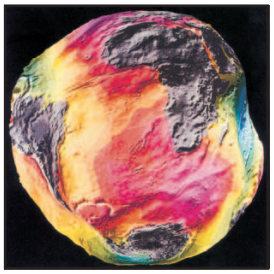

Research Field

Earth and Environment

Programme Proposal 3

Marine, Coastal and Polar Systems

Participating Helmholtz-Centres

AWI	**AWI**	Alfred-Wegener-Institut für Polar- und Meeresforschung
GKSS Forschungszentrum	**GKSS**	Forschungszentrum Geesthacht GmbH
DLR	**DLR**	Deutsches Zentrum für Luft- und Raumfahrt e.V. (associated)
GFZ Potsdam	**GFZ**	GeoForschungsZentrum Potsdam (associated)

Co-ordinating Centre

AWI Alfred-Wegener-Institut
für Polar- und Meeresforschung

HELMHOLTZ GEMEINSCHAFT

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I The Helmholtz Research Field ”Earth and Environment”

Global Change and **Sustainable Development**, both universal keywords at the beginning of the 21st century, describe the societal hopes and fears of the future, the immediate economic and technological challenges and present requirements for environmental research. During the past century a boundary has been crossed when ”non-natural” processes have begun to influence life on earth at a global scale. Population increase and the development of technologies to sustain this population are responsible for the exhaustive use of non-renewable resources or the perceived threat to climatic and ecological stability.

The quest for a *sustainable development* of human society is closely associated with these ”non-natural” changes, but the concept – usually defined by equity arguments concerning present and future generations including the ecological, economic and social dimension of society – still needs clarification in order to be made operable.

The definition of the upcoming tasks, the identification of knowledge gaps and the development of solutions for the Grand Challenges ahead of us require a significant advance in understanding the functionality of the Earth system and the interconnections between society and nature. Actual environmental and resource problems have to be defined in scope, priority and character, so that technological and political efforts can be directed effectively. The actions require a knowledge-based platform in the political arena, to which the R&D of the Helmholtz Research Field ”Earth and Environment” contributes. The synergetic combination of expertise and viewpoints from the natural sciences, the earth sciences, the social sciences, the medical sciences and engineering is urgently asked for.

Various national and international bodies have defined **GRAND CHALLENGES** for a sustainable future human society on earth, which the research activities in the Helmholtz Research Field "Earth and Environment" address:

- **EARTH DYNAMICS and RISKS**
- **CLIMATE VARIABILITY and CLIMATE CHANGE**
- **WATER**
- **BIODIVERSITY – ECOLOGICAL STABILITY**
- **SUSTAINABLE USE OF RESOURCES**
- **THE SOCIO-POLITICAL DIMENSION OF GLOBAL CHANGE.**

Understanding the implications of far-reaching, complex changes of the earth and the environment to a degree that allows the provision of guidance to policy-makers and the public is a daunting task. Nevertheless, the Helmholtz Centres participating in the Research Field ”Earth and Environment” are prepared to tackle the Grand Challenges. None of these challenges can, however, be dealt with on its own since all are interconnected. For instance, a R&D programme on climate variability will only have socio-political impact if the chemical, biological and societal consequences are taken into consideration; a biodiversity programme must consider land use and economics as well as geological aspects.

The research co-operation is not restricted to the Research Field ”Earth and Environment” but also includes the participation of other Research Fields such as ”Health” and "Traffic and Space". In the former, the influence of environmental impacts on human health are being studied, whereas in the latter satellite imagery and satellite modelling are of particular importance. In addition, the research activities attain strong international or even global levels of co-operation, signifying also that not all research planned can be Helmholtz defined.

The relation between the Grand Challenges and the programmes is summarised in Fig. 1. (different shades of colour symbolising the depth of involvement – darker = higher)

Grand Challenges	Progr. **P1**	Progr. **P2**	Progr. **P3**	Progr. **P4**	Progr. **P5**	Progr. **P6**
Earth Dynamics and Risks						
Climate Variability						
Water						
Sustainable Resources						
Biodiversity						
Socio-political Dimension						

Fig. 1 Relation between Grand Challenges and Programmes 1 – 6 of the Research Field ”Earth and Environment”

Programme 1 ”Geosystem: The Changing Earth” aims at understanding global processes and the interaction between geosphere, atmosphere and hydrosphere as a precondition for future prosper life on our dynamic planet. The focus will be to reveal and model relevant geoprocesses, to monitor the status and trends of the system Earth (including paleoclimatology), to determine the physical / chemical limits of critical conditions, as well as long-term monitoring of global and regional variations. For this reason a large-scale Earth science infrastructure will integrate near-Earth satellites, air-borne sensing systems, a global network of permanent geophysical and geodetic stations, mobile instrument arrays as well as integrated analytical and experimental facilities. Focal aspects will be the gravity and magnetic fields of the Earth, natural resources and material transfer, climate variability and human environment, geo-hazards and risk reduction strategies as well as the utilization of the subsurface. The programme takes part in developing solutions for Grand Challenges like ”Earth Dynamics and Risks”, ”Climate Variability and Climate Change” or ”Water”.

Programme 2 ”Atmosphere and Climate”: The atmosphere determines to a large degree the environmental conditions on earth. Programme 2 focuses on analysing the atmosphere and its changes considering the complex interactions within the atmosphere and the exchange processes with adjacent compartments, e.g. with the biosphere. The impact of

human activities on the chemical composition of the atmosphere and hence on climate is investigated. Dynamical, chemical and microphysical processes as well as related feedback mechanism are studied in order to improve the predictability of global and regional climate change. Large-scale international experiments are planned and novel satellite (ENVISAT) data are used for the various scientific projects. Programme 2 will contribute essentially to the Grand Challenges ”Climate Variability and Climate Change”, ”Water” and to a lesser degree ”Earth Dynamics and Risks”.

Programme 3 ”Marine, Coastal and Polar Systems” investigates the physical, biological and geo-scientific base of global marine systems including coastal regions and, with special emphasis, the polar regions. Processes and interactions, occurring in these systems, play central roles for global climate and hence for environmental change. For this reason, the actual changes in key regions and the responsible processes as well as global changes documented in specific archives are focal points of interest. As major goal it is envisaged to develop a model system with predictive capability which includes the interactions between the cryosphere, the oceans and the marine bio- and geo-chemosphere and quantifies the impact of these regimes on climate, flow of energy and matter and biodiversity on various spatial and temporal scales. Based on this understanding, the second goal is to develop scenarios for the management and sustainable utilisation of the marine environment, in particular of the coastal zones.

Programme 4 ”Biogeosystems: Dynamics, Adaptation and Adjustment” focuses on the dynamics, the interaction and the adaptation of key compartments in biogeosystems to human activities and environmental changes. Agricultural systems with their compartments soil, water, plants and air will be in the focus, but also crops in forest and agroforestry systems and their interaction with the environment will be taken into account. The programme aims for an analysis of sensitivity of the response of these essential components to environmental and human-induced changes. The identified sensitivities, concepts and methods provide a profound basis to correct and adjust negative and non-sustainable developments in biogeosystems. Key research topics are the maintenance and control of soil functions and functional biodiversity and genetic resources in soils and plants. By this means programme 4 will contribute to developing concepts and strategies for protection, restoration and sustainable use of biogeosystems including the natural resources soil, water and plants.

Programme 5 ”Sustainable Use of Landscapes” analyses the influence of human activities on environmental resources in landscapes, focusing on a regional (landscape) scale, with a strong emphasis on interdisciplinary research bridging natural and social sciences. The problem-oriented programme concentrates its attention on two different yet often intertwined landscape types: densely settled areas with a strong human 'footprint', such as urban agglomerations, large contaminated areas or mining landscapes, on the one hand, and semi-natural landscapes with a special but non-exclusive focus on arid and semiarid environments on the other hand. The questions and challenges addressed include those of biodiversity and ecological stability, of the protection of water resources ranging from their availability and management to remediation technologies for large contaminated water bodies, of the consequences of climate change on land use and of socio-economic and legal conflicts.

In **Programme 6 ”Sustainable Development and Technology”** innovative technological development and research focus on Grand Challenges such as ”Sustainable Use of Resources", ”Water” and ”Socio-political Dimension of Global Change”. Technological innovations permitting the sustainable use of resources, offering solutions for reducing emissions from material fluxes and allowing for regeneration of natural resources will provide relevant contributions to sustainable development. These technologies are

developed following an integrated approach including technology assessment and socio-economic research. This approach enables – in cooperation with other Research Fields and programmes of the Helmholtz Association – advising politics and society by elaborating integrated strategies towards sustainable development.

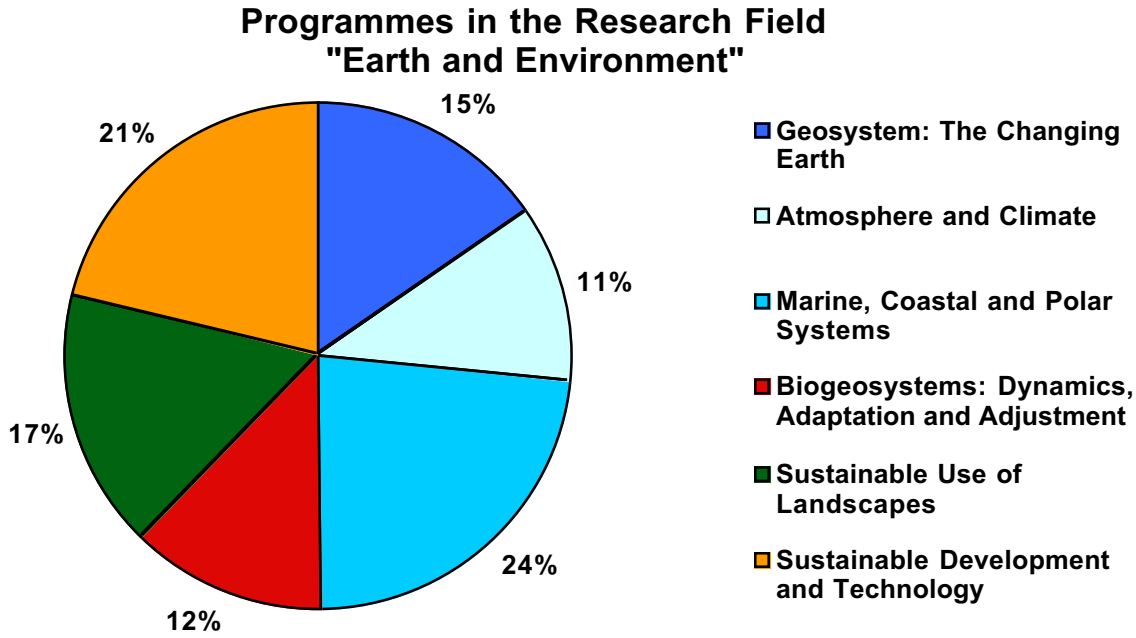


Fig. 2 Personnel Resources in the Research Field "Earth and Environment"
Distribution among Programmes
Basis: circa 9400 person years, 2004-2008, cumulative)

Participating Helmholtz-Centres

Alfred-Wegener-Institut für Polar- und Meeresforschung (AWI)
Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR) (associated)
Forschungszentrum Jülich GmbH (FZJ)
Forschungszentrum Karlsruhe GmbH (FZK)
Gesellschaft für Biotechnologische Forschung mbH (GBF)
GeoForschungsZentrum Potsdam (GFZ)
GKSS - Forschungszentrum Geesthacht (GKSS)
GSF - Forschungszentrum für Umwelt und Gesundheit (GSF)
UFZ - Umweltforschungszentrum Leipzig-Halle GmbH (UFZ)

2 Programme 3: Marine, Coastal and Polar Systems
(Programme Spokesman: Prof. Dr. Heinz Miller)

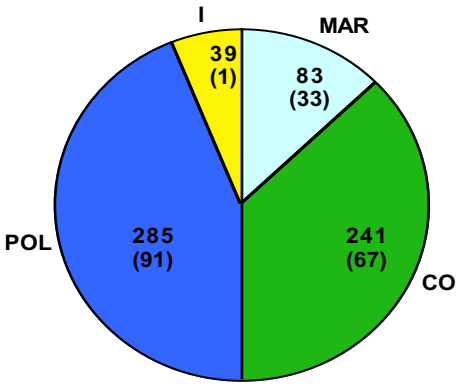
Introduction
The world's oceans cover about 70% of the surface of the earth and, not surprisingly, play a key role in regulating the planetary environment. They are home to rich life with high diversity and productivity and, together with their coastal and polar regions, offer humankind bountiful living and non-living resources. They also carry or impede marine traffic, which is imperative for the global exchange of goods, and they act as sinks, but also sources for many natural and anthropogenic substances which characterize our environment.

Human activities are mainly concentrated in shallow shelf and coastal areas resulting in conflicting interests between fisheries, extraction of mineral resources and marine natural products, the use for energy production and utilization as recreational areas, and conservation of habitats and ecosystems. Sustainable use, therefore, has to be based on an understanding of the structuring forces that underlie these systems which in turn requires a comprehensive investigation of interacting physical, chemical, biological and geological factors across the entire gamut of space and time scales.

The polar regions play a special role within the earth system. They are characterized by very low temperatures, marked seasonality, huge continental ice shields, large oceanic areas permanently or seasonally covered by sea ice, massive and deep reaching permafrost layers. The polar regions react sensitively to climate change on the one hand but on the other they govern global climate evolution on a broad range of time scales and directly influence global sea level change and hence impact on coastal regions. Due to extremely long recovery cycles polar ecosystems are highly susceptible to perturbation.

The open oceans, coastal areas and polar regions are systems linked by a large number of processes and interdependencies. Each, however, poses its own very special challenge, emanating from its unique environment and role within the Earth System, which needs to be met individually. This programme, therefore, is divided into three research topics with a fourth topic on the infrastructure required for reaching the envisaged goals. They are:

- Ocean and Global Climate (**MAR**)
- Coastal Areas (**CO**)
- Polar Regions (**POL**)
- Infrastructure (**I**)



Distribution of person-years on programme topics (2002). Third party funded person-years in parentheses.

Total: 648 (192) person-years

Objectives
The Helmholtz-Programme “MARCOPOLI” aims at developing the scientific base for the assessment of observed environmental change as well as sustainable ecosystem utilization, by investigating the multiple physical, chemical, biological and geological interactions within the marine and associated terrestrial systems and by quantifying their interaction with other compartments of the earth system. Central to the programme will be research for deciphering processes in the polar regions relevant to global climate, their coupling to lower latitudes and their variability in space and time by observation and modelling of the past and present. Furthermore the programme aims at the scientific evaluation of possible impacts of observed and expected changes by assessing scenarios of future developments in the Earth system. These goals require a wide range of long term in-situ and remote sensing observations, as well as regional and global modelling and a high degree of multidisciplinarity. Whenever our accumulated understanding leads to reliable assessments, these findings are to be used in management and monitoring of marine and associated ecosystems. Examples are sustainable use of coastal regions, enhancement of coastal protection and safety issues of marine traffic, offshore industries as well as marine nature conservation.

