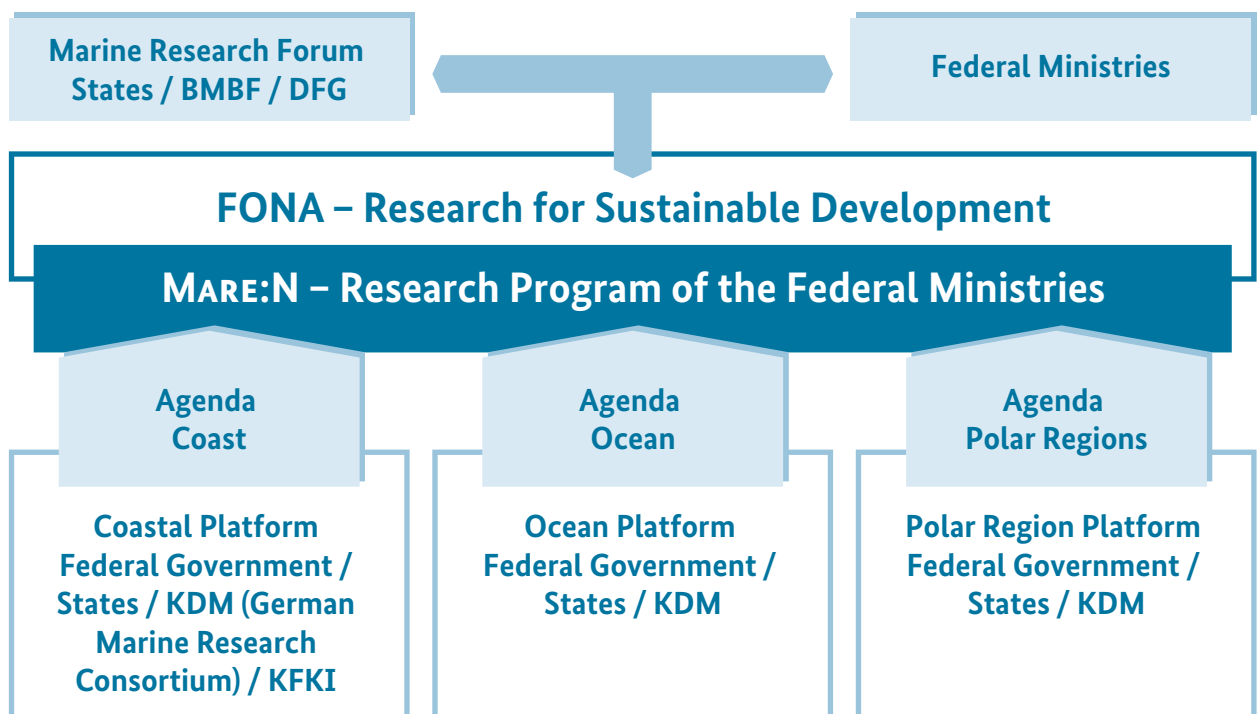


Fig. 2: Agenda Processes in Coastal, Marine and Polar Research.



6. Program Structure

The MARE:N program will provide comprehensive preventive research to empower decision-making and contribute to the development of forward-looking, innovative maritime technologies. The scientific program consists of six major interdisciplinary, cross-ministerial topics which are relevant to society and two cross-sectional activities (Fig. 3).

The research focus on **Global Change and Climatic Events** will include an analysis of the long-term natural and anthropogenic changes to the state of the environment. The only way in which to comprehensively describe the complexity and importance of the ocean as a driving force for climate is through an iterative process based on observation and modeling which must lead to reliable forecasts.

If we are to assess the consequences of global change on biodiversity, it is essential to have a comprehensive understanding of variability as well as the adaptation mechanisms at the species and system levels. On this basis, in the research focus on **Ecosystem Function and Biodiversity**, MARE:N will address the change in impact potentials and the resilience of ecosystems with regard to the many changes and the consequences of the growing demand for exploitation.

Research activities under the focus on **Global Biogeochemical and Energy Fluxes** will target an understanding of the carbon and nutrient cycles, as these cycles influence biodiversity and thus ecosystem functions. An understanding of these processes, some of which take place at a very small scale, and the balancing of the material volume are essential to understanding regional and global material cycles and makes it possible to record the effects on marine life communities.

Future projects under the research focus on **Management of Natural Hazards** will target the development of new and improved procedures for the prognosis and early detection of natural hazards and civil defense strategies. This includes the prediction of extreme meteorological events and their consequences in the context of long-term climate changes and to the prognosis and early detection of geological processes. The aim of research activities is to minimize damage and risk in affected coastal regions.

The authoritative definition of the sustainable use of resources and the successful implementation thereof as well as an assessment of the importance and robustness of ecosystem services are the challenges which will be addressed under the research focus on the

Sustainable Use of Resources. In the context of concomitant and follow-up ecological research, this will include process investigations of the long-term and cumulative effects on marine and polar ecosystems.

The problems and conflicts associated with climate change and the increasing use of marine resources require multilateral solutions and adaptation strategies which must be developed within the context of a broad societal consensus. **Governance and participation** are therefore intrinsic components of all the research focal points of MARE:N.

In order to adequately address the research focal points mentioned above, the provision of modern **research infrastructure** is indispensable. This includes measurement, observation, information and data technology. In view of steadily rapid technological progress, the development of needs-based innovative technologies for selected marine activities is also one of the prerequisites for MARE:N.



Fig. 3: Research focal points and cross-sections of the MARE:N research program.



7. Scientific Program

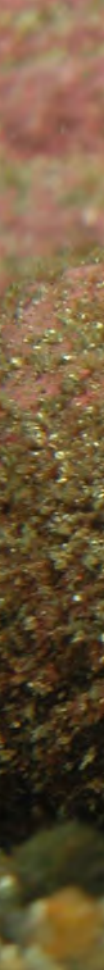
MARE:N is designed as an adaptive program to react flexibly to current societal and research policy developments and to identify new topics. The program focal points outlined below will be technically supported and further developed through agenda processes (see Section 5).

7.1 Global Change and Climatic Events

The sea plays a fundamental role in global climate change, even for terrestrial climates: Almost all of the water content of the atmosphere, and thus precipitation, is generated by means of evaporation at the surface of the sea. The atmospheric heat balance is largely determined by sea currents. Oceanic circulation acts as a global conveyor belt, transporting warm water near the surface, from the equator to the North Atlantic, and cold water from the poles back to the Pacific in deeper water layers. The oceans currently buffer more than 90 percent of global warming. They constitute an important sink for the carbon dioxide resulting from the burning of fossil fuels and ultimately absorb all of the meltwater from land-bound glaciers.

Coastal regions are of crucial importance to humanity. Eight of the ten largest mega cities in the world are located near the sea. Both, short-term weather influences, particularly extreme events, and long-term climate change are altering coastal regions throughout the world. The impact is being exacerbated by the increasing, partially uncontrolled, exploitation by humans and the construction of infrastructure such as coastal protection and port facilities or wind parks.

One of the most important current research topics is the reliable recording and modeling of the long-term natural and anthropogenic changes to the state of marine and coastal environments. In order to investigate and assess the long-term and cumulative impacts of human interference, we need interdisciplinary research approaches which involve the collaboration of all stakeholders from the scientific community and from society. It is also necessary to develop innovative and sustainable procedures for coastal and floodwater protection, maritime transport, and the planning and maintenance of offshore structures.