The following objectives reflect the collaborative efforts of the contributing scientists who cover many different scientific disciplines:

To investigate the oceans’ role in global climate processes and change by

- Synthesis of data and models of varying complexity
- Bridging the gaps between physical and biological sciences
- Modelling marine biogeochemistry including the functional role of organisms
- Reconstructing global climate since the Cenozoic

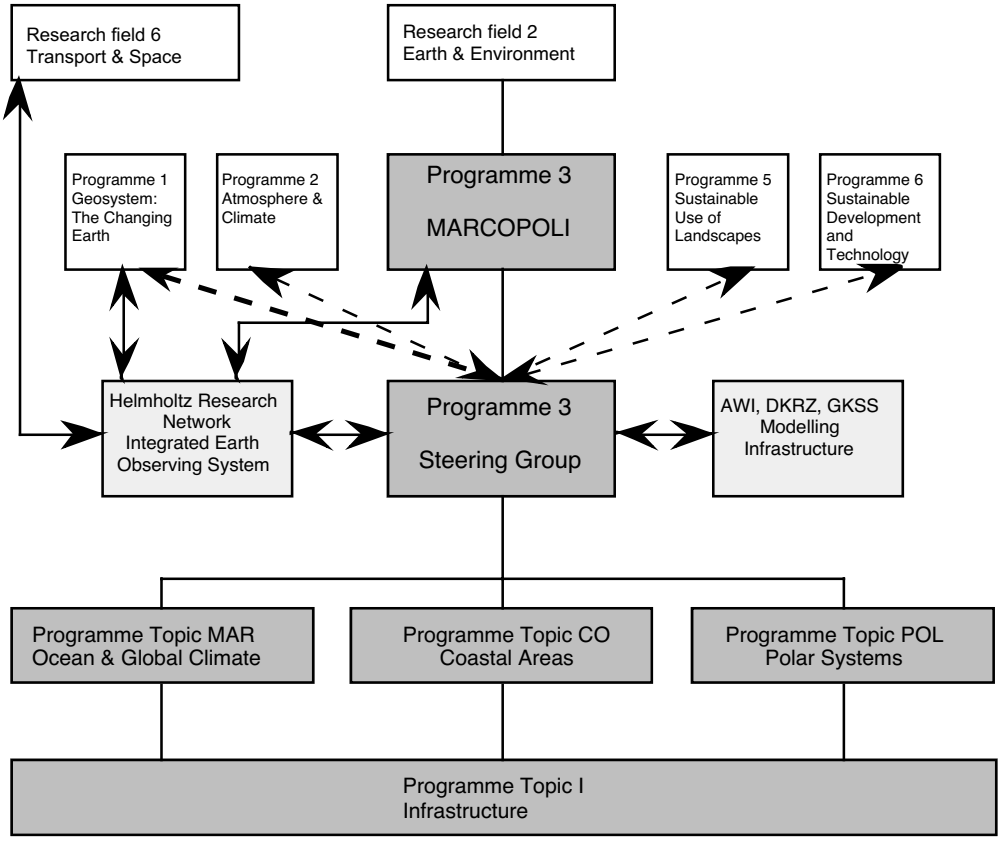
To evaluate natural and anthropogenic processes within coastal regions and define knowledge based management tools by

- Identifying key processes responsible for coastal changes
- Developing strategies for the sustainable use of marine living resources
- Developing an operational monitoring system for the North Sea

To assess the role of the polar regions within the earth system by

- Identifying key processes responsible for recent changes
- Quantifying lithosphere-ocean-cryosphere-atmosphere interaction
- Reconstructing global climate cycles from polar archives
- Unravelling the role of climate for evolution, biogeography, and biodiversity

For their realisation these goals require certain approaches in the way research is carried out. We envisage a multi tiered structure. Subject-specific understanding of environmental states and processes within different compartments is obtained from within the traditional scientific disciplines. On intermediate levels we link this information in a multidisciplinary approach wherever relevant, and at the top we have complex views of the studied earth system parts, which will then be linked to other programmes within “Earth and Environment“ in order to arrive at the global view. Obviously this Programme must also be transparent at all levels of aggregation to the other programmes and Research Fields, and receive input from them in order to steer the programme dependent on new findings as they develop. The schematic shows the most important links and interdependencies.



Programme structure and links to other Research Fields and programmes

Strategic importance of the programme

Within the Research Field "Earth and Environment" the focus on polar regions, oceans and coastal areas will contribute to the overarching goal of better understanding natural and anthropogenic changes within the system. This will be achieved by providing data, ensuing numerical models, combining these to scenarios for sustainable use but also quantification of future changes. This will be done especially by

Providing unique scientific, methodological and technical competence

This programme will combine the methodological, technical and scientific competence of two research centres (AWI, GKSS). AWI is the German national polar and marine research institute and as such has developed leading competence in a variety of scientific disciplines and their integral application to problems of Global Change. It is an established Antarctic as well as Arctic operator, which is a special prerequisite for research at higher latitudes. GKSS has special competence in monitoring and simulating coastal systems, combining profound analytical capacity, specific observational systems and dynamical models. Both centres will continue to provide their specific competence and logistics to collaborating scientists from universities and other research institutions within Germany and abroad, engaged in comparable complementary research. As the objectives of this programme are of global scope they are of great importance to many international programmes.

Providing assessments of the state of the environment

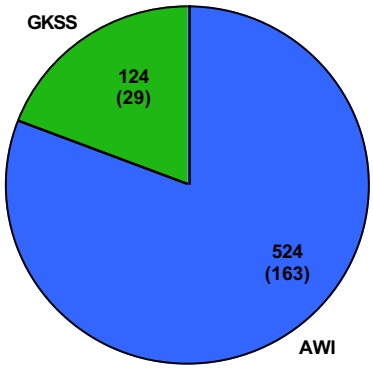
The programme will shape understanding of the changing global environment in compartments playing a key role for sustainable and rational use. The economic importance

of quantification of sustained usability of the oceans and shelf seas, for instance as providers of food resources, is evident. By looking at the role of key organisms in trophic webs and biogeochemical processes, solutions to these problems will be given. Coastal regions with their inherent burden from many competing interests for use will be studied such that recent and historic conditions, changes in morphodynamics and nutrient fluxes are analysed as well as expressions of regional climate change such as storm floods, sea state, river floodings and wind patterns. Polar regions, which arguably will most rapidly respond to climate change, are early indicators of impending consequences. Assessment of these changes together with the enhanced understanding of involved processes will allow consequential action. Altogether this environment assessment will serve basic political and societal needs for a political process based on scientific findings even in the case where our present or future knowledge is insufficient to derive or define specific regulatory measures.

Infrastructural and subject related concentration

Pooling of expertise

AWI and GKSS are the two Helmholtz-Centers with marine expertise. They are capable of carrying out sea going research and have an infrastructure which is suitable to link field research with modelling efforts. In addition AWI has the expertise for operating in the polar regions, both on land ice and sea ice. It is therefore obvious that this expertise should be pooled in one program, where the greater involvement of GKSS in coastal regions is augmented by AWI expertise in the shelf seas, the open ocean and at the poles. This joint programme also allows for comparative studies of coastal areas in lower and higher latitudes, which will greatly enhance identification of relevant processes.



Contribution from participating Helmholtz-Centers in person-years (2002).

Third party funded person-years in parentheses.

A major new component will be the availability of a new icebreaking research vessel, capable of carrying out drilling operations in sea ice covered regions. It will serve obvious needs of this programme to become an integral part of the European contribution to IODP. This proposed new vessel “Aurora Borealis” is envisaged as a joint European large scale research facility and will together with “Polarstern“ enable us to study polar processes in their full seasonal cycle and longer term variability, which is urgently necessary.

Guaranteeing the availability of research devoted large scale infrastructure

This programme guarantees the availability of a fleet of research vessels from the large research icebreaker “Polarstern“, which is capable of operating both in the Antarctic as well as the high Arctic, to a number of medium sized research ships, dedicated to multidisciplinary use in shelf sea areas as well as the coastal regions. Furthermore two

research aircraft capable of fully operating over and from ice and snow and equipped with changeable scientific instrumentation will be maintained as well as permanently operating research stations in the Antarctic (Neumayer base) and the Arctic (Koldewey base, Svalbard). These permanent and some temporary bases (Dallmann Laboratory, Kohnen Station) serve long-term observational needs as well as short term scientific requirements. Research infrastructures with laboratory space for visiting scientists and students are available on Helgoland, Sylt and Büsum and especially serve needs in coastal research such as the gathering of long-term observational data on marine ecosystem changes but also educational purposes by offering the possibility for course work in the marine environment for universities based inland.

AWI and GKSS are partners of the German Climate Computing Centre (DKRZ) and thus provide computing expertise and computing time to the wide scientific community. AWI will host a pool of marine geophysical instrumentation such as Ocean Bottom Seismometers or digital streamer systems, and operates an autonomous underwater vehicle (AUV).

AWI and GKSS will expand their existing collaboration with Geoforschungszentrum Potsdam (GFZ) and Deutsches Zentrum für Luft- und Raumfahrt (DLR) towards a more substantial Helmholtz *Research Network: Integrated Earth Observing System*, thereby linking Research Areas 2 (Earth & Environment) and 6 (Transport & Space). This Network will support research activities concerning the dynamics of various compartments of the changing Earth, with special emphasis on climate variability, marine and coastal ecosystems, the global water cycle and sea level change, and natural disasters. The activities will involve, among other things, data management, development of higher level data products, improved software and retrieval algorithms, including validation procedures, use of combined data sets for disciplinary and interdisciplinary research questions, and development of a central information infrastructure for the general scientific community.

National and international links

The complexity, global importance and relevance, as well as the large scope of these programme topics require national and international cooperation. The participating Helmholtz-Centers have nationally and internationally recognized expertise. They serve central focal roles, and are capable and willing to further enlarge outside cooperation.

In addition to other Helmholtz-Centers, prominent national partners are institutions dedicated to marine sciences at universities (Bremen, Hamburg, Kiel, Oldenburg) as well as institutions outside universities (BGR, GEOMAR, IOW, PIK, the Max Planck Institutes for Meteorology, Marine Microbiology, and Biogeochemistry , and the Senckenberg Institute). The German Climate Computing Centre (DKRZ) with its Model&Data Group is an indispensable partner for this programme as well as the wider community.

Strong ties exist internationally with many research institutions as documented by many joint projects also within the EU framework programmes. Especially for polar regions there are many successful and reliable partnerships.

Results from this programme will serve the needs of public agencies such as BAW, BFN, BSH, DWD, UBA and public offices of the environment. Furthermore, results will also support the private sector e. g. shipping and insurance companies. Political bodies such as HELCOM, COSPAR, IPCC and the North Sea Conference are advised on the basis of results and views obtained.

The programme also builds the foundation for effective political advice to the German government related to international treaties such as Law of the Sea, the Antarctic Treaty System, and serves requirements laid down in these treaties.

Large parts of this programme are contributions to international Global Change Programmes such as WCRP and IGBP, in particular GEWEX-BALTEX, LOICZ, PAGES, ACSYS, CLIVAR, CLIC, SPARC, IGAC, GLOBEC, and JGOFS as well as the Arctic (IASC) and Antarctic (SCAR) programme portfolios.

We aim for an appropriate share in the upcoming networks and integrated projects of the EU 6th framework programme.

Programme relevance to the Helmholtz mission

The programme conforms to the Helmholtz core missions, i.e. to advance basic research in earth system science, to allow complex interdisciplinary research, to provide large scale research infrastructure with easy access via an open-user concept, which also extends to the international scene and which through exchange Programmes also makes available the research infrastructure of other nations. Furthermore the development, application and evaluation of novel diagnostic and prognostic tools for the interpretation of field and model data will be of value. The programme focuses on understanding naturally and anthropogenically driven processes of interaction between different compartments of the earth system and their relevance in global processes with the aim to reduce our present uncertainties in assessing future developments. These will be described by way of scenarios, which can be used in the general political decision making process.

Management of Programme

The programme will be managed by the programme speaker and the programme topic speakers in close coordination with the centre managements. A work plan will be developed taking into account the breakdown of programme topics into work packages with the programme speaker being responsible for the overall coordination. There will be long-term planning for the use of the infrastructure accounting for international, national and our programme needs. Since there is a tradition in taking a systemic approach to the research topics no great effort will have to be made in order to integrate the working scientists into the programme topics, especially since there is a natural predisposition within each participating centre towards different specialities, which will easily merge as we have already realized while developing the programme. After implementation the programme will conduct formal and informal reviews to ensure adequacy of scientific output, schedule and cost. Such reviews will be held with representatives of partner institutions, the scientific councils of the centers and outside experts where appropriate. Informal meetings within programme topics will be held as necessary. Where required we will initiate a programme of workshops and meetings during which we will further familiarize ourselves with each others' specialities and overcome disciplinary barriers.

3 Programme Topics

3.1 Programme Topic MAR: Ocean and Global Climate
(Spokesman: Prof. Dr. Dirk Olbers)

Personnel	Institutional funding			Third party funding		
2002	Scientists	PhD Students	Technicians	Scientists	PhD Students	Technicians
AWI	27	10	10	17	12	3
GKSS	2	0.5	0.5	1	0	0
total number	29	10,5	10,5	18	12	3

The global ocean as part of the climate system
The global ocean plays an important role for several urgent environmental problems with high priority on the international agenda of climate change. The ocean circulation provides a dynamic link between polar and extra-polar parts of the climate system, with long intrinsic time scales of decades and longer. On smaller time scales, ocean and atmosphere contribute to climate variability, with dominant effects from the atmosphere, according to the present state of knowledge. For time scales of tens to a few thousands of years, the ocean is considered the key component in determining the dynamics of the climate system and climate change. On the longer time scales of this range of climate variability polar ice sheets come into play, which build up and retreat in reaction to and interaction with the oceanic and atmospheric transport of heat and moisture as well their imprints on Earth's lithosphere. On time scales of tectonic changes, with opening or closing of water passages, the ocean circulation adjusts to the changing sea floor topography and continental geometry and provides new pathways for transport of water, heat and dissolved and suspended matter. Changes in the abundance and isotopic composition of marine biomass are affected by climate conditions but they also document climate change in the oceanic sediment, providing an archive of climate history which can be opened if species geochemical or isotopic proxies can be related to physical climate variables.

Challenges for our research
Climate dynamics and climate change are thus research items which can only be dealt with sufficient understanding of the ocean dynamics and its influence on the global climate system. Consequently, the Programme Topic "Ocean and Global Climate" combines our efforts in two work packages to meet the objectives of MARCOPOLI which are relevant to these topics, namely to investigate the ocean's role in global climate processes and change by

- *Synthesis of data and models of varying complexity*
  The enormous increase of the global climate data base, mainly by utilization of satellite based instruments and by large internationally coordinated research programmes, has lead in the recent decade to a new approach in data oriented modelling. In addition, climate models have gained complexity as consequence of our increased understanding of processes and by advance of computer capacity. We use and plan to extend our existing working tools as combination of observations and simulation models, accompanied by theoretical models of processes and subsystems, to gain an integrated view of climate variability and its causes.

- *Bridging the gaps between physical and biological sciences*
  The integration of various science disciplines in climate research has been established in various important international research plans. Interaction of the

physical and biological subsystems is particularly manifested in the ocean where transport and mixing inherently accompany biological processes. Also, on the micro-scale, biological organisms are strongly influenced by the physical environment. We intend to analyse and model the physical and biological systems in a holistic approach.

- *Models of marine biogeochemistry including the functional role of organisms*
  The step from a bulk primitive compartment approach in ocean biogeochemistry toward a detailed understanding and model simulation of organisms is an urging research topic. We intend to identify leading organisms and model their functional role in biogeochemical cycles.

- *Reconstruction of global climate since the Cenozoic*
  The search for the dominating mechanisms establishing the transition between glacials and interglacials is still in the center of climate research. The huge and rapid climate oscillations in the last glacial period are currently investigated with new sediment and ice core archives and dynamical systems mathematics applied to the climate dynamical equations. We address these questions with a hierarchy of models of differing complexity, intensive use of climate archives and proxy models.

Work plan and networking
The research in Topic MAR largely resides with the working groups of AWI; contributions of GKSS are only present in the work package MAR 2. The work packages can be arranged according to the dominant time scales and the compartments (atmosphere, ocean, sea ice, ice sheets, and sediments) of the climate system.

In the work package

MAR 1: Decadal Variability and Global Change

we have combined the research themes:
- Atmospheric decadal-scale climate variability,
- Extreme anomalies and climate change,
- Oceanic subpolar exchanges in both hemispheres,
- Ocean, ice sheets and sea level in a changing climate,
- The impact of global change on marine organisms and consequences for marine biogeochemistry.

In this set we describe our efforts for the present climate state and time scales associated with present global change. It aims towards discrimination between natural decadal climate variability originating from atmospheric dynamics alone and from processes in the coupled ocean-atmosphere system (by use of a hierarchy of atmospheric circulation models). The work package is also dedicated to identify causes and evolution of extreme climate anomalies occurring in or connected to polar regions. Furthermore, our investigations attempt to identify the pathways and clarify dynamical mechanisms of impact and interaction of polar climate changes on the global ocean circulation (by use of global ocean circulation models). We assess the present state and recent changes (50 years) of ocean circulation and sea level (by use of models and satellite and in-situ data). Finally, the impact of global change on marine organisms is assessed.

Longer time scales – up to glacial cycles – are considered in the work package

MAR 2: Palaeo Climate – Mechanisms and Variability

where the themes:

- Mechanistic models of palaeoproxies,
- Palaeoclimate simulations and climate reconstruction from archives,
- Ocean gateway and basin evolution – consequences for ocean circulation and ice sheet development

are implemented. Climate archives in the oceanic sediments will be related to climate change (by models of climate proxies). Many of our process studies and modelling attempt to unravel subsystem interactions and assess the fundamental nonlinear climate behaviour on long time scales by use and promotion of intermediate complexity palaeo climate models, including proxy modules (by coupled ocean-atmosphere-cryosphere models with reduced physical complexity). We also will reconstruct climate variability for the last glacial-interglacial cycle (100 ka) with the help of glaciological evidence and simulations (with a full-sized ocean-atmosphere model). The reconstruction of primary drivers of climate change on time scales of millions of years is the aim of the last item where time slices will be studied with ocean and climate models of the preceding packages.

Finally, as an “Additional Funding” work package, we propose various computing and archiving tools as well as the establishment and long-term support of a numerical ocean model code for the German climate research community. This is combined under the heading

Collaborative Computing and Community ocean model and algorithms

We suggest establishing and concentrating in the present programme national efforts to build and extend a global ocean community model and the C^3-grid software for climate simulation data.

These studies concern the dynamics of ocean and the global climate on time scales of tens to thousands of years and above (shorter time scales of climate are considered in Programme 2 “Atmosphere and Climate”). To achieve our goals we envision a strong collaboration among this group of work packages, combining data and models of various accuracy, complexity and source. Interdisciplinary work is mandatory.

Synergy

The Programme Topic MAR has strong links to the two other topics of the MARCOPOLI Programme. It is partly based on the process studies of the polar oceanic and atmospheric system of Programme Topic POL; it provides global conditions for deriving scenarios and reconstructions for climate variability and change in coastal regions (Programme Topic CO). Socio-economic relevant aspects of global and regional sea level change are considered here in MAR1 and in the coastal Programme Topic CO.

The work proposed in this programme is also positively acknowledging the Helmholtz-Centers’ need to support the formation of national and European co-operations in the field of climate research. A specific effort is the support of the DKRZ (the German Climate Computing Centre) and the community support group Models & Data. Within this framework, the programme is helping in establishing community models and in advanced set-ups to allow a broad community accessing climate simulation data.

Strong links for this topic exist to programme 1 Geosystem: The Changing Earth. They have been forged with GFZ within the Helmholtz strategy fund projects KIHZ und SEAL and will in future lead to still stronger pooling of expertise in the areas of sea level change, climate change and solid earth processes.

Work packages

MAR 1: Decadal Variability and Global Change

Atmospheric decadal-scale climate variability

Objectives
There are various physical mechanisms that control the observed atmospheric circulation patterns in the Arctic and their related global consequences for decadal scale climate variability. The observed variations of Arctic circulation patterns can be attributed to changes in the polar energy budget caused by internal nonlinear dynamics and external forcing factors. Most important are forcing factors which influence the excitation and propagation of large-scale planetary waves due to e. g. changed temperature patterns of the tropical ocean, greenhouse warming of the tropical atmosphere, changed radiation budget due to changed stratospheric ozone and regional polar feedbacks. An improved understanding of the variations of Arctic circulation patterns and their feedback mechanisms with the global circulation will us enable to distinguish between natural and anthropogenic contributions to the observed climate variations and hence, to deliver realistic climate scenarios on the decadal time scale and to improve the prediction capabilities.

Implementation
The causes of decadal scale climate variability will be studied using a hierarchy of climate models with increasing complexity; these are simplified atmospheric circulation models, a new atmospheric circulation model with an adaptive finite element grid and coupled atmosphere-ocean models of high complexity. The studies will concentrate on the nonlinear influences of thermal, orographic and transient synoptic forcing processes on the low-frequency variability of large-scale atmospheric circulation structures and the determination and characterization of the transitions between preferred circulation states. As one of the key processes the coupling between the troposphere and the stratosphere will be investigated. It will be analysed, how the interaction of stratospheric dynamical processes and radiation changes due to a changed ozone distribution influences the large scale atmospheric circulation patterns and hence decadal climate variability. The simulated decadal scale climate variability will be compared with results from the palaeoclimatic analysis of ice cores which provide useful additional insight into the natural variability due to the longer time frame. Improved parameterisations of regional Arctic and Antarctic climate feedbacks will be implemented into global coupled atmosphere-ocean circulation models to determine and understand their global influences via atmospheric and oceanic teleconnections and consequences for decadal scale climate variability.

Deliverables
- Quantification of observed climate variations of the Arctic and Antarctic and their global consequences in terms of planetary wave dynamics;
- Distinction between natural and anthropogenic contributions to the observed climate variations in both polar regions and realistic climate scenarios of the Arctic for the next decades.

Extreme anomalies and climate change

Objectives
Extreme climate anomalies are outstanding features of the climate system. They are apparent in both polar regions. Examples are the Great Salinity Anomaly (GSA) and the current sea ice thinning in the Arctic, and the Weddell Sea Polynya (WSP) and the ongoing ice shelf decay (ISD) in parts of the Antarctic. Currently one can only speculate about the origin of these anomalies, like increased sea ice and fresh water export initiating the GSA, ocean current and tidal interaction with special feature in the bottom topography combined with special atmospheric forcing creating the WSP, and atmospheric warming which forces the ISD. Similarly, the impacts of these anomalies on regional and global climate are far from clear. Of special interest is an interaction in both directions: Does global climate change initiate extreme anomalies in polar regions and do these in turn influence the global circulation pattern? To unravel these mechanisms, it is planned to study the conditions that lead to extreme anomalies, to explore their evolution, and to investigate the consequences of these anomalies for hemispheric and global climate. A special focus is put on feedback mechanisms in order to determine sensitivities and to improve model parameterisations for climate scenarios.

Implementation
A combination of historical data and long-term observations at critical points will be used together with advanced data analysis techniques. The observation will include the monitoring of fluxes in Fram Strait and water mass characteristics along 75°N, the monitoring of hydrographic conditions near Maud Rise (WECCON and German ARGO), and in the western (ISPOL) and northwestern (DOVETAIL) Weddell Sea. In addition, a hierarchy of numerical models (small-scale to global) of different complexity (including coupled atmosphere-ice-ocean models) will be applied and optimised through comparison with the observations.

Deliverables
- Identification of the causes and the evolution of extreme anomalies in polar regions;
- Assessment of their influences on the regional and global ocean climate.

Oceanic subpolar exchanges in both hemispheres

Objectives
Fresh water redistribution between the polar and subpolar oceans will be investigated with regard to its variability and dependence on atmospheric forcing, continental run-off, and the oceanic circulation connecting polar regions and the subpolar seas. What is the reason for fluctuations in the polar fresh water reservoirs and which circumstances lead to anomalies of fresh water transport into the subpolar domain? What is the effect of fresh water signals on the circulation in the subpolar gyres? What changes in the polar seas are related to fluctuations of poleward flowing waters of subtropical origin? How is the transformation into equatorward intermediate, deep, and bottom flows affected and how does it feedback on the poleward flow?

Implementation
Time series of transports at key locations of the meridional circulation will be generated from numerical hindcast experiments and observations. Results from long term monitoring of polar-subpolar fluxes will be used to validate the models. Combined with inverse modelling techniques these observations will be utilized to achieve quantitative estimates of important components of the polar-subpolar exchanges. Additional response experiments with detailed ocean-sea ice models will be used to calculate scenarios for future

development and to test hypotheses regarding the exchanges. Finally, integrations of coupled regional atmosphere-ocean-sea ice models will be used to study the interactions of the different climate subsystems.

Deliverables

- Time series of transports at key locations in the Nordic Seas, the Arctic Ocean, and the Weddell Sea/Southern Ocean boundary;
- Relation of these transports to forcing fields and clarification of the feedback mechanisms between poleward transports and water mass transformation processes.

Ocean, ice sheets and sea level in a changing climate

Objectives

The global sea level is inversely related to the volume of land ice stored in ice sheets, glaciers and snow. Furthermore, global warming increases the volume of the ocean via thermal expansion. In order to be able to predict sea level rise with confidence its past must be accurately assessed and its various contributions need to be understood and quantified. The global ocean thermohaline circulation has a memory of centuries. Glacial isostatic adjustment and delayed evolution of ice sheets which are not in equilibrium with the present day climate link sea level to even longer time scales. State estimation which reconstructs sea level from available observations can be achieved with global ocean general circulation models using a consistent data assimilation technique (4DVAR). Ice sheet modelling enables us to distinguish the longer-term ice-dynamic evolution from short-term mass-balance changes, and to extract the current evolution from gravity and altimetry trends contaminated by post-glacial rebound. Glaciers and ice caps may dominate the response on a century time scale. They are investigated by global algorithms incorporating area-wise glacier distribution, mass-balance sensitivity, and dynamic response.

Implementation

The study of sea level change comprises disciplines as diverse as oceanography, glaciology, geophysics, geodesy and satellite altimetry. We estimate sea level by combining all available information in a global ocean general circulation model applying a consistent data assimilation technique. Such models assimilate measurements like hydrographic data, satellite derived altimetry, surface temperatures, salinities and sea-ice coverage, velocity measurements and transport estimates, atmospheric fluxes and river runoff and tide gauges among others. Major data bases are derived from the World Ocean Circulation Experiment and satellite altimetry in conjunction with tide gauge records. The contribution from the Greenland and Antarctic ice sheets is assessed from 3-D thermo-mechanical ice sheet models coupled with detailed mass-balance models which are driven by output from oceanic/atmospheric general circulation models. Land ice data used for input and validation include continent wide satellite altimeter measurements and complex field campaigns based amongst others on airborne radio echo-sounding, SAR interferometry and ice-core drillings. The AWI Computing Centre is involved in the modelling efforts by providing computational support and by the development of efficient and accurate algorithms such as solvers for large sparse unsymmetrical systems of equations. These problems are extremely poorly conditioned and must be solved with consideration of computer architecture depending on memory/cache design and parallel processing capabilities.

Deliverables

- Reconstruction of the global and regional development of the sea level for the last 50 years with quantitative analysis of driving mechanisms: warming, evolution of ice sheets and glaciers and internal redistribution;

- Reanalysis of the World Climate Research Programme data for the ocean over the same period. Calculation of oceanic transports, circulation and their changes.

The impact of global change on marine organisms and consequences for marine biogeochemistry

Objectives
Natural variations and anthropogenic perturbations cause changes in climate and environment. The increase of atmospheric CO_2 since the onset of the industrial revolution led to acidification of the surface ocean. In addition, global warming will lead to changes in surface ocean stratification and in nutrient transport. These changes will impact marine biota and hence biogeochemical cycling. Our aim is the investigation of the influence of varying/changing environmental conditions on marine organisms and the development of prognostic models for global cycles of biogenic elements.

Implementation
Various functional groups of phytoplankton have different influences on global cycles of biogenic elements (C, N, P, Si, Ca etc.). The regulation of elemental fluxes on the cellular and ecosystem level will be investigated by laboratory experiments and field studies in close cooperation with mathematical modelling approaches. Of particular interest is the role of phytoplankton functional groups in marine biogeochemistry and the underlying regulating mechanisms for their occurrence and succession. The aggregation of particles and extracellular material and the sedimentation of aggregates will be investigated and simulated. Based on refined ecosystem models we will develop, integrate and analyse regional and global general circulation models for biogenic elements.

Deliverables
- Cellular model that allows for the simulation of the response of microalgae to different CO_2, nutrient and light conditions;
- Ecosystem and biogeochemical ocean general circulation models that are able to simulate the occurrence and succession of various functional groups of phytoplankton (silicifiers, calcifiers, picoplankton) under current and future (next 100 years) climate conditions.

MAR 2: Palaeo Climate – Mechanisms and Variability

Mechanistic models of palaeoproxies

Objectives
Elucidating climate variations on long time scales requires reconstruction of the palaeo environment using proxy relationships. Proxies such as isotopic and elemental compositions of calcite shells of foraminifera are currently interpreted using empirical relationships with environmental parameters. The application of such relationships, derived from modern observations, to the geologic record is questionable as long as the underlying mechanisms are not understood. Our aim is the development of mechanistic models of palaeo-proxies for the reconstruction of marine carbonate chemistry and of nutrient utilization. The ultimate goal is to use these proxies and carbon cycle models for palaeoceanographic reconstructions.

Implementation
The composition of biogenic minerals is usually different from inorganically precipitated minerals because of “vital effects”. The fractionation of isotopes and elements during

incorporation into minerals will be studied in inorganic and organism mediated precipitation experiments. We will address the following topics. The isotopic ($\delta^{11}B$, $\delta^{13}C$, $\delta^{18}O$, $\delta^{44}Ca$) and the elemental (Mg/Ca, Cd/Ca, Ba/Ca, U/Ca, Zn/Ca) composition of foraminiferal calcite shells is used to derive pH, temperature, carbonate concentration etc. over geologic time scales. The size and the mechanisms of vital effects will be investigated by experiments with living planktonic and benthic foraminifera under controlled culture conditions. Mathematical models of kinetic processes at the organismal level will be developed in close cooperation with experimentalists. The isotopic fractionation of silicon isotopes in diatoms will be investigated in laboratory experiments. A spectrum of models with different approaches and complexity will be developed to simulate the global carbon cycle in the geologic past on glacial-interglacial time scales. These models will profit from refined and corrected interpretations of palaeo-proxies.

Deliverables

- Mechanistic understanding of the incorporation of isotopes and cations in calcite and opal;
- A reconstruction of the marine carbonate chemistry and nutrient utilization in the glacial ocean based on refined proxy interpretations and global carbon cycle models.

Palaeoclimate simulations and climate reconstruction

Objectives

The goal is to provide a global and physically coherent picture of the variations of Earth's climate using global climate models, thereby integrating the local and regional information derived from palaeoclimate indicators in ice cores and sediments. Time scales of interest are oriented at what is manageable with earth system models (some k-years to a glacial cycle) and what is resolved in the data archives (some glacial cycles). Climate archives (from AWI and other sources) and models simulations will contribute to the assessment of the importance of the different external factors for global climate variations, to better understand the internal physical processes that amplify or damp the influence of the external factors, and offer a coherent picture of past regional climate variations needed by geologist, coastal oceanographers and polar researchers.

Implementation

A series of climate simulations with a three-dimensional state-of-the art coupled atmosphere-ocean model (as the community model ECHO-G) will be carried out to reconstruct the climate cycle from the last interglacial to present (about 100 k-years). The model ECHO-G is implemented with the DATUN method (Data assimilation through upscaling and nudging) that allows for the incorporation of the information derived from proxy data, and has been used for long (~1 k-year) simulations within the Helmholtz KIHZ project. The climate model should be further improved with interactive vegetation and ice-sheet dynamics, and the DATUN method should be extended to the ocean dynamics (western boundary and circumpolar currents). Simplified and conceptual models will be used and extended to backup the ECHO-G experiments and investigate the nonlinear dynamics in the climate system and promote our understanding of the state and variability of the coupled atmosphere-hydrosphere-cryosphere system, in particular with long simulations of the Last Glacial Maximum (LGM). These models include biochemical and proxy modules and will be analysed by dynamical systems tools, as bifurcation and continuation techniques. Emphasis is placed on the role of polar processes and interhemispheric coupling in the climate system as well as synthesis of palaeo proxy data and dynamical models for a better understanding of glacial/interglacial climate variations.

Deliverables

- A three-dimensional, low resolution (4°x4°) climate reconstruction of the Earth's climate in the last 10k years, physically coherent and consistent with the available information from proxy data;
- Dynamical systems analysis of conceptual and simplified models unravelling the dominant modes of variability during the last LGM.