Future marine climate research will focus on the complex interactions between the ocean, cryosphere, atmosphere and land masses. Developing reliable model-based scenarios of the consequences of rising temperatures, changing global and regional circulation, the acidification of the oceans, rising sea levels and the role of the ocean as a heat accumulator is vital for assessing the impacts on ecosystems, fisheries, coastal areas, maritime economy, tourism, and consequently, on our society as a whole.

7.2 Ecosystem Function and Biodiversity

Life began in the sea. The number of genetic blueprints, i.e. biological diversity, is even greater in the sea than on land. More than a million species have been recorded in the world's oceans over the past two centuries; it is possible that the number of species which has not yet been described is much higher, particularly at the microbial level. In addition, biodiversity at the molecular and genetic levels is already effective below the species level. The organisms in the marine habitat have also developed immense functional diversity during the course of evolution.



Hermit crabs, such as *Pagurus comptus*, must repeatedly change their shells as they grow. Their shells are often covered by numerous other organisms.

Changes to the Earth system have a strong impact on life in the oceans. Scientists have already been able to detect rapid changes in marine biodiversity at local, regional and global levels. Whereas species expand their spatial distribution with changing water temperatures and currents, alien organisms are also introduced, via the ballast water from ships, into habitats which were previously inaccessible to them. The consequences are far-reaching: Predator-prey relationships are changing, and previously persistent, native, structure-forming species are disappearing. Rising temperatures, acidification, the influx of pollutants, the extraction and introduction of biotic and abiotic substances, the introduction of alien species, construction activities and shipping are just some of the many other stress factors. It is therefore necessary to intensify research into the ways in which ecological communities are changing in the context of climate change and increasing exploitation as well as their degree of adaptability.

Biodiversity and changes to the systems due to human interference is therefore one of the major challenges in current coastal, marine and polar research. We know little about the short and long-term impacts of the various stresses on the ecosystems and their services; therefore, we need better research into their natural variability, functional interactions, adaptability and resilience with respect to species, population and system levels. It is also essential to understand the functional role of biodiversity and interactions with the flows of substances and energy. This knowledge is crucial, if measures are to be taken to reduce stress potentials and develop integrative concepts for usage and protection. Tourism, active-substance research, material development and nutrition are among the areas in which humans benefit from a high level of natural biodiversity and the integrity of ecosystems. This particularly applies to the marine biosphere with its high level of genetic diversity.



The research catamaran, MYA, has run aground at low tide in the Königssee at List (Sylt) on a mussel bank.

7.3 Global Biogeochemical Cycles and Energy Fluxes

Biogeochemical cycles and energy fluxes of the coastal, marine and polar regions are characterized by closely coupled physical, biological and biogeochemical effects. They are subject to natural and anthropogenic influences with impacts on local, regional and global scales. The processes of heat and energy exchange between the ocean, the atmosphere and the cryosphere, as well as the exchange of various biological and chemical substances between the Earth system compartments are of particular interest, as they directly affect the climate system and the ecosystem structures of the Earth.

One of the most serious effects of mankind's interference in global material cycles is the elevated increase in carbon dioxide emissions caused by the burning of fossil fuels and changes in land use. In addition to damaging the coral reefs, the resulting warming and acidification of the ocean could also threaten other marine ecosystems and thus endanger the food chain up to the level of humans. In order to derive action and decision-making options, we need to be able to predict how natural variability and human activity affect material cycles and energy fluxes, and further reduce uncertainties in the existing models. This can be achieved only by focusing future research on quantifying and parameterizing the biogeochemical cycles and energy fluxes on the various spatial and temporal scales as well as on the various trophic levels.

Nutrient cycles have a decisive influence on the productivity of coastal, marine and Polar Regions. Humanity interferes strongly with these cycles by over-fertilizing and overfishing. The effects are further reinforced as a result of climate change and changes in oceanic circulation. The consequences are coastal eutrophication and the propagation of oxygen-depletion zones in the seas and oceans coupled with the loss of species, habitats and whole food webs. Therefore, investigating the biogeochemical processes and climatically controlled variability in oxygen-poor zones as well as the ecological and biogeochemical consequences of their propagation is of vital importance.

The melting of polar ice leads to a greater intake of fresh water into the polar seas. The resulting changes in the release, uptake and transport of gases, nutrients and trace metals cannot be adequately predicted on the basis of knowledge available today. This freshwater input and the changing ice conditions are expected to result in increased productivity in the free water zone of the Polar Regions. The consequences of the material and energy fluxes of the Polar Regions and the ways in which they affect marine life communities have not yet been adequately researched.

The coasts and their hinterlands form the ecological, social and economic interface between land and sea. They are highly productive ecosystems which play a major role in the global carbon, phosphorous and nitrogen cycle despite their small surface areas. These are the areas in which human beings influence the material cycles through agriculture, industry, fisheries, the exploitation of mineral resources, tourism, ship operation, waste disposal and control structures.

The systemic quantification and balancing of the inflow, transport and conversion of materials and the development of the necessary systems for observation, modeling and assessment are essential requirements for sustainable coastal management.

The range of substances recorded in the marine environment has expanded considerably over the last decades due to the increasing amounts of litter in the seas, among other things. The litter includes both dissolved organic compounds and particulate substances. When we consider the increased input of plastics into the marine environment and the detection of microplastic particles in many organisms, the extent of the pollution in the oceans is self-evident. Our understanding of the short and long-term effects, transport, transformation and the fate of the recorded substances in the marine systems is still very limited. Future research must therefore focus on studying the ecological impacts on ecosystems and food webs as well as the development of better analytical and test methods and the correct placement of the measuring stations.

Social Action Requires Reliable Research

The 5th IPCC Assessment Report states that anthropogenic climate change will affect nearly every region of the oceans by the year 2100. The seas are warmer, more acidic, and oxygen-depleted in virtually every area. The increase in ocean warming may also influence atmospheric and oceanic circulation, the sea ice cover and the oceanic carbon flows.

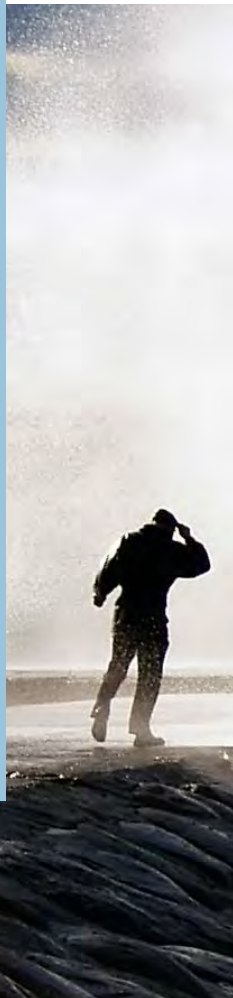


Strombidae such as *Limacina costulata*, are only a few millimeters long, but an important part of the food chains in the polar seas. Persistent acidity in the ocean could cause the decomposition of its protective armor made of calcium carbonate.