Ocean gateway and basin evolution – consequences for ocean circulation and ice sheet development

Objectives

Plate tectonics is one of the primary drivers of global climate evolution as evidenced by the fact, that cold climate states with appreciable amounts of ice only exist when continental landmasses are in polar or near polar positions. Ocean gateway and basin evolution linked to plate tectonics shapes ocean circulation and related polar ice sheet development and thus acts together with changes in global albedo as trigger to initiate relatively rapid climate change. Understanding of the causes of initial Antarctic ice sheets build up, terminating a long period of ice free-conditions on Earth, and the subsequent Cenozoic Antarctic ice volume history will enhance our perception of global climate system components and interactions. Similarly we need to enhance our understanding of the causes of the onset of Northern hemisphere glaciation, which is much younger than the Southern hemisphere one, and which by cycling through large ice volume changes has had much more pronounced effects. Once directional changes together with their exact timing of palaeocean current systems in key areas are identified this will lead to a description of the global palaeocean in time slice frames. Using these snapshots as boundary conditions palaeocean models will be used to get a dynamic view and link the key regions into a globally consistent picture. Furthermore, the expected result will be used diagnostically in models of evolutionary changes in marina flora and fauna.

Implementation

Studies of the tectonic evolution will as first order tools set the frame in time and space. These will be combined with high resolution geophysical studies of internal structures of ocean basins and polar continental margins sedimentary covers and by using models of sedimentary drift the palaeocurrent directions will be derived. Tied into available ocean drilling data such seismic sections will yield timing of changes and also document the changing ice sheet covers. In addition to drilling within the ODP, respectively IODP, additional drilling is envisaged within the ANDRILL program close to the present Antarctic ice sheet margin. Evolution and spatial distribution of marine microfossils present second order tools for the detection of opening/closure of oceanic gateways and climate change (e.g. build-up and stability of polar ice sheets) as they mirror changes in pathways of ocean circulation and thermal gradients. Southern Ocean Palaeogene and Neogene siliceous microfossil assemblage analyses will help to constrain the timing of the development of Antarctic ice sheets, the opening of Tasman Seaway and Drake Passage and document the related environmental response.

Deliverables

- Identification of the response of diatom assemblages on Eocene-Miocene changes in ocean circulation and latitudinal thermal differentiations;
- Derivation of bounds for changing ice sheet extent in Bellingshausen and Weddell Sea regions;
- Scenarios for past ocean circulation changes in the Southern Ocean and assimilation into global palaeocean models.

Additional funding

Personnel	Institutional funding			Third party funding		
2002	Scientists	PhD Students	Technicians	Scientists	PhD Students	Technicians
AWI	5	2	2			
GKSS	1	0	0			
total number	6	2	2			

Collaborative Computing and Community ocean model and algorithms
Modelling the earth climate by comprehensive earth system models is a major numerical and data intensive challenge for the climate research community. We propose two major activities to support the current Helmholtz-Programme and the national climate research groups.

Collaborative Climate Community Data and Processing Grid (C^3Grid)

Objectives
With higher grid resolutions, coupling of new model components and integration of additional complex processes the simulation models produce terabytes of data today and will produce petabytes in future. The data are distributed over many sites where teams are working in the field of climate research. In order to fulfil the goals of the German climate research program (DEKLIM) and to cooperate effectively with European and other partners the distributed data have to be accessible for all teams of researchers.

The C^3Grid enables the researcher to exploit interactively massive distributed data resources, high bandwidth networks and remote computation and data analysis. Research and development activities of the C^3Grid project address the construction of a distributed data grid prototype for the German climate community. Similar initiatives exist in the U.S. with the Earth System Grid project. Our project gives a substantial contribution to the European Network for Earth System Modelling (ENES) by adding a powerful network component dedicated to climate and earth system modelling, thereby complementing the PRISM project for the development of a flexible model structure in Europe.

Implementation
Based on middleware initiatives, like the Globus Project and OGSA, existing tools for authentication, resource discovery and resource access will be used to build the prototype data grid. Processing steps like extraction of a region of interest from global datasets or filtering can be done remotely with the implemented data analysis toolset. In the initial phase beside the AWI and GKSS the M&D group Hamburg (DKRZ and MPI for meteorology) and PIK from the climate community will cooperate. Support from the technical viewpoint will come from ZIB and University Dortmund, both having wide experience in the field of distributed systems and grid technology.

Deliverables
- Prototype self scheduling data and processing Grid software environment with intelligent request management. This is the basis for the initial testing phase of the C^3Grid. Major components are a central metadirectory system with information of all remotely stored model datasets and high-level replica management tools for rapid networked acces of mass-data held at the partner institutions and DKRZ.

- The Integration of the enhanced data analysis toolset enables the sharing and inter-comparison of model results and model diagnosis in collaborative research projects. The self scheduling feature of the C^3Grid software allows data to be processed and extracted at its point of residence, thereby reducing the amount of unnecessary bandwith consumption over wide area networks.

German community ocean model code

Objective
For quantitative predictions of climate change, a necessary tool are three-dimensional ocean circulation models which are able to simulate the present circulation and water mass distribution, including their seasonal variability, with sufficient accuracy. The German ocean modeling community is currently working with two global OGCMs, either based on the MOM code of the GFDL family of models and the HOPE model of the MPI/Hamburg (now called OM1). A few attempts are running in Germany (at AWI and IfM Kiel) to use the OPA (http://www.lodyc.jussieu.fr/opa/) code. On the other hand, the German climate research community has created the Model&Data (M&D) Group, steered by the Wissenschaftliche Lenkungsausschuss (WLA), situated at the MPI, and financed by a BMBF project for the whole community, to support community models for the various compartments of the climate system. To obtain support by M&D the German community is asked by WLA to agree on one code for a global ocean model route and utilization in coupled models.

Implementation
AWI and GKSS scientist, with support from the AWI computing centre, are volunteering to establish a global model code with the following criteria

- up-to-date parameterization of subgrid-scale processes,
- same circulation models for physical oceanography, biogeochemical and paleo applications,
- terrain-following s-coordinate system and free surface,
- conformity with emerging coupling standards (PRISM),
- enhanced portability and performance features for all computing platforms (parallel and vector computers) with adaptation of new numerical core solvers.

The model will be used for ocean prediction (including e.g. ecosystems), understanding ocean variability, climate prediction with coupled models, and applications in data assimilation. The code should evolve with the scientific and technological advances in our research. The design should follow from general programming objectives and technical and economic possibilities.

3.2 Programme Topic CO: Coastal Areas
(Spokesman: Prof. Dr. Hans von Storch)

Personnel	Institutional funding			Third party funding		
2002	Scientists	PhD Students	Technicians	Scientists	PhD Students	Technicians
AWI	41	19	22	7	29	3
GKSS	55	10.5	26.5	25	1	2
total number	96	29.5	48.5	32	30	5

The coastal environment: problems and challenges
Coastal areas, as defined for this programme, are wide transition zones between continents and the open ocean, including drainage basins, coastal lowlands, estuaries, and the shelf seas. Our programme will be focused on the German coasts of the North Sea and the Baltic Sea, but with a global perspective. Thus, it will include coastal zones of similar type and with similar problems in other parts of the world. The polar coasts are treated in the programme topic “Polar Region”, and the outer shelf as well as global climatic aspects in the programme topic "Ocean and Global Climate".

During the past decades coastal zones have experienced a tremendous increase in population and utilisation by men. It is estimated that today more than half of the world population settles in a zone not more than 60 km apart from the sea, with increasing tendency. In many areas, such as in the North Sea and Baltic Sea, coasts are no more a natural environment but heavily affected and modified by past and ongoing human activities: exploitation of gas and oil, shipping and industry, offshore wind-farming, utilization of marine resources and mariculture, and tourism with all kinds of construction work including protection of coastal settlements. Coastal zones are subject to environmental threats that endanger the human population, economic activities and the ecosystem. Examples of such threats are weather extremes such as storm surges, flooding, and wave activity. Ongoing climate change will enhance some of these risks. Other examples are anthropogenic threats related to water quality such as contamination by hazardous substances, eutrophication, and oil spills.

Concurrently, many coastal zones are areas of high productivity and biological richness. They are important if not absolutely vital breeding and feeding grounds for many marine organisms and migrating birds. Because of this fact and its value for recreation, many coastal zones are protected areas. As an example, most of the German North Sea coast has been declared a National Park with different zones of utilization. A sustainable use of coastal zones requires a rational management, balancing the various human activities and the natural developments in the framework of democratically formulated goals. Thus, the main challenge and task of coastal research is to provide policy makers and society at large with the required knowledge about the functioning and potentials of the system “coast” as the basis for an Integrated Coastal Zone Management. This knowledge consists of understanding the relevant dynamical processes, the ability to monitor and interpret the environmental state and ongoing change, the documentation of long-term change and of scenarios of possible future developments.

Consequently, the objective of the presented programme is to prepare the scientific basis for rational management. In doing so, the Helmholtz partners AWI and GKSS have developed basic and applied research endeavours, which complement each other. With this programme we combine our efforts to a coherent support scheme for society and policy makers. However, the existing basic knowledge of the fundamental processes is not always

sufficient. Therefore, fundamental ecological, morphological, physical and chemical studies need to be included.

The programme forms an integral part of the German contribution to LOICZ – II, Land Ocean Interactions in the Coastal Zones, which is part of the International Geosphere Biosphere Program. Contributions will be made to the themes: “River basin and human dimension”, “Fate and transformation of materials in coastal and shelf waters” and “System sustainability and resource management”. A general new theme is called “Coastal change and people”, which fully covers many, if not all, aspects of this programme. Similarly, the programme relates to the BALTEX-programme, which is presently generalized to not only cover the dynamics of the energy and water flux in the Baltic catchment but also to deal with long term hydrological and climatic changes in the wider Northern European perspective.

Challenges for our research
Coastal areas are studied from different perspectives, e.g. to understand natural dynamics and consequences of human activities, and to explore the potentials for improved use, exploitation and protection. In fact, in order to satisfy the social needs, coastal research has to focus on integrated studies on multiple aspects of land-ocean and human interactions. The proposed research and development programme is aiming at the following challenges and has the following goals:

As the backbone for informed decisions *Operational monitoring systems* combine efficient analytical and measurement skills, strategies and information management with the timely transfer of the achieved knowledge to stakeholders and the public. All this serves the overarching goal of *Biogeochemical and physical assessment of the North Sea, the Baltic Sea and other shelf seas, as well as the adjacent land areas.*

This goal addresses two different aspects and two different sorts of clients. The first is short term operational assessment, which needs efficient instrumental (in-situ and remote) measuring systems, operational model-assisted data analysis and forecast systems; it allows administrations to respond to actual developments. The second deals with long-term changes, which is based on the evaluation of recent and historical data and Regional Environmental Models (REMs). Such documentations of past and ongoing change is addressing the political process. The REM-methodology is an important element in another challenge, namely *Scenarios of the coastal environment in the next decades*.

Such scenarios will consider not only environmental change but also economic and land-use change as well as changing public preferences and perceptions. For this activity some social science competence is available, but more competence needs to be brought in through cooperation with, for instance, our Helmholtz partners FZK and UFZ.

Process knowledge and detailed data- and model-based reconstructions of the coastal environment in the past decades serve the goal of *Understanding the role of the changing coastal environment for ecosystem function and biodiversity.* Most species of small-sized organisms in the coastal sea still remain unknown to science, and genetic analyses reveal that there are many ‘hidden species’ among those, which have been morphologically described. We are faced with challenges to improve our *Knowledge on the biota of the coastal sea,* their spatial and temporal patterns, the spread of diseases and toxic algal blooms, the extinctions and the great global interchange of species mediated by human transports. Models should be based on solid knowledge of the key species involved at the different trophic levels.

For the challenge of sustainable coastal use we want to develop *Strategies and rationales for the use of new marine resources and mariculture.*

Work plan and networking
The joint coastal research of AWI and GKSS is grouped into three major endeavours reflecting the grand challenges and the complexity of the coastal environment. These work packages cannot be organized as a linear sequence, but as a network.

CO1: Causes of Coastal Change

The more basic aspects, which are necessary to improve our models for system analysis and for developing scenarios are dealt with under the headings of

- Linking coastal diversity to ecosystem functions: Sediment shores;
- Linking coastal diversity to ecosystem functions: Rocky shores and shelf sea.

Of ongoing concern are anthropogenic substances in the coastal environment and their effects on the biota. Presently, effects of many contaminants are insufficiently assessed with respect to impoverished biodiversity, human and ecosystem health. These problems will be treated in:

- Bio-molecular effects of hazardous chemical substances;
- Chemistry, dynamics and long-range transport of anthropogenic substances.

CO2: Changes Scenarios and Operational Assessment of the Coastal Environment

With continuous observations, analyses of interacting impacts and with a focus on biodiversity, we aim to understand the temporal and spatial dynamics at scales relevant to coastal management:

- Finger at the pulse of the coastal ecosystem.

All these aspects are brought together in a holistic regional environmental model, which is used to document long-term change, also in terms of extreme events, and to construct scenarios of the changing coastal zone. These past and anticipated changes are examined with respect to their impacts. The relating work packages are:

- Weather extremes and climatic anomalies and their impact on the coastal zone;
- Scenarios of the changing coast, using holistic regional environmental models.

To improve coastal sustainability we develop new monitoring strategies, geographic information systems and operational models to supply managers and decision makers with the information they need:

- Tools and strategies for coastal monitoring and information management;
- Operational models for management of coastal areas.

CO3: Natural marine resources and mariculture

Biodiversity and biochemistry are at the basis of our efforts to explore new marine resources by compound analyses and by developing new techniques in mariculture.

The *main achievements* we expect from the work plan are:

- an improved understanding of coastal ecological processes, also under the impact of human activities;
- a model system, which links physical, bio-geochemical and biological processes to analyze the cause – effect relationships on different temporal and spatial scales;
- documentation of past changes in the coastal zone;

- evaluation and nomination of bio-effective substances as candidates for future regulations;
- improved knowledge on biological resources, which can be utilized for food and medical purposes, and on farming of these organisms;
- scenarios describing possible future climate changes and other anthropogenic factors and their effects on coastal zones;
- a system of monitoring, information management and model based decision making tools for the integrated management of coastal zones, e. g., for applications such as morpho-dynamics, coastal protection, security of traffic and offshore activities and wind farming.

Work packages

CO1: Causes of Coastal Change

Linking coastal diversity to ecosystem function: sediment shores

Objectives
Biodiversity and species composition are changing at an increasing rate by coastal development, exploitation, species introductions and possibly by global warming. We hypothesize that the identity of particular key organisms and their diversity determines the functional properties of coastal ecosystems with consequences on land-ocean interactions and human use of the coast. We therefore combine analyses on population dynamics, genetics and species interactions with studies on production, energy flow and biogeochemical fluxes. Comparative research across bio-geographical boundaries will improve the understanding of the role of particular species in regional ecosystems. From the recognition of convergences and particularities we attempt to identify general patterns. Global comparisons provide a standard for the evaluation of local and regional developments in a similar way as our long-term studies. This basic research helps coastal management to refine and revise its strategies and aims.

Implementation
Field experiments at various temporal and spatial scales, manipulating species composition and environmental variables, are a major tool to link diversity to ecosystem function. Since spatial dynamics, dispersal capacities and genetic heterogeneity in coastal populations have all been underestimated in the past, we will considerably expand the spatial and temporal scales of these experiments. In addition, species invasions and natural events are treated as experimental-like constellations. Currently, biodiversity estimates are based on morphological differences between species. However, we found evidence of a ‘hidden diversity’ by not yet recognized sibling species and therefore expand our competence in population genetics. The biogeochemical studies concentrate on the exchange and transformation processes of nutrients and organic matter in view of the presence-absence of key species structuring the benthic habitat. From these studies conceptual models are derived to predict interactions between biodiversity and ecosystem function at sedimentary shores. Cooperative research with institutes at distant coasts will be continued to proceed with comparisons on a global scale.

Deliverables
- Universal patterns in sediment shore biota of polar, temperate and tropical regions;
- Role of key species for ecosystem resilience, production and biogeochemical fluxes;

- Interactions between biodiversity and coastal ecosystem processes at sediment shores.

Linking coastal diversity to ecosystem function: rocky shores and shelf sea

Objectives
The objective is to understand, assess and forecast marine biodiversity on the species, genetic and community level in an ecosystem context. Complementary to research on sedimentary shores, the characteristic species richness of the rocky littoral and surrounding shelf-waters at Helgoland is studied in particular. We investigate the function of biodiversity and in turn the functional diversity of species with regard to the causes and consequences of changes in biodiversity. The ability of a rich ecosystem to provide goods and services to humans is considered.

Implementation
Process studies in the field are combined with experiments in the field and the laboratory

- Rocky shores are structured by seaweeds which form dense submarine forests in temperate to polar regions. These rich benthic communities will be investigated as habitats, nurseries, feeding grounds, species interactions and in their economic relevance. The consequences of altered water temperatures, enhanced UV radiation conditions, increased atmospheric CO_2 concentrations and other factors are largely unexplored and will thus be of special focus. Digital geo-referenced aeria photography with high resolution is used to develop an elevation model to simulate exposure duration to air during low tides and its implications for specific communities, seen also under the scope of elevated flood tide levels.
- Detailed studies are carried out on the physiology, life history strategies and species competition of typical pelagic and benthic invertebrates, particularly crustaceans, being also compared in various climatic zones in other shelf seas. Applications relate to mariculture-techniques, e.g. in shrimp and lobster. The response of individual key species will be studied from the molecular, cellular and organ level. Such studies are compared at polar and temperate rocky shores.
- Key species in the surrounding pelagic foodweb are identified. Species interactions and chemical communication within associations and consortia of organisms are a major point of focus. In the seasonal succession of bacteria, phytoplankton and zooplankton the biotic interactions are still not understood and therefore studied. The spatio-temporal dynamics in the pelagic communities are analysed with respect to major driving factors such as the seasonal temperature and light regime, as well as currents and nutrient concentrations. Case studies in benthic-pelagic coupling will complement the truly pelagic aspects.

Deliverables

- Scenario on seaweed performance, invertebrate interactions and their future role in rocky shore ecosystems;
- The role and potential of crustaceans at rocky shores and the adjacent shelf seas;
- Conceptual model of bottom-up and top-down effects in the pelagic food web at Helgoland.

Bio-molecular effects of hazardous chemical substances

Objectives
Marine and particularly coastal environments are severely affected by the charges of multifarious natural and anthropogenic substances introduced via rivers or atmospheric deposition. In order to safeguard the diversity and health of aquatic organisms and to

sustain the environmental quality, it is essential to identify and assess the potential risks induced by these inputs. A considerable challenge remains in establishing cause-effect relationships, i.e. to link (possible) effects on the health of marine organisms and of human consumers of seafood containing impurity substances. The overall objective is to identify, characterize and quantify potentially harmful substances in coastal waters as well as in marine organisms by utilizing effect-related bio-molecular processes. The development of effective and specific biomarkers will provide a toolbox for practical, effect-oriented monitoring techniques. This approach will enable the assessment of the quality status of coastal waters to be made on the basis of biological-chemical effects which is a prerequisite for making decisions on suitable precautionary or preventative measures.

Implementation
Studies will be focused on the experimental investigation and modelling of processes at the cellular level, especially the uptake, metabolisation and elimination of xenobiotics in a wide variety of marine micro-organisms to marine mammals. The necessary and available expertise involves a combination of various disciplines such as cell biology, pathology, and chemical/instrumental analysis. The culture of cell lines as well as cell and molecular biology techniques such as flow cytometry and the sequencing of relevant genes involved in detoxification processes have to be employed in order to study the molecular and biochemical mechanisms operating during the uptake of contaminants. The determination and characterization of effects or effect potentials is carried out either by pathological investigations or by the use of specific bioassays at various levels of biological organization or bio-molecular recognition components. The identification of relevant causative substances is performed via a combination of chemical fractionation and non-target analysis with bioassays/bio-molecular recognition components (bioassay-directed chemical analysis/ bio-response-linked instrumental analysis).

Deliverables
- Toolbox for bio-response based identification and assessment of hazardous substances;
- Nomination of bio-effective substances as candidates for future regulations.

Chemistry, dynamics and long-range transport of anthropogenic substances

Objectives
The sink and the resource function of the coast are linked by adverse effects on marine biota caused by anthropogenic substances, especially those with high persistence and bioaccumulation potential. The knowledge on their pathways and deposition, how they will affect water quality and thus human life and ecosystems is very limited. Hazardous substances are already targeted in several international protocols and agreements such as the Stockholm Convention on Persistent Organic Pollutants (POPs), signed in 2001. In addition, new substances which are supposed to be future candidates targeted in regulations to come will be investigated. Emphasis will be given to persistent organic substances with genotoxic and endocrine disrupting potential. Observational data on their occurrence, spatial and temporal distribution and their interaction with coastal aerosols are basic requirements for the development of an atmospheric chemistry and aerosol physics module for an operational ecosystem model for the North Sea. Furthermore, scenarios for the assessment of the impact of possible future regulations on ambient concentrations and deposition patterns will be developed.

Implementation
A tool-box of methods will be applied to investigate the chemistry, dynamics, long-range transport and transformations of chemical substances in the coastal and marine

environment. Their medium- and long-range transport via atmospheric circulation and convection, sea surface microlayers, coastal aerosols and coastal clouds will be investigated by a combination of laboratory studies, field observations and numerical models. A strong interplay between measurements and modelling is an established pre-requisite in order to parameterize and validate the numerical schemes and, on the other hand, to identify chemical key species that have to be targeted in field and laboratory measurements. Based on the experience on the effects of lead emission-regulations in Europe, past pathways and deposition patterns of hazardous substances, mainly attached to atmospheric aerosols, will be simulated with REM.

Deliverables

- Atmospheric chemistry and aerosol physics module for aerosol-traveling hazardous substances;
- Reconstruction and scenarios of pathways of aerosol-travelling substances on a multi-decadal scale.

CO2: Changes, Scenarios and Operational Assessment of the Coastal Zone

Finger at the pulse of the coastal ecosystem

Objectives

To achieve sustainable development, coastal managers need appropriate indicators of the environmental status and reliable cause-and-effect analyses of human impacts. This requires a suitable data reference provided by ecological long-term observations, reconstructions and predictions. Such long term studies are available from the long research tradition of the field stations Helgoland and Sylt and their easy and direct access to the coastal sea. These observations are a finger at the pulse of the coastal marine environment, and provide coastal managers and policy makers with a description of its present status compared to the developments in the past.

Implementation

Regularly repeated surveys and time series measurements are conducted. Comparisons with historic data reveal changes over centuries to decades. New technologies like automatic measuring devices and remote sensing are adapted in the observation programmes while GIS tools visualize and quantify changes. Interregional comparison of time series helps to discriminate local effects from regional trends. The analysis of time-series generates the hypotheses of the causes for change to be tested by experiments and detailed process analyses. Multiple interactions between the various impacts, e. g. eutrophication and contaminants, and time-lag responses constitute a major challenge.

Deliverables

- Contributions to next Quality Status Report of the Wadden Sea (2004) and the North Sea (2010);
- Evaluation of the present ecosystem status relative to previous conditions;
- Identification of impact effects and predictions on responses of marine life to ongoing impacts.

Weather extremes and climatic anomalies and their impact on the coastal zone

Objectives
Both, the ecosystem as well as the socio-economic fabric in the coastal zone, are threatened by weather and climatic extremes. Storm surges are the most dangerous phenomenon, which has a long history of dramatic losses of live and infrastructure in the coastal zone; ocean waves (wind waves, swell) threaten shipping and off shore activities as well as coastal defence. Ecological functioning and composition (such as seagrass and mussel beds) may significantly be altered by a persistent change in wind directions and seasonal temperature anomalies. Critical is the temporal coincidence of biological developments with wind driven currents and wave induced sediment dynamics. Excessive rain storms and rainy seasons are cause to excessive remobilisation of pollutants and nutrients in river catchments, estuaries and coastal seas. The objective of this work package is to document the presence and role of weather extremes and climatic anomalies in the recent past.

Implementation
Variations in the abiotic coastal environment during the past five decades will be reconstructed and documented with a Regional Environmental Model (REM). Special emphasis will be laid upon the emergence of extreme (rare) events, trends and recurrent climatic anomalies. The intensity of rare events in terms of wind speed, rainfall amount and wave heights as well as storm surges and stream flow will be mapped, and compared to estimates based on proxies from the earlier part of the 20thcentury. The effect of anomalous seasons, in terms of wind speeds and temperatures, will be examined in particular with respect to biodiversity and ecosystem function. Shifts in species distributions in response to warm winters are investigated in terms of the tradeoffs in thermal adaptations at the molecular and cellular design as well as physiological and ecological performances of coastal organisms.

Deliverables
- Maps of extreme events in wind speeds and temperatures over Northern Europe, based on REM-reconstructions 1950-2000; for rainfall amounts over and stream flow in the relevant catchments; for wave height in the North Sea and Baltic Sea, as well as storm surges along the North Sea and Baltic Sea coast line. Maps of trends for mean conditions and variability for the aforementioned variables; identification of key climatic anomalies, significant in terms of temporal extension or intensity. Contribution to 4th Assessment Report of the IPCC;
- Systematic assessment of wind as a primary forcing function for ecological processes at the North Sea coast leading to an improved understanding of the interaction between anthropogenic and natural processes; providing a basis for projections on the effects of a possible change in climate on the coastal ecosystem.

Scenarios of the changing coast using holistic regional environmental models

Objectives
The regional coastal environment is permanently undergoing significant change because of both natural reasons and the intensive human use of the coastal zone. At the same time, the perception of the coast and its utility is also changing, affecting the decisions taken by society and government. The purpose of this work package is to provide detailed plausible scenarios of future regional development. Such scenarios are constructed by a mix of methods, ranging from the application of detailed models, like global climate models and

regional environmental models (REMs), system analysis tools of socio-economic change to ad-hoc guesses based on expert knowledge.

Implementation
REMs describe not only the dynamics of the regional atmosphere and of marginal seas but also the hydrology in river catchments, the transport and transformation of matter, the dynamics of natural and managed ecosystems and of the coastal morphology. While considerable progress has been made in the construction of modules of such a holistic system, much is left before all modules can be considered as being a quasi-realistic model, capable of describing detailed, complex evolutions. It is intended to construct a REM to be integrated with a spatial gridding of five and more kilometres and for time horizons of several tens of years.

After adequate adaptation of the weather forecast model LM, by introducing appropriate parameterizations, detailed testing and validation, the regional atmosphere model CLM will be implemented as climate community model at the German Climate Computing Center (DKRZ) (in cooperation with an array of partners). A morphodynamical model based on physical principles will be set up and tested in a series of test cases based on detailed repeated surveys in parts of the North Sea. An ecosystem model, such as ERSEM, will be imported from partners and implemented. A methodology to quantitatively validate and assess simulated variability and change will be developed. In the first five years, detailed scenarios of regional climate change will be constructed, based upon the IPCC SRES scenarios. Special emphasis will be laid upon coastal climate, particularly storms, waves and storm surges and sea level rise. Furthermore, holistic scenarios based on a “green” perspective, a “new economy” perspective and unconventional perspectives for Northern Germany will be elaborated upon. In doing so, changing fluxes and deposition of anthropogenic matter and the impact of different land-use and perceptions will be touched upon as well.

Deliverables
- Construction of detailed SRES scenarios of plausible future climate change in the coastal zone, until 2100; Contribution to 4th Assessment Report of the IPCC and of ad-hoc holistic scenarios of the environmental and economic development in Hamburg and Schleswig-Holstein for the time horizon until 2030;
- A first version of a REM will be available with the components regional atmosphere, regional ocean, land hydrology, atmospheric transport and ocean waves coupled together in a computationally effective manner.

Tools and strategies for coastal monitoring and information management

Objectives
Backbone of any Integrated Coastal Zone Management is the continuous observation of the coastal system in order to identify and quantify (1) trends, (2) natural and anthropogenic causes of changes and (3) effects of measures regarding e.g. the economical use, the introduction of new substances and species or the protection of the coastal environment. Monitoring has to be carried out in an efficient and cost effective way. Thus, the development of a monitoring system comprises (1) advanced measurement and analysis techniques and platforms including quality assurance, (2) efficient sampling strategies including the use of proxy variables and indicators, (3) management of data and derived information, (4) data evaluation techniques including the integration of observational data into models and (5) visualisation of the information for scientific, public, educational and management purposes. Modern concepts also include social and economic variables as well as traditional knowledge.

Implementation
Goal of this work package is to contribute to improved monitoring systems. New observation, data evaluation and visualisation techniques will be developed and tested to a level where they can be integrated into existing or planned monitoring procedures. Thus, the development will be carried out in tight cooperation with national environmental monitoring agencies and international programmes. New techniques for the measurement of trace substances and their biological impacts are dealt with in CO1.

First focus of this work package is to improve the observation and quantitative assessment of the spatial and temporal distribution of indicators and key variables. Main measurement tools will be different remote sensing techniques and automated or autonomous systems, which are operated on fixed platforms, buoys and ships of opportunities, e.g. ferries. Efficient in-situ techniques and procedures will be developed and used for the validation of these data and as complementary measurements, which allow us to extend the spatial and temporal fields to variables, which cannot be observed directly. This part will include e.g. ground observations on tidal flats for mapping the distribution of sediment, organisms and habitats.

Second focus is to optimize the sampling strategy. It will include the analyses of spatial and temporal scales and of the variability of proxy relationships between variables. Representative stations and transects will be identified and the impact of exceptional events and the far field, i.e. regions outside the core monitoring area, will be assessed. Third focus is the assimilation of various monitoring data into models, which will allow us to use the synergy of this data for process studies, analysis of cause – effect relationships on different temporal and spatial scales and for the prediction of possible trends. Fourth focus is the visualisation of results in particular for cases with complex interactions between different variables on different spatial and temporal scales. This should help to make results understandable to other fields of science, to managers and decision makers, and for public and educational purposes.

Deliverables
- Operational prototypes of instruments, procedures and models, which have been tested in form of case studies;
- Toolbox: results will be integrated into a growing, documented toolbox with examples and procedures for measurements, data evaluation, information management, data assimilation and information visualisation.

Operational models for management of coastal areas

Objectives
Management of coastal zones require quite often near real time information and predictions in order to act on events such as flooding, oil spill accidents, navigation of ships or maintenance of offshore structures under bad weather conditions, control of waste water discharge or warning of harmful algal blooms. Like with weather predictions, various data from different geographic positions have to be integrated, assessed and assimilated into a forecast model, which, depending on the problem, operates on a temporal scale of hours or even several months. Goal of this work package is to develop such models to an operational level and to demonstrate and validate their applicability in form of case studies. This work package will be based on monitoring tools and partly extend the measurement capability for real time purposes. On the other hand, the models will also be provided as monitoring tools to integrate data from various sources and to interpolate fields where samples are sparse.

Implementation
The work will comprise the analysis of dynamical processes in the coastal environment, the assessment of appropriate sampling scales and the adaptation of models to those scales and variables which are of interest. As data sources mainly remote sensing (satellite and ground based) as well as autonomous stations on fixed platforms or buoys will be used to get input for those variables, which are of interest for continuously driving and validating the model. However, also dedicated ship campaigns will be necessary for restricted periods to augment the point measurements from in-situ stations and snap shots from satellites e.g. for quantifying cause - effect relationships.

The exploitation of the environmental data and their comparison with the output of numerical models will lead to the capability for flexible data acquisition and adaptation of numerical models. The rapid adaptation of models is especially important for extraordinary events like ship accidents (Pallas disaster) or coastal and river flooding (Odra flood in 1997 and Elbe flood in 2002). To enable the near real time use, the results will be made available immediately to authorities, private organisations and to the public via the internet (e. g. websites of the institutes).

Deliverables
- Operational models for the near real time prediction of critical variables, such as waves, water level during flooding periods, transport of pollutants and harmful algal blooms;
- Numerical models to integrate environmental data from area covering remote sensing data and from long time series of in-situ-sensors;
- Tools for near real time data visualization and publishing;
- Recommendations for mitigating natural and anthropogenic risks and disasters by model based scenarios.

C03: Natural marine resources and mariculture

Objectives
This work package focuses on strategies and rationale for the sustainable use of marine living resources with special emphasis on substances of potential value and methods of marine aquaculture. It aims to investigate natural substances in individual marine organisms and in complex biocoenoses with respect to their natural functions and their potential uses, e.g. as biopharmaceuticals. Of special interest is the understanding of the relationships and interactions in symbioses. Marine organisms have well-developed metabolic capabilities often not found in their terrestrial relatives. Therefore, the potential to discover new, unknown, pharmacologically active substances with diverse properties is very high. Interdisciplinary research, combining the experience of natural sciences with biotechnology and process development is a crucial prerequisite for investigations in this field. Bundling of these expertises will thus act as a nucleus for an innovative centre for research on marine natural substances within the Research Field 2.