Since the beginning of the Industrial Revolution, the ocean has absorbed about 30 percent of the carbon dioxide produced by fossil fuel consumption. Carbon dioxide changes the chemical composition of the water and leads to the acidification of the ocean which is already at measurable levels. With the BIOACID project, the Federal Ministry of Education and Research has launched one of the world's first and largest national research projects on oceanic acidification, thereby contributing significantly to the IPCC reports. We now know that the function of the oceans as a „carbon dioxide sink“ which mitigates climate change is likely to weaken, and the greenhouse effect will be further intensified. The acidification of the oceans damages species whose shells and skeletons are composed of calcium carbonate. This affects not only coral reefs, which are considered to be hotspots of global biological diversity, but also tiny mollusks, such as the Strombidae, which are an important source of food for fish. Other species, such as jellyfish and the smallest marine algae known as „picoplankton,“ can benefit from the additional carbon dioxide in seawater.

We can expect that the composition of marine ecosystems will change dramatically and that biological diversity will decrease. The Nordic fish and seabird stocks are already endangered by climate change. In conjunction with rising temperatures, oxygen deficiency, over-fertilization, overfishing and pollution, the impact on marine food webs will become even more serious. The consequences of climate change, such as the impact of changes in oceanic circulation and the associated changes in the fishery income of coastal residents in the upwelling regions of the oceans, may lead to a worsening of economic inequality and social

conflict, poverty and hunger. Therefore, reliable research on climate change will be an ongoing need for government, business and society. Action targets for policy and society can be defined only on the basis of scientific findings and reliable forecasts.



7.4 Management of Natural Hazards

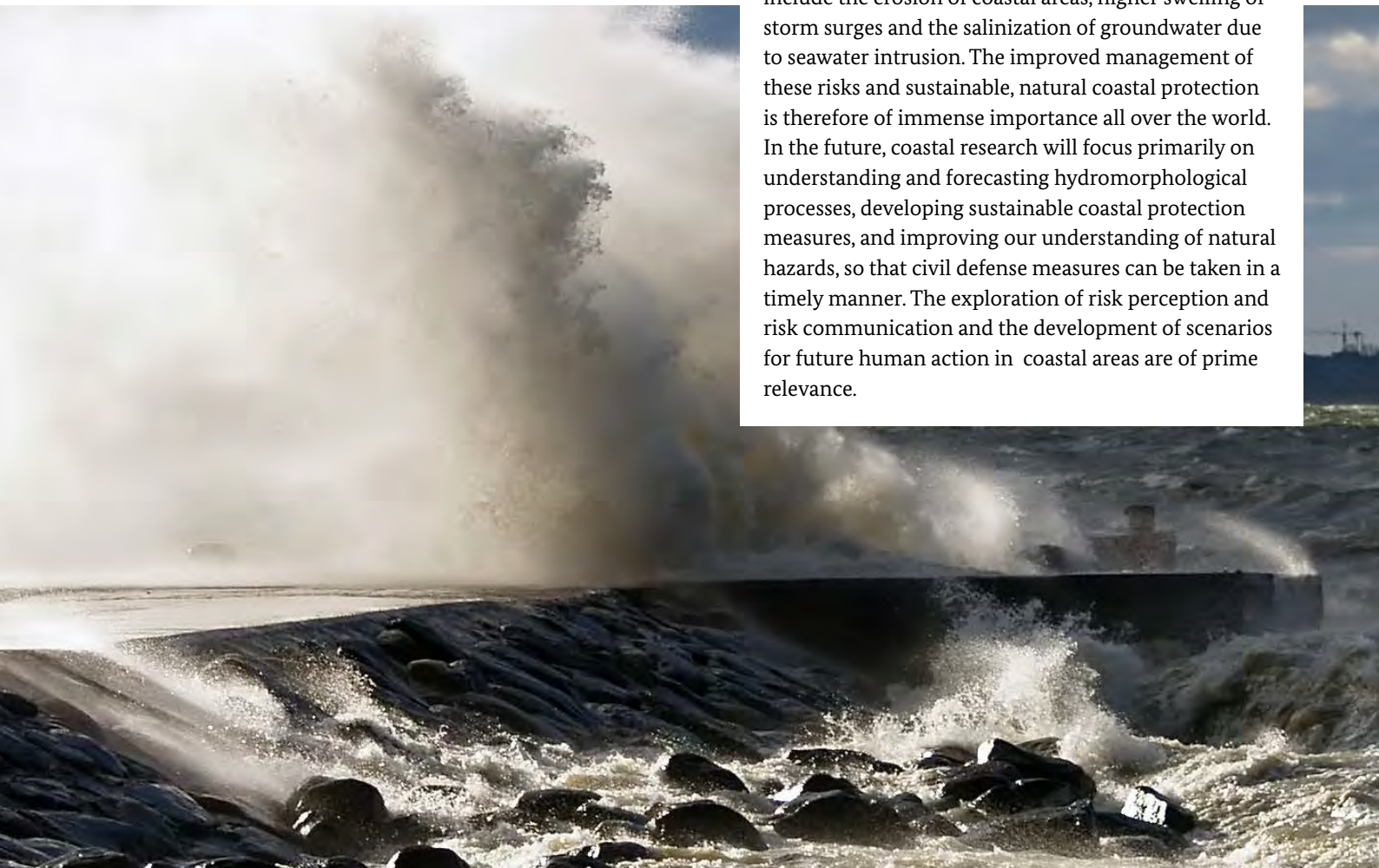
Every year, natural disasters claim human lives and cause material damage on a vast scale. Natural disasters originating in the seas (tsunamis, storm surges and coastal erosion) are caused by geological, meteorological and hydrological events, and primarily affect densely populated coastal regions. Therefore, powerful earthquakes at active continental margins have the potential to trigger enormous waves which can generate high tidal surges. The consequences of such tsunamis are often devastating, as demonstrated by the events of 2004 in Southeast Asia and of 2011 in Japan. Underwater landslides constitute another trigger for tidal waves. As the offshore industry installs increasing numbers of marine structures in shelf areas and on continental slopes, root-cause analyses and follow-up research on landslides are also becoming focal points of increasing interest.

Even though natural hazards emanating from the open seas cannot be influenced, the extent of destruction can be reduced. Therefore, subjects of future research will include an understanding of the processes involved and the development of natural disasters as well as the

development of new and improved procedures for early detection and damage analysis, and effective information systems for early warning. Major efforts have already been made to develop early warning systems in the past. Nevertheless, many regions of the world still suffer from major deficits with regard to the comprehensive civil defense. Therefore, there is still a need for research on improving the prediction of extreme natural events; this research should also take long-term changes and cascading effects into consideration.

The problems of marine geological research go hand in hand with the challenges of marine research. Consequently, interdisciplinary research approaches are of particular importance for research funding. Complementary research approaches are addressed in the Geological Research for Sustainability (Geo:N) technical program of the BMBF's FONA framework program.

Global changes, particularly climate change and its consequences, can have far-reaching effects on the protection of coastal habitats and economic zones. Not only does the rise in sea level itself represent a danger to the lower-lying coastal zones, but its consequences include the erosion of coastal areas, higher swelling of storm surges and the salinization of groundwater due to seawater intrusion. The improved management of these risks and sustainable, natural coastal protection is therefore of immense importance all over the world. In the future, coastal research will focus primarily on understanding and forecasting hydromorphological processes, developing sustainable coastal protection measures, and improving our understanding of natural hazards, so that civil defense measures can be taken in a timely manner. The exploration of risk perception and risk communication and the development of scenarios for future human action in coastal areas are of prime relevance.