Implementation
The work package encompasses taxonomical studies and genetic fingerprinting (DNA-micro-arrays), the isolation and characterization of biopharmaceuticals and the genes involved, the demonstration of their physiological and pharmacological functions and the clarification of signalling pathways (receptor-interactions, ion-channels). Target organisms of interest include selected microorganisms of viruses, bacteria, fungi and algae, as well as selected higher plants, invertebrates and vertebrates. It is anticipated that these research activities will lead to new perspectives in the areas of marine drug discovery, health care and nutrition (food supplements). Together, AWI and GKSS cover this range of expertise

ideally. Whereas the AWI provides the logistics, structural analysis and ecological, molecular, and cell biological research experience, the GKSS contributes expertise in sensitive chemical and instrumental analysis, process development and bio-specific separation.

New techniques in algal culturing are developed on the basis of newly discovered circadian rhythms in growth and photosynthesis. Continuously high growth rates not interrupted by reproduction are achieved by short day length. Macroalgae are coupled with fish or shellfish cultures to prevent excessive nutrient release into the coastal environment. The prospective offshore wind parks will be explored for their potential capacity for mariculture. Therefore, experiments are performed with macroalgal and mussel cultures under open ocean conditions.

Deliverables

- Characterized and purified chemical substances of economic value;
- Techniques and new potentials for sustainable marine aquaculture.

Additional funding

Personnel	Institutional funding			Third party funding		
2002	Scientists	PhD Students	Technicians	Scientists	PhD Students	Technicians
AWI	2	1	0			
GKSS	4	1	2			
total number	6	2	2			

The suggested programme is complete and rests on a reasonable planning of resource. However, there are a number of items, which could be done with considerably better results, if some additional funding would be available. The following list represents a list of suggestions formally originating from GKSS, but which serve joint interests of the program partners GKSS and AWI. There are four areas, for which additional resources would be particularly helpful, related to national infrastructure ("Virtual Institute for Coastal Research"), modelling capabilities for ecosystems and sediments in marginal seas, and "sustainable mariculture". The first three items are planned together with neighbouring universities.

Virtual Institute for Coastal Research

Objectives

Presently the northern part of Germany hosts many research institutes which deal with a variety of coastal research topics. Main players are the University in Oldenburg, including its field station in Wilhelmshaven, the University of Kiel with the research institute in Büsum (FTZ-Westküste). Another institute closely involved in coastal research is the IOW in Warnemünde, with main research items in the Baltic Sea. As Helmsholtz-Centers, both AWI and GKSS host significant groups dealing with coastal research.

So far, the activities between all of the institutions are not optimally coordinated. The need and goodwill for an improved cooperation and collaboration was documented in February 2002, when almost all scientific institutions as well as many stakeholders joined the workshop "Horizonte der Küstenforschung" ("Horizons of Coastal Research") in Hamburg. From such an improved cooperation, a better competitive situation for the German coastal

research, a better embedding into the international arena (LOICZ), a better division of labour as well as a better utilization of the broad range of competences is expected. It is suggested to form a kind of virtual German Coastal Research institute, serving the community in these matters.

Implementation
GKSS and AWI want to set up a joint office as a national focal point for coastal research, both on a national as well as an international basis. The responsibility for this office shall be shared among GKSS, AWI and IOW. A project office of the international LOICZ program will be established, also a liaison with the Dutch EU-FP 6 coordinated ENCore initiative will be provided. Furthermore, the office will continue the recently initiated “Coastal Schools” for PhD and master students. Also, the office will help to provide the community with the different infrastructure facilities, such as small ships and laboratories, offered by AWI and GKSS. The office will also offer relevant information to the public and intends to eventually set up a regional international Academy of Coastal Issues.

Ecosystem-modelling

Objectives
Since the last two decades modelling of whole ecosystems has become a subdiscipline in ecology. Nowadays many people are actively engaged in modelling primary processes of phytoplankton growth and succession up to population dynamics of marine mammals and seabirds. Due to a basic lack of knowledge on the principles of distribution and behaviour, the latter attempts are still in its infancy. More successful are modelling exercises on the relationships of phytoplankton growth based on nutrient concentrations including the transport of organisms by water currents and tidal movements. Many people call these models ‘ecosystem’ models although they only contain a minimal part of the biological complexity of ecosystems. Recently inverse modelling has been adopted as an alternative to ‘standard’ carbon or nutrient based models.

Before such models can be applied, i.e. short term forecasting, and long term simulation and reconstruction, further efforts are needed. These efforts are related to direct links to available on-line and archived long-term data, including mechanisms for data assimilation; population dynamic dynamics containing detailed data on population structure, mechanisms for their distribution, or life cycle characteristics.

Implementation
GKSS, AWI and University of Kiel have agreed on a joint effort to build a group in the field of eco-system modelling, which may serve both the operational monitoring purposes and the reconstruction of long-term variations and changes in the North Sea. Dependent on the purpose, the model will feature different key ecological variables, dynamics and complexities. In both cases, the main purpose of the models is the provision of realistic time-space detail of the ecosystem, which is enforced by assimilating observational data. The output of such models will be used to unravel the complexity and to construct suitable conceptual models. These models, both operational and long term versions, are needed to construct the operational model and the REM needed in the work packages of the programme topic C.

Quantifying the role of sediments in nutrient cycles of marginal seas

Objectives
Nutrient cycles in coastal seas of Europe have seemingly changed with the additional loading by human activities over the last decades. Based on new and preliminary results from the Baltic Sea, we postulate that currently accepted concepts and models are in error, and that natural processes by far dominate the nutrient cycles. This hypothesis is supported by recent re-evaluation of P-reflux from anoxic sediments and from distribution patterns of stable nitrogen isotopes in surface sediments. Existing modelling tools to describe the nutrient cycles treat sediments as sinks for nutrients only. They neglect their role as reservoirs of mobile phosphorus on the one hand, and underestimate their role as sinks of nitrate due to denitrification on the other hand. Despite of these tacitly accepted shortcomings, such deficient models are currently the basis for defining targets in international treaties aiming to reduce anthropogenic loads and to restore the coastal sea environments to conditions before the influence of man – at immense costs to the national economies. To alleviate these shortcomings requires the creation of internally consistent, spatially resolved data sets on the biogeochemical role of sediments.

Implementation
In a joint effort with the Institute for Marine Biogeochemistry of the University of Hamburg, the role of sediments in nutrient cycles of the North Sea and Baltic Sea shall be studied. Emphasis will be given on establishing definitive estimates of nutrient element (N, P) burial rates, of diagenetic nutrient reflux from oxic and anoxic sediments, and loss of nitrate to denitrification. These activities require extensive field studies. In a novel approach, results of empirical studies will be collected in a geographical information system, which will serve as the basis to integrate spatially resolved sedimentary sinks and sources with numerical models of diagenesis in different sediment types.

Deliverables will include gridded data sets and (electonic) maps of biogeochemical properties of sediments, their capacity as nutrient sinks and sources, and their capacity to eliminate or to liberate nutrients under changed hydrographic and redox status. These data will be made available for existing ecosystem models of both seas (North Sea: ERSEM, Baltic Sea: ERGOM), and thus directly enter the efforts for operational and long term modelling of the coastal seas.

Sustainable mariculture

Objective
While traditional exploitation of living marine resources is approaching or has surpassed unsustainable conditions, mariculture is becoming the prime alternative. However, in the case of salmon farming, mussel cultures or shrimp ponds, cascades of undesirable effects are evident as well. The challenge is to develop mariculture techniques which meet the criteria of sustainability. Available expertise in AWI and GKSS are a prerequisite for a successful mariculture endeavour.

Implementation
Generally, there are two ways to achieve this goal. Poly-cultures have the advantage to minimize demand on external sources as as well as the amounts of effluents. For example: fish may be fed with cultured food, and algae are employed to filter nutrients form the discharges. These algae may then be further used to feed grazing snails of high commercial value. In this way, culture systems are developed with little effect on the coastal environment.

Harmful effects of fish and shellfish cultures develop particularly in embayments and other inshore sites with stagnant or slowly flowing waters. Techniques need to be developed which allow maintaining these cultures in offshore regions where a larger water body passing the cultures mitigates or even solves the problems encountered further inshore. Mariculture in offshore regions is best to be combined with other users such as offshore windparks. Here storm surges constitute the major technical challenge.

It is intended to conduct the experimental phase of these novel mariculture techniques to allow for the outsourcing of aquaculture companies and to export expertise to other coasts worldwide.

3.3 Programme Topic POL: Polar Systems
(Spokesman: Prof. Dr. Peter Lemke)

Personnel	Institutional funding			Third party funding		
2002	Scientists	PhD Students	Technicians	Scientists	PhD Students	Technicians
AWI	108	41	45	37	34	20

Polar processes and climate

Polar regions are the areas on earth where the influence of the cryosphere is a dominating factor. The particular significance of polar regions becomes evident when considering that about 90% of the volume of the world's oceans, comprising the deep cold waters, is connected to only 10% of their surface area, and most of these ventilation windows lie in the polar regions. Very specific physical and chemical processes shape this environment. Through atmospheric and oceanic teleconnections they influence the global environment and its changes. Examples are the formation of cold air above the white, highly reflective snow and ice surfaces; the production of cold, dense water masses, which drive global atmospheric and oceanic circulation; the seasonal cycles in sea ice extent and thickness with resulting changes in ocean-atmosphere coupling; and the specific conditions for chemical reactions in the stratosphere during polar winters.

Sea ice cover changes, as part of the surface freshwater flux, also play an important role within the system. At the same time, sea ice acts as a habitat for many species of marine flora and fauna and sea ice physics are influenced by the biological components living in the brine channels. Sea ice allows primary productivity to be high even under very harsh environmental conditions. The Antarctic Circumpolar Current system effectively tends to isolate the Southern Ocean system but communicates matter and heat with the oceans to the north, whereas continents surround the Arctic Ocean, allowing for only one deep-water passage. Continental ice sheets are a further special characteristic, acting as integral parts of the climate system by responding on the one hand to changes in external forcing, on the other hand driving changes e. g. by altering global albedo while growing or shrinking. They also act as archives of palaeoclimate. Polar ice cores are unique because, of all palaeorecords, they are most directly linked with the atmosphere and contain information for many forcing factors of climate. Polar marine ecosystems and organisms are special in that they live under conditions of permanent cold, extreme seasonality and food shortage.

Challenges for our research
Global change is a result of external forcing and internal interactions. It is a response to regional processes via large-scale dynamical mechanisms. Predominant areas in this regard are polar regions and we therefore need to understand processes in polar regions and their role within the earth system. This will be achieved by

- *Quantification of lithosphere-ocean-cryosphere-atmosphere interaction*
  Central research subjects are the study of dominating physical, geological, biological and chemical processes from the polar seafloor through the hydrosphere – cryosphere – atmosphere system, which govern the temporal evolution of climate and the biota. The aim is to understand polar processes, their global significance and their consequences, to describe climate and ecosystem states and to enhance our ability to predict future changes. This requires that the global climate system be studied with special emphasis on polar regions with the aid of regional models of

ocean, sea ice, land ice and atmosphere and considering past, recent and plausible future climate and ecosystem development.

- *Identification of key processes responsible for recent changes*
  The past few decades provide a substantial wealth of fairly accurate data of parts of the climate- and ecosystems, which allows an initial comparison to and optimisation of numerical models. In order to enhance our understanding of key processes and to improve the basis for earth system models to include physical and biogeochemical components, integrated data sets have to be developed. This requires new observational and modelling techniques for the study of processes and their relation to global change. The time-scales involved in these activities range from days to decades.

- *Reconstruction of global climate cycles from polar archives*
  To better understand the role of polar regions in the global climate system it is necessary to reconstruct the interactions of the geosphere, hydrosphere, cryosphere, atmosphere and biosphere during natural climate variations, especially during the more recent geologic past. Important information in this context can be gained by plate tectonic reconstruction of polar deep-sea basins, of their continental margins together with the definition of structures of their sedimentary cover, which also yields palaeo proxies defining past oceanic states. In the marine realm, species extinction, subsequent radiation and recent distribution reflect processes in the past and the tradeoffs and constraints in adaptation. In the terrestrial realm environmental change is documented in permafrost layers and lake sediments. Studies of fluxes in permafrost regions contribute to understanding of the global carbon cycle. The climate archive, preserved in ice sheets and opened by ice coring, allows the reconstruction of changing climate and ocean – atmosphere - lithosphere interaction as well as the dynamic response of ice sheets which leads to more reliable modelling of future scenarios and their contribution to sea level change. The palaeoclimatic diagnostics from ice and polar sediment cores will be interpreted using regional climate models of varying complexity in order to derive a better understanding of climate change during the past glacial cycles. In the biological context these findings will be applied to understand the role of polar regions, especially Antarctica, as evolutionary centres leading to characteristic patterns of species formation and biodiversity.

- *Understanding the role of the changing polar environment for biogeography and biodiversity and definition of the mechanistic role of climate factors in evolution*
  Important research questions are environmental variability in relation to stress tolerance and resilience of polar organisms and ecosystems. The role of key organisms in trophic webs and biogeochemical processes with global relevance are of special interest. Dominant species, which are adapted to their physicochemical environment and characterized by specific biological interactions, define the structure of ecosystems and seem to be particularly sensitive to environmental change in these regions.

Work plan and networking

The research activities in Topic POL are carried out by physical, biological and geological working groups at AWI. Many of the work packages are characterised by interdisciplinary collaboration between these working groups. In work package

POL 1: Processes and interactions in the polar climate system

we will address

- Physics of processes in polar regions;
- Atmospheric circulation structures and scenarios of polar climate changes;
- Trace constituents in the polar atmosphere;
- Ice sheet dynamics, mass balance and lithospheric response,

where the research is focussed on mechanisms regulating key processes in atmosphere, ocean, sea ice and ice sheets together with the interactions (like exchange of energy, mass, momentum, freezing and melting) between these components. An application of these findings will be performed in studies where polar climate and its changes on time-scales from seasons to decades, both for the Arctic and Antarctic, are investigated with coupled regional climate models involving atmosphere, ice, ocean, land and snow components. Contributions to these activities will come from investigations of the variability of atmospheric aerosols and trace gases, which are studied with new remote sensing techniques and advanced regional modelling to assess their influence on the polar climate system. On longer time-scales the variability and stability of ice sheets is addressed with special emphasis on outlet glaciers, ice stream behaviour and flow mechanisms using new observational techniques and improved 3-D-thermomechanical models.

In work package

POL 2: Southern Ocean climate and ecosystem,

we will integrate the physical, chemical, biological and geological disciplines of the ocean sciences and combine observations, experiments and models to

- identify changes in and links between physical, chemical and biological processes that regulate biogeochemical fluxes;
- develop new biological and geochemical proxies for improved interpretation of the palaeo records;
- explore sea-ice climate feedback mechanisms and their role in the ecosystem;
- provide input to improve models to hindcast and forecast climate change.

Our focus is on the poorly explored Southern Ocean and its major feature, the Antarctic Circumpolar Current, because of its key role in ocean circulation and the carbon cycle and hence global climate.

In work package

POL 3: Variations of the Arctic physical environment

we will combine activities with the aim to understand the origin and structure of the variability of the Arctic Ocean and its heat and fresh water fluxes in present and past climate regimes with a special focus on

- Arctic changes in the current climate state;
- the glacial history of the Arctic;
- the role of Arctic river runoff.

This work package is based on a collaboration of meteorological, sea ice, oceanographic and geological working groups, and it combines observational and modelling efforts.

In work package

POL 4: Benthic organisms in polar marine food webs

we will focus on
- Trophic relations of benthic organisms in polar marine food webs;
- Role of temperature, oxygen and CO_2 in evolution;
- Response of polar marine life to recent change.

Organisms within their food webs are investigated to address the question to what extent specific adaptations of species shape the trophic food web in polar regions and affect the overall energy flow. We plan to identify the driving forces of climate driven evolution as well as the tradeoffs and constraints in adaptation. On a shorter time-scale the response of polar marine life to recent change is investigated with respect to marine ecosystems that are subject to fluctuations and sudden shifts of environmental factors ranging from climate change (NAO, ENSO, etc.) to pollution.

The work package

POL 5: Autecology of planktonic key species and groups

will be investigated because
- key species shape the structure of pelagic ecosystems in relation to biogeochemical fluxes;
- biogeochemical cycles are driven by trophic interactions among a yet unknown range of species;
- key species have evolved mechanical and chemical defense systems.

Ocean biogeochemistry is seen as a major regulator of atmospheric CO_2 concentration. As biogeochemical cycles are driven by trophic interactions within the pelagic food webs we try to achieve a better mechanistic understanding of the wax and wane of involved key organisms, including factors ranging from physico-chemical characteristics of the environment to interactions with other organisms.

In work package

POL 6 Earth climate variability since the Pliocene

we will address
- mechanisms of climate change on a variety of time-scales;
- inter-hemispheric connections;
- the role of the cryosphere in climate variations;
- physical and biological processes that regulate atmospheric CO_2.

Information is collected and analysed from documentations in continental ice, permafrost and marine sediment cores, which represent unique archives of the phase and amplitude of climatic change on seasonal to millennial time scales.

The work package

POL 7: From permafrost to deep sea in the Arctic

will focus on

- The role of permafrost-coasts in the Arctic system;
- Methane budgets in terrestrial and marine polar environments;
- Benthic diversity and fluxes in the polar deep-sea.

The work package aims to identify and understand the key processes controlling Arctic coastal dynamics and especially the associated material fluxes and methane emissions and their role in the entire Arctic System. One objective is to study formation, pathways and fate of methane in different Arctic terrestrial and marine environments and to assess their contribution to the global methane cycle. We will extend our research into the arctic deep-sea to identify key factors governing functional benthic biodiversity from a biological, geological and geochemical perspective using free falling lander systems, long-term experiments and observations with ROVs and AUVs.

For “Additional Funding“ we propose two work package

New keys to polar climate archives
Under this heading we propose research aimed at developing new proxies for polar climate archives, their validation with observed changes and their determination for longer time series.

Portal for earth and environmental sciences in polar regions
which is proposed to provide to the scientific community a basis to foster cross-institutional cooperation in polar studies within Europe and to improve the scientific planning of future expeditions.

Synergy
The research within Topic POL is based on field work including experiments and long-term observations, using ice breaking research vessels, ocean observing systems, and permanent as well as temporary polar stations or camps. The field component is enhanced by increasing use of remote sensing techniques which need to be specially verified by ground-truth measurements. There is an inherent linkage between such field work and modelling efforts, using models to define key areas and parameters to be measured and to facilitate interpretation of field data. Results from fieldwork in return serve to optimise and validate model results. Most of the research in Topic POL is embedded in the relevant projects of the World Climate Research Programme, the International Geosphere-Biosphere Programme and DIVERSITAS.

Topic POL has strong connections to Topic MAR with respect to exchanging information on process dynamics and teleconnection mechanisms, and to Topic CO concerning the comparisons between Arctic and mid-latitude coastal regions. An interface with the Programme 2 “Atmosphere and Climate” is present for research in the troposphere within the TRACKS project and for the investigations concerning trace constituents in the atmosphere (POL 1). Very strong links exist with Programme 1 (GFZ) for a number of topics und synergies in the geophysical disciplines will be exploited.

Work packages

POL 1: Processes and interactions in the polar climate system

Physics of processes in polar regions

Objectives
A clear understanding of the physical processes which determine the interaction between ocean, ice, and atmosphere on different space and time scales strongly contributes to improving the interpretation and simulation of climate states and their changes. Our research will focus on the assessment of the exchange of energy, mass (H_2O and other trace constituents), and momentum between the polar subsystems together with the identification of the controlling parameters and investigation of the related processes within each of the subsystems. Key processes to be studied are, among others, cloud and precipitation formation, impact of aerosols, horizontal and vertical transports in the atmospheric boundary layer over the polar ocean and over inhomogeneous ice surface, growth, decay and transport of sea ice, shelf ice, and icebergs, and convection of dense water along the continental slope, triggered by ice formation.

Furthermore, diffusion of trace gases within snow and their transfer between snow and atmosphere will be investigated to support the interpretation of ice core signals. Studies on the feedback between atmospheric processes in polar and in extra polar regions will be carried out in cooperation with other HGF-institutes (TRACKS, see Programme “Atmosphere and Climate”).

The research contributes to a consistent picture of the role of polar processes in the climate system, and it supports the quantification of key processes responsible for polar changes.

Implementation
The recognition and assessment of key processes will be based on interpretation of observational data sets and on modelling results. Many of the required data sets have to be gained from measuring campaigns using "Polarstern" and the research aircrafts in both polar regions. “Polarstern” will be used e.g. as a drifting platform to study ocean-ice-atmosphere interactions in the western Weddell Sea. Data sets and logistic facilities are also provided by the Neumayer, Kohnen, and Koldewey Stations. Advanced remote sensing facilities will be used to deduce spatially and temporally continuous fields of physical parameters (especially those for sea ice), which requires the derivation of adequate retrieval algorithms.

Conceptual and complex numerical models are used for simulation studies. Examples for complex models used at the AWI are the operational weather forecast model 'Lokal-Modell' of DWD, the small-scale research model 'METRAS', the regional climate model REMO, and the ocean - sea ice model system 'BRIOS'. Further development of the models is required, e.g. for some parameterisations and for improved representation of the other subsystems. Simulations of idealized situations, case studies for observed situations, and sensitivity studies are to be performed and to be analysed.

Deliverables
- Quantification of the freshwater budget in the Weddell Sea, the Arctic Ocean and the Greenland and Labrador Seas;
- Estimation of sea ice changes and development of a technique for monitoring thin ice areas by means of remote sensing data;

- Quantification of the effect of ice characteristics on the structure of the atmospheric boundary layer over ocean and ice.

Atmospheric circulation structures and scenarios of polar climate changes

Objectives
The investigation of the polar climate and its variability requires the holistic view of a coupled atmosphere-ocean-ice-land-snow system. Both, non-linear interactions and feedbacks between these climate subsystems – due to energy-, water-, momentum-, and trace gas fluxes, among and within each of these subsystems – contribute to the observed climate variability and can cause climate anomalies. The main objective is the understanding, quantification and reconstruction of the natural variability of the coupled atmosphere-ocean-ice-land-snow system on timescales ranging from seasons to decades, both for the Arctic and Antarctic regions. Regional climate models are a suitable tool to derive reliable assessments of regional climate and environmental changes. Improved regional models will be used to develop reliable scenarios of regional polar climate changes and its impact on the status of the marine and terrestrial ecosystems.

Implementation
Seasonal to decadal simulations with regional climate models (HIRHAM) of the Arctic and Antarctic will be carried out to study the natural variability and to quantify the responsible key processes and feedbacks. The main focus lies on the investigation of the atmosphere-land-snow and atmosphere-sea ice processes and interactions. Future scenarios and time-slices from the past, determined by means of General Circulation Models, will be downscaled with regional models, helping to derive a regional assessment of changes in the climate (changes in extreme events, storm tracks, hydrological cycle, permafrost distribution, glaciers mass balances). Marine and terrestrial ecosystem models will be forced with the simulated natural variability and future/past changes to determine the impact of different scenarios on the status and vulnerability of the ecosystem. Regional climate models will be applied to the Antarctic to study atmospheric dynamics and variability due to various internal and external mechanisms and to compare the results with these from the Arctic.

Deliverables
- Reconstruction of atmospheric circulation structures within the Arctic atmosphere-ice-ocean-land-snow system responsible for recent and future changes;
- Assessment of polar climate variability and change on the regional scale for the European North, Arctic and Antarctic and its impact on the ecosystem.

Trace constituents in the polar atmosphere

Objectives
The variability of atmospheric aerosols and trace gases exert a strong influence on the polar climate system. To predict the evolution of the troposphere-stratosphere system and the coupling to the biosphere, comprehensive information about the vertical and horizontal distribution of water vapour, aerosol, ozone and other trace gases and their temporal variability is required. Improving the data availability of trace constituents during the next decade due to new remote sensing instruments and techniques, advanced regional modelling will allow determining the feedback mechanisms between changing trace constituents, atmospheric circulation structures and biological impacts.

Implementation
The representation of key processes that regulate the distribution of trace constituents on seasonal to decadal time scales in polar regions will be improved in coupled chemistry climate models by deriving advanced diagnostics of the basic transport and chemical mechanisms. Particular emphasis is on ozone in the stratosphere, which has strong impacts on the ultra-violet radiation at the earth's surface and on the biosphere. To improve the representation of these processes in coupled chemistry climate models, advanced diagnostics will be derived. Vertical coupling in the troposphere-stratosphere system will be investigated by analysing turbulence, gravity waves, and meso-scale dynamical processes and their signatures in the aerosol, water vapour, and other meteorological data. Seasonal variation of the direct and indirect climate effects of the tropospheric aerosol loading will be established by analysing multi year data sets. The atmospheric contribution to the hydrological cycle will be determined by analysing the spatial and seasonal distribution and variation of water vapour. For the above goals we will apply new measurement techniques at our polar stations, conduct air-borne campaigns and apply advanced regional climate and chemical transport models. Our work will rely on observations in a network of research stations, satellite measurements and long-term meteorological data sets.

Deliverables
- Improved predictions of future ozone levels;
- Quantification of aerosol and water vapour variability in polar regions.

Ice sheet dynamics, mass balance and lithospheric response

Objectives
Since polar ice sheets are major factors effecting global climate and at the same time react to it we need to understand the dynamic behaviour and response times, which can vary in the range from centuries to hundreds of thousands of years. In general ice sheets are fairly stable, but there is some evidence for unstable behaviour. We need to assess this possibility in order to more confidently work out future scenarios and we also need to narrow the bounds on the present mass balance in order to study its temporal changes. Of special importance will be the study of outlet glaciers, ice stream behaviour and flow mechanisms. This closely links into determining causes for rapid iceshelf disintegration and ensuing possible influences on ice sheet behaviour.

Implementation
Simulations on all relevant timescales will be carried out using advanced thermo-mechanical models of ice sheet dynamics, which will incorporate ice sheet-lithosphere response and which will be developed further in order to include anisotropic flow laws of ice and rapidly changing conditions at the ice-bedrock interface for ice stream simulation. These simulations will be augmented by remote sensing data on ice sheet surface elevation changes, surface velocities and their directions using a number of ongoing and future satellite missions such as ERS1/2, RADARSAT, GRACE, GOCE, CRYOSAT and ICESAT. Some of these data sets will also allow constant monitoring of ice shelf behaviour, which will give early warning of impeding break-up and thereby possibly allow appropriate field observations. In addition, further detailed boundary values for model runs will be provided by dedicated aerogeophysical investigations on total ice thickness and ice sheet internal structures in key areas.

Deliverables
- Improved 3D-thermomechanical models of ice dynamics;
- New high resolution, high precision datasets on ice sheet geometry and its changes;
- Improved projections of change under different future scenarios.

POL 2: Southern Ocean climate and ecosystem

Objectives
The overarching goal of the proposed research is to deliver improved scientific understanding of climate change that could result *inter alia* from anthropogenic CO_2 emissions. Knowledge of the processes governing the recurring patterns of CO_2 variations in the past is a prerequisite to forecasting future climate development. The research effort will focus on the poorly explored Southern Ocean because of its crucial role in the global climate machinery.

A major feature of the Southern Ocean is the broad ring of cold water - the Antarctic Circumpolar Current (ACC) - which encircles Antarctica and isolates its ice cap from warming. The ACC connects all the other oceans and thus plays an important role in the global heat and freshwater transports and ocean-wide biogeochemical cycles. It harbours a series of unique and distinct ecosystems along concentric, zonal bands that displace each other with changing climate regimes as indicated in the sedimentary record. Due to the upwelling of deep water masses from all ocean basins in the Antarctic Divergence the plant nutrient concentrations are the highest worldwide in the surface open ocean. These concentrations could support much higher phytoplankton primary production and hence CO_2 uptake than observed. The paradoxically low rates of primary production have been attributed to insufficient light availability due to wind-driven deep mixing, limiting concentrations of trace nutrients such as dissolved iron, or heavy grazing by zooplankton. Recently, a series of open ocean experiments have demonstrated that addition of small quantities of dissolved iron results in dramatic phytoplankton biomass build-up. Since the glacial CO_2 minima correlate well with aeolian deposition of iron-rich dust on the ACC, a strong case has been made that phytoplankton blooms represent a significant sink of atmospheric CO_2 during glacial periods. However, since the fate of biomass produced by iron fertilization has not yet been documented, the role of the ACC as a potential sink of CO_2 has yet to be demonstrated.

The complexity of interacting processes, which determine the internal and external forcing and amplification mechanisms of climate change, shall be elucidated by integrating physical, chemical, biological and geological disciplines of the ocean sciences and by coordinating field observations, experiments and modelling exercises.

Implementation
Research activities will be focussed on enhancing our ability to reconstruct past environmental conditions and productivity regimes from *sediment cores*, collected in different regions of the ACC, by identifying links between physical processes in the water column and the generation of the sediment record. Identification of habitat preferences of plankton key species, the remains of which are preserved in the sediments, will constitute a major step forward in this direction.

The pelagic environment of the phytoplankton, zooplankton and also higher trophic levels is determined by general hydrographic conditions and by mesoscale ocean dynamics, which will be studied by finescale ocean surveys. The mesoscale dynamics moreover account for the equatorward subduction of intermediate waters, which either carry with them the unused nutrients or their equivalent in biogenic carbon. Finescale surveys will help to improve our understanding of the interaction between the mesoscale dynamics and the turbulent motions in the mixed layer, and the exchange of matter between the mixed layer and the stratified ocean below.

In-situ iron fertilization experiments in the open ocean are a powerful method to test hypotheses about ecosystem response and concomitant biogeochemical fluxes. The next

experiment (EIFEX) currently being planned will focus on the iron-driven deep CO_2 drawdown after a longer-lasting bloom.

Time series of daily to decadal variability in the kinematic and hydrographic properties will be recorded through a three-pronged observational approach: a) the continuation of one decade of temporally highly resolved velocity and hydrographic measurements at selected mooring sites and repeat stations, b) by means of ice-adapted ARGO compatible profiling floats, and c) integral measurements of the ACC strength with Pressure Inverted Echo Sounders deployed along selected TOPEX-Poseidon satellite ground-track crossover points. Meteorological data taken routinely at the Neumayer station observatory are instrumental for weather models needed to relate the ocean variability to a possible atmospheric forcing.

Remote sensing will be employed to obtain data of sea surface height variability needed for assimilation in circulation models and to reveal horizontal distribution patterns as well as the seasonal to interannual variability of the near-surface phytoplankton chlorophyll concentration. Remote sensing will also be used to map the large-scale variations of the sea ice cover that limits the open ocean zone of the Antarctic Circumpolar Current to the south.

Ship-board sea-ice research will be conducted to better understand the mechanisms which affect this geophysical variable that is most sensitive to climate variability and plays a crucial role in climate system feedback mechanisms. Sea ice controls the magnitude of pelagic primary production by virtue of its influence on light penetration and buoyancy fluxes, and provides a habitat for organisms living in its brine channels and pockets. Work conducted during the planned cruise ISPOL will contribute to identify key organisms which are typical for different types of sea ice and are preserved in the sediment.

Modelling will be an integral part of all approaches listed above. The foreseeable increase in computer power renders our ambitious plans to develop circum-Antarctic or even global, eddy-resolving, coupled models of ocean circulation, sea ice and biology, feasible. We will also study the interaction between the ocean, the continental shelves and the ice shelves, with special emphasis on the iceberg-mediated supply of iron to the sea. Runs of large-scale models for selected time slices, as for instance the Last Glacial Maximum, are planned to hindcast palaeoceanographic conditions. Data assimilation into regionally focussed circulation models will be employed to support the analysis of existing data sets as well as the design of future ocean surveys. Mechanistic models on the scale of single species populations are being developed in order to derive reliable interpretations of palaeo-proxies as, for example, isotopic composition and elemental ratios in foraminiferal shells. Inverse modelling techniques will be further improved and applied to global data sets to diagnose the biological productivity of the ocean and the export of carbon and nutrients into the deep sea and sediments.