Preventive Coastal Protection in the Context of International Cooperation

As part of the „International Cooperation“ Action Plan, the Federal Ministry of Education and Research also promotes innovative and sustainable coastal protection projects outside the German coastal regions. For example, cooperation with China and Southeast Asia is a focus of coastal research. The Chinese province of Shandong, with its 3,000-kilometer-long coast, has become one of the most prosperous provinces in the country over the last few decades. Settlement along the coastal strip, and thus the importance of coastal protection as well, has increased enormously. In cooperation with Chinese research centers, German researchers have logged flow data and wave heights on endangered coastal sections and calculated various scenarios for coastal development. The scenarios have been integrated into a decision-making support system. In the future, this should help to reduce the damage that is expected as a result of the projected rise in sea level and intensification of storm events.



For decades, the clear-cutting of mangrove trees on tropical coasts has been uncontrolled. As mangroves play a central role in coastal protection, reforestation of these trees is now being intensified.

Research activities involving the mangroves growing in tidal areas on tropical shores also show great success. Mangroves represent an extraordinary ecosystem which provides not only a habitat for many species of animals but natural coastal protection as well. The deeply rooted mangrove trees slow down the momentum of the rolling waves and thus protect the hinterlands from major damage. This type of natural coastal protection has declined significantly in Southeast Asia over the past decades; the trees have been used as firewood or cleared, so that the land can be used for aquaculture facilities. Meanwhile, jointly developed management plans and the integration of the population have had an effect; mangroves are being reforested in many places, and there has been a noticeable increase in understanding among the coastal inhabitants that further depletion must be prevented.

7.5 Sustainable Use of Resources

Societal demands on the resources and ecosystem services of the coasts and seas, including the deep sea and the marine polar regions, will continue to increase in scope and intensity. This always involves massive encroachment into marine habitats.

Despite great gains in knowledge regarding the functioning of marine ecosystems and their responses to changing influences, the existing knowledge is not sufficient for mapping out the extent of the changes in reliable future scenarios. This means that the prerequisite for the sustainable management of the marine environment as demanded by the EU's Integrated Maritime Policy and the EU Framework Directive on Maritime Spatial Planning, is not completely met.



The model of a wave power plant will be tested in the large wave channel of the Coastal Research Center (FZK) in Hanover.

External pressure on marine and coastal ecosystems has attained complexity due to climate change and the massive use of the coastal zone as well as the biological, mineral and energy resources; this severely complicates the investigation of cause-and-effect webs. It is also difficult to estimate the sustainable exploitation of finite resources. A scientifically sound understanding of the long-term, cumulative effects of resource use on ecosystems which can be used as a basis for decision-making must be generated in order to resolve the conflict between the demand for exploitation and the conservation of coastal and deep-sea ecosystems. Comprehensive protection of marine ecosystems will require the development of sustainable, conservative methods of exploitation as well as innovative, cost-effective systems for observation, monitoring and data acquisition, so that the effects of coastal and marine exploitation can be monitored and documented. Both should also be provided in a user-specific manner. The macrosocial discussion regarding the global use of resources in a sustainable society is also of great importance. This should include a broad discourse on the definition of sustainable use involving all stakeholders as well as an assessment of the importance and robustness of marine ecosystems and their services to humanity.

The complex relationships render our current ability to make predictions regarding the consequences of the extraction and use of marine resources inadequate. Whereas shallow coastal water areas were focal points of scientific and economic interest in the past, the exploitation of resources is increasingly shifting to the deep open sea.

The seabed and its subsoil contain mineral-based raw materials and hydrocarbons, which are of considerable importance for resource conservation in the long term. We therefore need a global inventory of the occurrence of raw materials and their quantities. New research approaches must be used to lay the foundations for risk assessments for marine resources recovery. Long-term and cumulative effects must be identified, and the development of multifactorial management concepts must be advanced. Researchers can develop the basic principles for the structuring of risk assessments and the development of legally binding regulations on environmental protection in the marine sector before marine resources, particularly mineral-based raw materials, are exploited.



Mussel harvest in Southern Chile. The traditional collection of mussels in the littoral zone is being increasingly replaced by the intensive breeding of mussels in sheltered bays with longlines.

A modified form of this can also be applied to energy resources. Renewable energies in coastal and marine areas are important areas of sustainable marine exploitation in the future. In addition to the specific economic and technological issues, the interrelationships between competing demands for space utilization must also be researched. This concerns both the conservation of ecosystems, particularly the habitats of marine mammals and sea birds, and the competing usage of the space as fishing grounds, for shipping routes, or for cultural and tourism purposes.

In a world where more than 800 million people are suffering from chronic malnutrition, fishing and aquaculture play an essential role in securing nutrition. This role, however, also includes safeguarding natural resources for future generations and thus their responsible and sustainable management. The challenges associated with fishing and aquaculture can only be solved in an international context. The importance of the climate to fish-rich upwelling areas, fishing in subpolar zones with diminishing ice cover, and the development potential of sustainable aquaculture technologies are just some examples of the scientific challenges.

International maritime transport is of enormous importance to the global economy. It will continue to grow in importance in the face of global population growth. In order to safeguard the required transport infrastructure, it is necessary to develop comprehensive strategies and measures for the sustainable use of coastal waters.

The potential of marine organisms for recyclable materials, active substances and natural fabrics has barely been investigated yet. This is a comparatively unused resource which will, however, gain importance in the future. Marine habitats are much more biologically diverse than terrestrial areas and thus offer a wider range of bioactive substances and metabolic pathways. The aim of research into marine-sourced natural fabric and active substances is to seek, isolate and describe new biotic substances which can be used in medicinal, pharmaceutical, food and material technologies.

Resource-Efficient Fisheries and Aquaculture

The sustainable use of biological resources and the preservation of biological diversity has been an international guideline for the development of marine environmental and resource policy since the United Nations Conference on Environment and Development in Rio de Janeiro in 1992.

In order to protect and sustainably exploit natural fish stocks in the long term, the entire ecosystem needs to be taken into account, for example by accurately recording the bycatch. This is the only way to make reliable statements about the impact of fishing on the oceans.

More than 190 million tons of fish, seafood and algae were harvested in 2013. The classic marine resource is the fishing of wild stocks. There are 30,000 species of fish in the world, but only a fraction of them are commercially exploited. Nearly 30 percent of the fish stocks are overfished, with more than 60 percent being exploited to their maximum threshold. Aquaculture has only been around for the last few decades, but it already contributes to more than half of the annual harvest. The management of this resource, which accounts for the employment of nearly a tenth of the world's population, is of high priority and can only be implemented in an international context.

Aquaculture-specific research needs: As with factory farming, for example, it is possible to achieve optimal results which are compatible with animal welfare, such as reducing water pollution resulting from additional nutrient input, or preventing the destruction of natural habitats by aquaculture. One example of this is the clear-cutting of most of the mangrove stocks in order to make room for shrimp farming. In Germany, more than 80 percent of the fish are imported, and aquaculture has only limited growth potential compared to many other countries. The idea of sustainability must therefore not stop at national borders.



Plaice (*Pleuronectes platessa*) is the most famous and most important representative of the flatfish in the German coastal waters.

7.6 Governance and Participation

The conflict between the principles „mare liberum“ (the sea belongs to all) and „mare clausum“ (the sea belongs to the coastal states) can be overcome only by means of binding international agreements and voluntary obligations. The United Nations Convention on the Law of the Sea (UNCLOS) is the most important international legal basis for the protection and use of the world's oceans and is also referred to as the „Constitution of the Seas.“ Large areas of the oceans are massively overfished, heavily polluted, and increasingly exploited as the last great source of resources on the Earth. If no universal agreements are made for their protection, irreversible damages can be expected: We can ensure sustainable exploitation of the oceans only by providing long-term protection for them. The use of tools from governance and participation plays an essential role.

Governance generally refers to the system of control and regulation in complex social structures. In addition to federal governments, various private and public stakeholders (for example, companies, interest groups, organizations, and associations) are involved in a society and work through formal and informal networks. Governance also includes the cooperation of nations in the regulation of common interests, such as on the high seas or in Antarctica. Participation is understood as the involvement of citizens and civil society organizations in decision-making and policy-forming processes. Citizens are showing a growing interest in participation, primarily as a result of digitalization, demographic change, a more diverse society and new living and working habits.



Society and Policy Declare War on Garbage in the Sea

The oceans are being increasingly polluted with PET bottles, plastic fibers and fish netting. Persistent plastic residues accumulate as macro- and microparticles in giant garbage vortexes, in deep sea sediments, and on beaches – and remain there for several hundred years. How big is our „plastic footprint“ in the oceans? What are the implications of the plastic particles for humans and animals? There are no comprehensive answers to these questions yet.



Every year, millions of tons of plastic waste end up in the seas. Joint initiatives to collect garbage after it washes up on the beach are sensitizing people to the problem.

During the fall of 2015, under the German Presidency, the G7 Ministers of Science agreed to work together on international research projects and initiatives to counter marine pollution. An intergovernmental pilot program in the JPI Oceans program under the auspices of the German Federal Ministry of Education and Research is addressing the impact of microplastics on the marine environment and developing internationally standardized analytic methods. On a national level, the interdisciplinary tender „Plastics in the Environment“ has been initiated: It is aimed at investigating consumer behavior, the introduction of plastic via land and rivers, and the effects on coasts and seas.

There has already been some success in countering pollution in the seas, for example ships are not allowed to dispose of their plastic waste in the sea thanks to international, legally binding regulations; however, the “oceanic garbage dump“ shows that intensive cooperation among research facilities, corporations, government and society is required. Common solutions must be found to avoid plastic waste, for example, by avoiding the use of plastic, improving recycling programs and developing fully biodegradable plastics. The task of the scientific community is to share existing knowledge in a dialogue with citizens and to raise awareness of the problem in society; that of government is to submit recommendations for action and develop innovative and sustainable products in cooperation with industry. Effective marine protection will not be achieved solely by means of a broad information policy, but will require the involvement and participation of a wider segment of the population. Marine research makes use of the great potential of participatory governance in order to preserve the oceans as the basis for life.

The sea, as the collective inheritance of mankind, belongs to all human beings as a global public good. For international environmental policy, this means that the Earth's natural resources must be protected so that they can be available to future generations.

The conflicts associated with climate change and the increasing use of marine resources therefore require solutions based on a broad societal consensus. The business models of the maritime industry in fisheries, shipping or the mining of mineral resources are often

geared towards short-term benefits and need to focus more on sustainability aspects in the future. The consideration and weighing of the different interests and responsibilities require interdisciplinary and transdisciplinary research approaches involving the social sciences. Control mechanisms can function sustainably only if they are legitimized by means of participatory processes involving the respective stakeholders. It is therefore important to actively involve citizens in participation processes as well as appropriate monitoring and assessment tasks, so that knowledge can be jointly

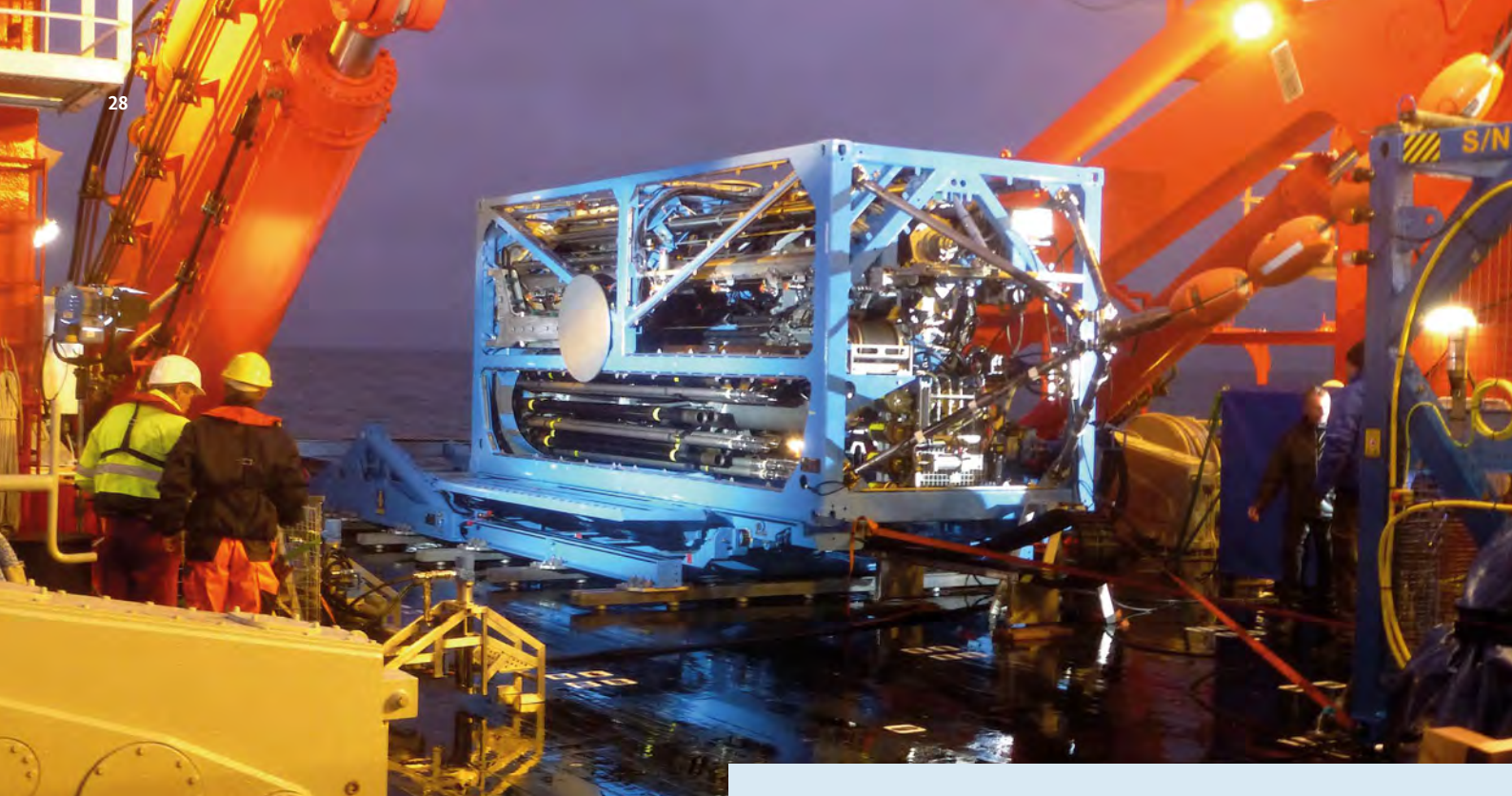


developed at local, regional and global levels and contribute to the shaping of opinions.

In this context, coastal, marine and polar research can make significant contributions to the development of national and international policies. Changing conditions such as access to new resources in the Arctic due to melting ice masses can create conflicts that have not been negotiated in existing intergovernmental agreements.

An important issue for MARE:N is to consider the principles of information, communication and participation right in the development of funding priorities and implement them consistently in the funding activities. This means that, with a systemic approach to research, these principles should not be considered as isolated components of scientific research. This should contribute to an increased acceptance and appreciation of marine ecosystem services by society, government and business and improve the chances for their conservation and protection.





8. Research Infrastructure

Researching the processes occurring in the coastal, oceanic and polar regions, which are highly variable both temporally and spatially, as well as the reciprocal interactions of these processes and their interactions with the cryosphere, lithosphere and atmosphere, is a major logistical challenge and will place enormous demands on the research infrastructure.

Scientists will need specialized measuring instruments supported by powerful observation platforms in order to record the processes. Some examples include satellites for global observation of the surface of the ocean, modern research vessels, and autonomously operating platforms or equipment carriers on the sea surface, in the water body or on the seabed.

Numerical process simulation, which is based on an internationally networked computing infrastructure, has also turned out to be an equally indispensable tool. This infrastructure includes state-of-the-art global data repositories for the retention of data and network structures for data distribution. These are essential for the timely exchange of data and information within the international scientific community.

The two components, the observational coastal, marine and polar research and the theoretical process simulation, cannot be viewed in isolation within the iterative cognitive process. The infrastructure for both components

must be available on a long-term basis, so that efficient coastal, marine and polar research can continue into the future. In view of the high development and operating costs, the resources must be bundled and effectively used. This is all the more important when it comes to establishing and managing national and international pools of research vessels, underwater vehicles and observatories.

8.1 Research Fleet and Large-Scale Facilities

Despite advances in the development of autonomous measurement systems, research vessels will continue to be important platforms for the global exploration and monitoring of the oceans and their margins. With research vessels operating around the world, including the ice-breaker, POLARSTERN, German marine researchers have high-performance vessels equipped for a wide range of research tasks at their disposal. The Federal Ministry of Education and Research will gradually renew the German research fleet with the construction of three research vessels. Commissioned in 2014, the research vessel SONNE was the first of the three newly-constructed vessels. One of the world's most capable research vessels has thus been dedicated to science. The replacements for the research vessels POLARSTERN and METEOR and POSEIDON will follow during the coming years.

In addition to the ships, there are a number of other infrastructural components as well as large-scale research facilities. Among these are the Antarctic research stations Neumayer III, GARS-O'Higgins and Kohnen, which operate year-round, the AWIPEV Arctic research base on Spitzbergen, and the Mindelo Ocean Science Center in the Cape Verde Islands off West Africa. New generations of satellites with complex sensor equipment are increasingly being viewed as research units. Due to the potential for obtaining data in high temporal density and over a large spatial extent, satellites with their ground-based infrastructures form an integral part of the global earth and ocean observation system. For example, in conjunction with the GARS Antarctic station, satellite technology facilitates long-term geodetic observations.

In addition to the satellite-based observation systems, German coastal, marine and polar research has been equipped with the research aircraft POLAR 5 and POLAR 6 on platforms equipped with state-of-the-art measuring equipment, particularly for ice-covered areas. The data collected are primarily used in geophysical, glaciological and oceanographic studies.

In the past few years, underwater vehicles which are becoming increasingly autonomous (AUV – Autonomous Underwater Vehicle) and cable-bound underwater vehicles (ROV – Remotely Operated Vehicle) have been used to investigate areas which are difficult to access, for example under the ice or in deep sea areas. AUVs and ROVs are also used to build integrated long-term ocean observation systems. A rapidly-growing fleet of mobile platforms, such as the approximately 3,000 Argo drifters, remote-controlled gliders and flight drones, extend the possibilities of cost-effective, long-term observations in the open ocean and in coastal areas.

The remote-controlled, deep-sea drill rigs MeBo70 and MeBo200, which were developed by BMBF at the University of Bremen, are in operation throughout the world. Due to their specific drilling parameters and the resulting diverse range of application, they are among the world's most cutting-edge technologies used for the extraction of undersea sediment drill cores.



The manned underwater vehicle JAGO can dive to depths of up to 400 meters. It is used for the exploration and research of aquatic systems and habitats.

Research Infrastructures - Deployment in Snow and Ice

Polar research focuses on the interactions of the cryosphere, hydrosphere and atmosphere, climate and ecosystem research and the conservation and protection of sensitive ecosystems. The polar regions can be explored only with the aid of high-performance platforms adapted to specific requirements. The ice-breaker POLARSTERN, which serves as a research and supply vessel, fulfills many different functions in this respect. It supplies the Neumayer Station III in the Antarctic and the Koldewey Station in the Arctic. Fifty-five researchers can work on board in nine scientific laboratories on biological, geological and geophysical as well as glacial, chemical, oceanographic and meteorological issues. Two helicopters are available on board.



The use of research aircraft is indispensable for scientific work in the often inaccessible, ice-covered areas of the Arctic and Antarctic.

For longer measurement campaigns, the German aircraft, POLAR 5 and POLAR 6, can transport nine persons. The traditional design of the POLAR 5, designed in 1942 (it is riveted and not glued) allows repairs, even on site. Extensive conversions have provided all the necessary functions for use in extreme environmental conditions; it has been used as a research aircraft since 2009. With the aid of combined ski and wheel-type landing gear, the aircraft can take off and land on concrete, gravel and snow runways. De-icing systems, heating mats for batteries and engines, as well as polar-capable navigation systems complement the special equipment and enable landings under very difficult weather conditions and in extreme temperatures of up to -54 degrees Celsius. There are also various scientific devices on board, which are installed separately, depending on the purpose of the flight. This enables the use, for example, of an ice thickness probe which is otherwise towed by a helicopter. The larger range of the aircraft compared to helicopters enables an extensive inventory of the ice volume, which plays an important role in the global climate system.

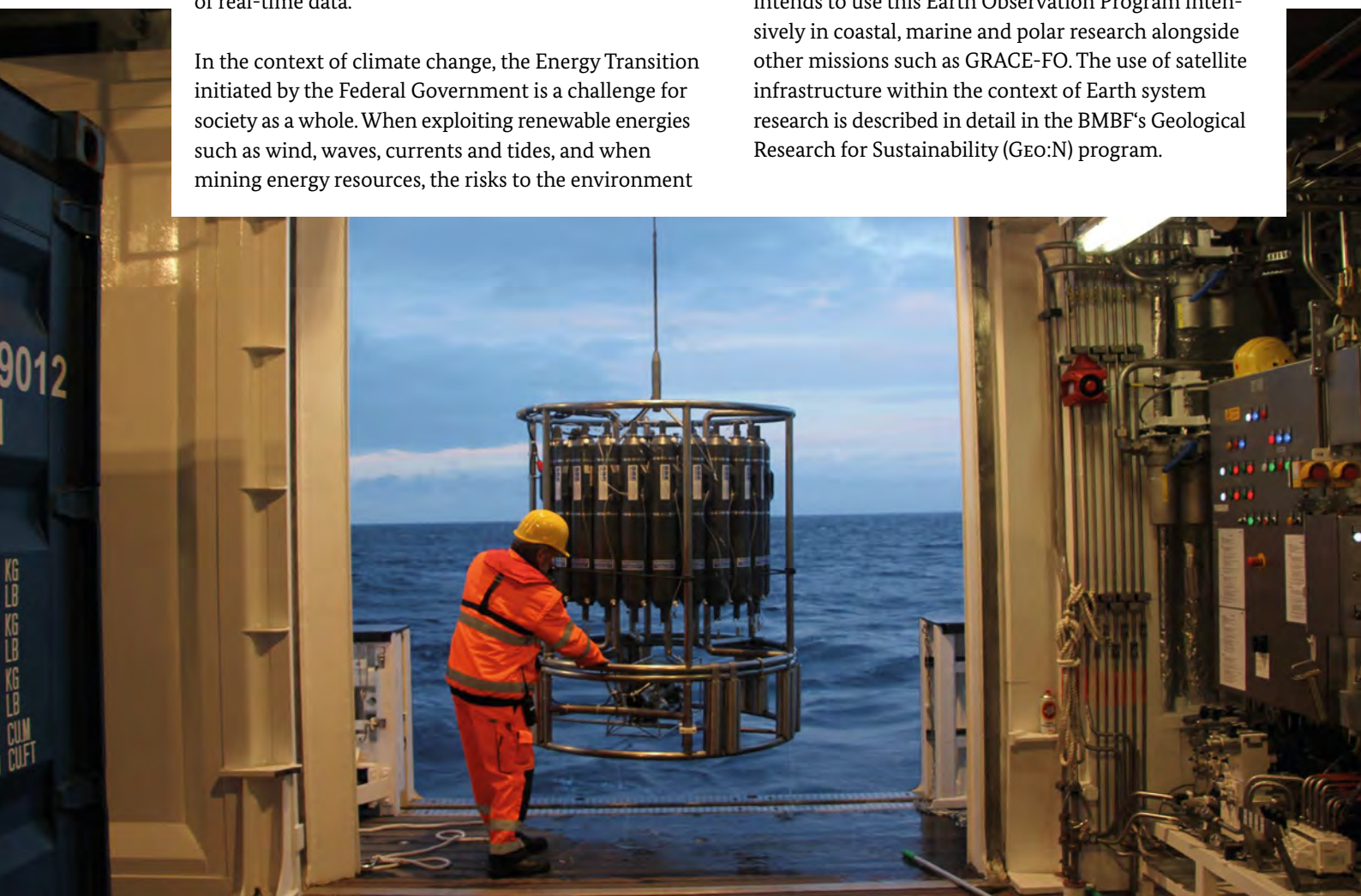
8.2 Measurement and Observation Technology

In addition to the research vessels, autonomously and interactively operated measuring system carriers are gaining in importance for the collection of physical, geochemical and biological parameters. The development and operation of new generations of carrier and measurement systems have become possible as a result of rapid technological progress in material and energy research, data storage and telecommunications and other technological areas. These can be firmly anchored or attached to mobile platforms in the sea or satellite systems in space with which long-term observation programs are carried out. Sensor systems on board autonomously-operating or remote-controlled underwater vehicles are becoming increasingly important for the collection of real-time data.

In the context of climate change, the Energy Transition initiated by the Federal Government is a challenge for society as a whole. When exploiting renewable energies such as wind, waves, currents and tides, and when mining energy resources, the risks to the environment

and people must be kept as low as possible. This will require environmental monitoring based on a technical system in the close and immediate vicinities of the relevant installations.

In the future, new marine measurement technologies and systems will have to meet the ever-increasing demands of accuracy, reliability, stability and continually-increasing data density. The use of satellite technology is of great importance. Satellite systems are now important sources of information for research on coastal, oceanic and atmospheric processes. The EU's COPERNICUS Earth Observation Program, with its services for monitoring the marine environment and climate change, is an essential tool for global, high-resolution, spatially-comprehensive measurement aimed at world-wide observation of the Earth. The Federal Government intends to use this Earth Observation Program intensively in coastal, marine and polar research alongside other missions such as GRACE-FO. The use of satellite infrastructure within the context of Earth system research is described in detail in the BMBF's Geological Research for Sustainability (Geo:N) program.



A rosette water sampler with sample material from various water depths is taken on board the research vessel SONNE.



Geodesists of the Federal Agency for Cartography and Geodesy are observed by a seal in the mud flats while measuring the Earth's gravitational field.

8.3 Data and Information Infrastructure

The rapid development of measurement, information and storage technology in recent years has opened up new possibilities and led to a large increase in the number of observations. This is true for short-term point measurements as well as long-term and continuous time series, which are of growing importance particularly for environmental and climate research. Thanks to global communications technology, this information is already available almost in real time. The operational provision of collected data is becoming increasingly important for a number of applications relevant to science, government and business. Often, only a few hours elapse from the time the Earth observation data are collected, to the time they undergo quality control and operational processing in a wide range of applications.

In addition to the data centers of the scientific facilities, various data management centers are operated in Germany. In this context, the Data Publisher for Earth

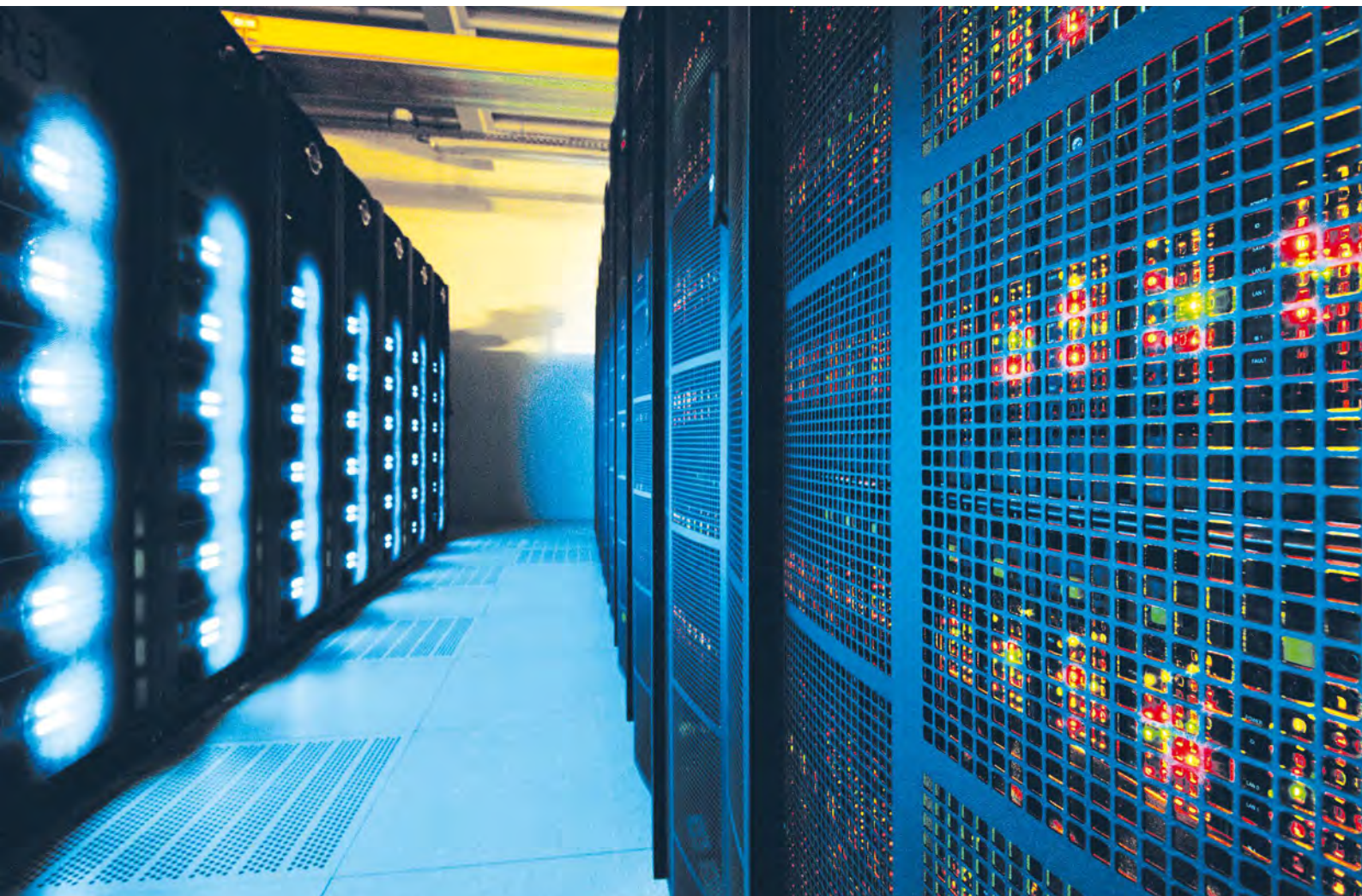
and Environmental Science (PANGAEA) is a key component in the archiving and communication of data on marine environmental observations due to its importance as a world data center.

One of the most urgent tasks is to sustainably secure the existing structures in the sense of a national data and communications infrastructure in the long term and to upgrade them for the growing volumes of data. In the context of European and national data policy, as manifested in the INSPIRE Directive (INSPIRE: Infrastructure for Spatial Information) and particularly in the IMAGI decisions (IMAGI: Interministerial Committee for Geoinformation), this must be done in order to connect the scientific data to the national Geodata Infrastructure (GDI-DE). This will ensure that these data are available in the long term for future social, administrative and economic tasks. The Federal Government considers the implementation of both the European data policy and the open data policy in research funding to be an important task.

8.4 Modeling Infrastructure

Modern marine research is increasingly characterized by an iterative process of observation and modeling as, due to the enormous spatial dimensions of the world's oceans, the ongoing processes cannot be fully recorded. The goal is to map the observed conditions in numerical models and to analyze and understand them as well as possible in order to ultimately make predictions regarding individual processes or global relationships. The continuous refinement of the models, both methodologically and numerically, requires not only the development of new theoretical concepts and new numerical solution algorithms but also an understanding of the deficits of existing models as well as the incorporation of comprehensive observation and measurement data.

Therefore, adequate computing technology infrastructure is of crucial importance for future research. Hubs such as these are available with the high-performance computers in Jülich, Munich, Hamburg, Stuttgart, Berlin and Hanover. Despite enormous advances in performance, large computers remain the limiting factor for implementing complex models or coupled model systems. In order to remain internationally competitive in this sector, coastal, marine and polar research requires access to modern computer infrastructure at the highest technical level.



With "Mistral," the German Climate Computing Center in Hamburg has one of the most powerful and energy-efficient high-performance computers in the world.



9. Innovative Technologies

In addition to the relevance of the oceans and poles as climatic factors and the coastal regions as settlement areas, the marine area is becoming an increasingly significant economic area and an important source of resources. This will escalate the urgency of protecting oceans and marginal seas, for which innovative technologies must be developed. They are necessary for measurement and monitoring, the exploration and exploitation of resources, energy production, sustainable fishing, aquaculture and mariculture. It is important that these technologies be geared toward the demands of sustainable environmental protection and economic and social interests.

The development of autonomous sensor and data transmission systems is a trend that must be further supported. Another task for future research is the development of sensors for the direct and selective determination of new parameters. Instrumentation will require additional improvement with regard to features such as stable, long-term behavior, reliability, freedom of maintenance and energy efficiency. New accumulators with considerably greater energy densities are also desirable.

It is already possible to use networked systems of autonomously operating robots for various measurement, sampling and experimentation tasks in deep-sea and the seafloor exploration.

Systems such as these must be expanded further in the future, as these types of supply nodes, in addition to being used for deep-sea research and environmental monitoring, serve as development and testing fields for deep-sea technology used in business and industry.

The provision of modern, innovative measuring and observation technology presents a great challenge for science as well as for the maritime industry. The technological fields which are relevant now and which will be relevant in the future are defined in the 2025 Maritime Agenda of the Federal Ministry of Economic Affairs and Energy. Close coordination and cooperation will be necessary in order to effectively and purposefully use the existing resources of all the ministries.

Economic areas such as maritime measurement and environmental technology, coastal engineering, coastal protection, aquaculture, mariculture, and resource exploration will benefit from modern, efficient, scientific maritime research. In return, the marine sciences can act only with the aid of a powerful maritime economic sector. The aim is to support the close cooperation between research institutes, authorities and small to medium-sized enterprises which has developed over the past decades.



10. Implementation of the Research Program

10.1 Funding Agencies, Project Structure and Funding Level

The Federal Government Research Program is aimed at university and extra-university research institutions as well as commercial enterprises.

The central instrument of research funding is the financial support of interdisciplinary and transdisciplinary research and development (R&D) projects.

Research facilities funded jointly by the Federal Government and the federal states may receive project-related funding for the additional expenses they incur only under certain circumstances, as a supplement to their basic funding. Extra-university research institutions receiving basic funding are expected to closely interlink their institutionally funded research activities with the activities in the project grant.

The work of industrial partners within joint projects should be restricted to pre-competitive areas and go well beyond individual economic interests. A project's focus on implementation should be documented as part of the application by means of an exploitation plan, which should be updated during the project's runtime.

The level of funding is dependent on the R&D intensity of the work and will be determined according to the definitions of the EU's Framework for State Aid for the Promotion of Research, Development and Innovation (Official Journal C 198/01 of 06/27/2014).

Commercial enterprises are required to contribute appropriately to the resulting eligible costs. Additionally, in the context of industrial collaborative projects, commercial enterprises are expected to contribute adequately, in accordance with their capacity, to the expenses of universities and publicly funded research facilities, provided that the latter cooperate as joint partners.



A rosette water sampler with sample material from various water depths is taken on board the research vessel SONNE.



10.2 Selection Procedures and Funding Regulations

As a rule, topics which have been identified for project funding will be published in the form of announcements in the Federal Gazette. The funding modalities and funding regulations will be specified in the respective announcement.

Priority will be given to application procedures which limit the administrative burden on applicants and speed up the decision-making process. The submitted projects will be in competition with one another. The BMBF and the commissioned funding agency reserve the right to consult independent national and international experts and, if appropriate, expert committees, when selecting the project proposals to be supported. The criteria underlying the evaluation and selection will be published in the announcement for the respective call.

Funding is subject to the principles of the Federal Ministry of Education and Research. The provisions for the allocation of expenditure-based or cost-based grants are available on the federal government's funding portal <https://foerderportal.bund.de/>.

10.3 Evaluation

The orientation of the research program as an open, adaptive operational framework is subject to constant adjustment and further development which is supported and promoted by the agenda processes described in Chapter 5 and by the stakeholders involved in them. The tailored orientation of the research content is therefore closely linked to the evaluation of individual calls and the overall research program. Ex-post and interim evaluations are intended to assess both the impact and effectiveness of research funding as well as to ensure the strategically sound adaptation of the objectives and funding conditions.



11. Further information and contact

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