Deliverables

- Documentation of changes in physical, chemical and biological properties that are currently underway in the circumpolar Southern Ocean;
- Identification of major links between physical, chemical and biological variability;
- Development of new biological and geochemical proxies for improved interpretation of the palaeo-record archived in sediments;
- Reconstruction of the palaeo-environment for selected time slices representing climate end-members as well as transitions during the last glacial-interglacial cycles;
- Contribution to quantifying modern and past global biogeochemical fluxes;
- Assessment of the feasibility and risks of large-scale iron-fertilization as a geo-engineering option to mitigate the greenhouse gas problem.

POL 3: Variations of the Arctic physical environment

Objectives
Our aim is to investigate the origin and structure of the variability of the Arctic Ocean circulation and its heat and fresh water fluxes in present and past climate states. In the recent past significant changes were observed in the Arctic: A warmer atmosphere was associated with thawing of Siberian permafrost and glaciers, increase of precipitation and of river discharge, and at the same time warming of intermediate water, decrease of the ice cover, changes in the ocean circulation patterns and weakening of the stability of the water column ("retreat of the halocline") occurred. These changes are closely linked to the variability of hemispheric atmospheric patterns like the NAO or the AO. All these changes impose substantial consequences for the biological system and for the climate on a global scale. According to model results, the Arctic fresh water balance has a strong influence on the meridional overturning circulation in the Atlantic. River runoff/ocean/ice changes are also expected to have a strong feedback to the atmosphere through changes in the heat exchange between ocean and atmosphere. The recent variations have been qualitatively reproduced by atmospherically driven ice/ocean GCMs. Yet it is unclear whether the Arctic environment is shifting into a state different from the past decades or if we observe a phase of an oscillatory pattern.

Implementation
To understand past changes of the Arctic system and to estimate future developments a close linkage between direct observations, high-resolution palaeorecords and modelling efforts is essential. Models will be used to provide integration of individual observations into a larger context and to explain causalities. To control model simulations, multiyear observations of critical parameters in key areas are necessary. Vice versa, models will assist in modification of observational strategies. Hindcast, scenario and time slice experiments with a detailed ocean-sea ice model of the Arctic-Atlantic domain will be conducted. Atmospheric forcing will be constructed from NAO anomaly patterns and will be taken from global warming scenarios with coupled GCMs.

Observational time series of key parameters of ice and ocean in key areas will be continued with stronger automatisation implemented. The main tool to obtain sustained ocean and ice measurements are moored, drifting (HAFOS) and airborne (HEM bird) systems specially designed to operate in ice-covered oceans in combination with remote sensing. High-resolution micro-palaeontological and sedimentological tracers and icecore records will be used to reconstruct the fresh-water discharge and transport pathways of terrigenous matter in the Eurasian Arctic and its variability on timescales from10^2 to 10^5 years. Influences of sea-level change and extent of glacial ice sheets will be considered. Proxy records will be simulated in models.

Deliverables
- Development and implementation of systematic observation systems for the ocean (HAFOS) and sea ice thickness;
- Records of palaeo river discharge in key cores from the Eurasian marginal seas and sedimentary budgets of terrigenous input in relation to climate change;
- Reconstruction of extent and history of Northern Hemisphere glacial ice sheets.

POL 4: Benthic organisms in polar marine food webs

Trophic relations of benthic organisms in polar marine food webs

Objectives
The question will be addressed to what extent species-specific adaptations shape the trophic web in polar regions and influence the overall energy flow. The relationship between food availability and specific life traits in polar marine ectotherms such as slow growth and late first maturity is of particular interest in comparison to organisms from warmer climates. What distinguishes polar trophic systems from those in temperate, upwelling, and warm tropical regions and how do they react to continued global warming and/or anthropogenic impact? The hypothesis will be tested that compensatory strategies, such as suspension feeding on the microbial food web, scavenging or carnivory, are predominant and make polar animals largely independent of the seasonal input. Moreover, to what extent are there differences between the Southern and Arctic Ocean systems, which differ in age and degree of isolation from surrounding oceans and shelves?

Implementation
A first step is to intensify the study of feeding habits of key polar species and find out whether the patterns encountered in the few cases analysed are of general significance. Trophic adaptations to low temperatures and presumed food shortage shall be investigated on the cellular and organismic levels, including the mechanisms eliciting metabolic depression, as a precondition for the capability of surviving extended periods without food. Balanced energy flow modelling will enable us to analyse polar ecosystems quantitatively and to compare them with other ecosystems on the level of system properties. This part of the programme will build on previous attempts to develop high Antarctic models and on the increasing number of models published for other marine systems.

Deliverables
- Clarify key trophic traits in polar ecosystems with emphasis on differences between the two polar systems, as a base for continued modelling;
- Scenarios how polar food webs will react to continued climate change and/or anthropogenic impact, and to what extent this will alter the availability of living resources.

Role of temperature, oxygen and CO_2 in evolution

Objectives
Large scale climate oscillations in earth history have most likely influenced the course of evolution and shaped biogeographic patterns; however, the driving forces involved are only vaguely understood. Huge climate oscillations have likely contributed to mass extinctions. The latter have generated room for increasing levels of organismic complexity, perfection and performance. Rapid changes in CO_2 concentrations are seen as a key to such evolutionary crises in the marine realm, however, cooling events may also have played an important role. Limited capacity of species to adapt to low but unstable temperatures may contribute to the decrease in biodiversity of marine macrofauna towards high northern latitudes. This trend is not observed in the south.

This project is to identify the driving forces of climate driven evolution as well as the associated tradeoffs and constraints in adaptation. For this purpose, the limiting and interacting roles of changes in temperature, CO_2 and oxygen will be investigated in extant organisms in order to understand their relevance for the evolutionary gain in organismic size, functional complexity and performance. Temperature dependent modifications in

energy budgets will be qualified as they may characterize all species of an ecosystem and form the basis of biodiversity and ecosystem structure and functioning. In polar areas particularly interesting cases to be studied are the consequences of glacial advances and retreats and the break-up of Gondwana with the resultant biogeographic patterns in Antarctica and the surrounding continents.

Implementation
An interdisciplinary blend of physiology, ecology, molecular and evolutionary biology will be applied to arrive at an understanding of the dynamics and patterns of evolution and macro-ecology. Palaeoclimate scenarios, plate tectonics, icecap variability, resulting changes in ocean currents and stratification as well as the separation, collision or displacement of species assemblages will be considered. Integrated molecular to organismic studies are expected to identify the unifying physiological and biochemical mechanisms and their genetic underpinning that have shaped the climate dependent evolutionary success or failure of macroorganisms. The reasons for the adaptive specialisation of higher organisms and their ecosystems will be addressed by comparisons of extant populations from polar and warmer climates.

Deliverables
- Develop a cause and effect understanding, how climate factors, molecular and cellular design as well as physiological and ecological performance are interrelated;
- Scenarios of the development of various levels of organismic energy turnover as well as associated macro-ecological patterns.

Response of polar marine life to recent change

Objectives
Marine ecosystems are subjected to fluctuations and, sometimes, sudden shifts of environmental factors, ranging from climate change to pollution (e.g. NAO, ENSO, iceberg scour, ice winters, current regimes and storms, thermal and UV extremes, oxygen deficiency, trawling, waste disposal). Their impact on fauna and flora depend on type, spatial scale, duration, severity, and the degree of reversibility of the disturbant as well as organismic resistance. Major ecosystem changes result such as shifts in geographic distribution, changes in ecosystem structure and functioning, in biodiversity and complexity. In the marine realm, ecosystem resilience is inversely related to system complexity. Ecosystem age, constancy of environmental conditions, (intermediate) disturbances and habitat complexity have been suggested as potential factors determining biodiversity.

The goal of this project is to investigate response patterns of reaction to disturbances and determine the levels at which those reactions occur, considering (i) the individual organism, its stress resistance and acclimation potential; (ii) the population as a genetic unity, based on the flexibility and specific capabilities as well as maximum performance levels of individuals; (iii) the assemblage as an interactive association of species populations and (iv) the ecosystem level defined, among others, by such properties as productivity, maturity and biodiversity.

Implementation
To arrive at this goal, the effects of sudden environmental change on organismic performance and resistance will be studied, as well as the consequences at the assemblage and ecosystem levels, e.g. for resilience, persistence, distribution and biodiversity. Effects of climate forcing, natural disturbances and anthropogenic stresses on marine fauna and flora will be elaborated in polar and compared to non-polar ecosystems (Antarctic continental shelf to Magellan, Arctic to North Sea, Humboldt Current), using field

and laboratory analyses. Unifying principles of disturbance effects and subsequent recovery will be identified empirically and experimentally, both involving studies of succession. An interdisciplinary integration of ecology and physiology is expected to provide a cause and effect understanding of the patterns involved.

Deliverables

- Identify principal factors that determine the selection of specific habitats, the pace of succession and, finally, biodiversity and complexity;
- Develop common principles that support mechanistic and numerical modelling of marine ecosystem dynamics, scenarios and predictions of the responses of marine life to change.

POL 5: Autecology of planktonic key species and groups

Objectives

Ocean biogeochemistry is increasingly coming under focus as a major regulator of atmospheric CO_2 concentrations. Biogeochemical cycles are driven by trophic interactions within pelagic food webs comprising an as yet unknown range of species. Categorising organisms into functional groups is a convenient way of rendering this biological diversity and hence complexity amenable to modelling. However, a mechanistic understanding of the factors regulating the wax and wane of the organisms comprising functional groups is a prerequisite to improving the predictive power of models. These factors range from physico-chemical characteristics of the environment (bottom-up factors) to interactions with other organisms (pathogens and grazers = top-down factors). Each species represents a set of adaptive traits that have been selected in the course of evolution by a given range of these factors. The relevant properties of these species can be determined by means of a variety of approaches that range from detailed, interdisciplinary field observations, *in-situ* perturbation experiments, mesocosm to beaker experiments, assessments of physiological and chemical properties and mapping of the genomic potential. Since relatively few genera and species appear to play key roles in trophic interactions and biogeochemical fluxes we will focus our efforts on understanding the autecology of selected species. This knowledge will help link biogeochemical cycles with ecological processes that shape the structure and functioning of pelagic systems. The ultimate goal is to advance the predictive power of earth system models.

Implementation

The properties of key species within different functional groups from sea-ice to open ocean habitats will be determined using the range of approaches outlined above. In polar regions, diatom and haptophyte species play key roles within each of the functional groups: primary producers, carbon recyclers and sinkers, calcifiers, silica sinkers, sulphur and other trace gas emitters. In addition to ecophysiological and life cycle studies, the genome of these species will be studied to ascertain the intrinsic factors enabling their dominance in pelagic ecosystems. Gene probes will be developed to enable rapid estimation of population size and life cycle stages of the target species. Species prominent in sediments will be given special attention to improve their value as proxies.

The role of mechanical and chemical defence systems (the evolutionary arms race) in the plankton has received peripheral attention so far. We will study predator/prey relationships in experimental and field conditions with an aim to pin-pointing defence and response mechanisms that reduce mortality and contribute to dominance status in pelagic ecosystems. The behaviour of different life cycle stages of dominant zooplankton (including krill) and the role of their grazing in shaping the structure of pelagic ecosystems will be investigated.

Carbon recycling within the surface layer is affected by the microbial foodweb, protistan microplankton and scavenging zooplankton. These organisms retard vertical flux and interact with dissolved organic matter (DOM), which constitutes a significant fraction of the global carbon inventory. We will study mechanisms of DOM diagenesis and preservation and identify the nature of recalcitrant compounds.

The studies will be carried out in the laboratory, mesocosms and in field observations of sea ice and mesoscale water masses. *In-situ* iron fertilization experiments carried out in different water masses of the Southern Ocean will be used to study organism interactions and test hypotheses in the light of biogeochemical fluxes in the open ocean.

In addition we intend to establish a chemical fingerprint of terrigenous sources of DOM and follow the fate of these refractory substances in the Arctic Ocean as a model system.

Deliverables

- An improved understanding of factors shaping the structure of pelagic ecosystems in relationship to biogeochemical fluxes;
- Data to improve the predictive ability of coupled earth system models;
- Development of new biological proxies for interpretation of sediment archives.

POL 6: Earth climate variability since the Miocene

Objectives

Natural climate variability is documented in continental ice, permafrost and marine sediment cores that represent unique archives of the timing and amplitude of climatic change at seasonal to millennial time scales covering long periods and a broad variety of conditions distinct from recent times. The decoding of the mechanisms driving and amplifying Earth's climate variability represents an essential prerequisite for the generation of numerical models allowing realistic simulations of past and future climate development. Special emphasis of our integrated ice/sediment/permafrost studies is placed on

- the determination of physical and biological processes that regulate atmospheric CO_2 concentrations during Pleistocene climate variability via ocean/atmosphere exchange;
- the identification of cryosphere- (ice sheet instability, melt water input, sea ice) related effects on ecosystems, thermohaline ocean circulation and sea level;
- the causes of warmer (higher sea level) than present conditions;
- the variability range and driving mechanisms of climate change at sub-millennial time scales during warm and cold climates;
- the detection of processes generating the range of variability between different climate cycles, as well as the shift in climate cycles periodicity, and
- the recognition of climate interhemispheric connections (e.g. bipolar see-saw) and involved transfer/feedback mechanisms.

Implementation

We will reconstruct climate conditions at sub-millennial time scales integrating information from atmospheric and oceanic time series documented in continental ice cores from Greenland and Antarctica (EPICA) and sediment records from northern and southern high latitude oceans and lacustrine environments. Ice core and marine proxies will be further developed and applied for the documentation of past changes in atmospheric circulation, ocean hydrography, sea ice distribution, and biological productivity. To substantially improve reconstructions of past hydrography and productivity in the broad polar areas (Southern Ocean, North Pacific and its marginal seas) that are characterized by biosiliceous deposits, new methods using stable isotope measurements on biogenic opal will be

established. Similarly, ice core analysis will be advanced by developing faster and more accurate analytical measurements such as stable isotope analysis on gases within the ice, or continuous dust and multi-elemental analysis. We will compare the magnitude and time relationship of hydrographic and ecosystem change documented in circumantarctic time series and time slices to elucidate the role and response of the Southern Ocean as part of the global climate system during the different stages of Pleistocene climate development. Studies in the polar North Pacific and its marginal seas (e.g. Sea of Okhotsk) will augment the knowledge of climate-related processes in an area, which has a great potential as a land/ocean climate transmitter and regulator. As the interior of the Arctic Ocean becomes more accessible through an enlarged fleet of research vessels capable of operating and drilling in that region (e.g. Aurora Borealis), new palaeoceanographic time series from this region will become available and will be integrated into the global data base. The collection of high resolution seismic and bathymetric data is required for extending the scope of polar latitude sediment sampling because such results set the frame for optimal sample locations. High-resolution climate time series from key areas and time slice reconstructions will be used to drive diagnostic numerical earth system models of varying complexity, with a close interaction envisaged between modellers and data analysts.

Deliverables

- Generation of polar climate proxy time series at millennial to decadal resolution covering the past 8 climate cycles (past 800 ka) and selected time slices;
- Generation of data sets documenting the behaviour of the polar ice sheets during glacial and interglacial periods;
- Collection of seismic and bathymetric data and sediment cores from the Pacific and Atlantic sectors of the Southern Ocean, and from the Arctic Ocean for palaeoceanographic investigations and the generation of deep sea (IODP) drilling proposals;
- Drilling of new ice cores from Greenland and Antarctica;
- Generation of new proxies for palaeoclimate reconstruction.

POL 7: From Permafrost to the deep sea in the Arctic

The role of permafrost-coasts in the Arctic system

Objectives

The coastal zone is the interface through which land-ocean exchanges in the Arctic are mediated. The Arctic coastlines are highly variable and their dynamics are a function of environmental forcing, coastal geology, geocryology (permafrost) and morphodynamic behaviour. Especially, the ice-rich, permafrost-dominated coastlines of the Siberian Arctic are rapidly eroded and it is assumed that the resulting coastal flux plays an important role in the material budget of the Arctic Ocean. The Arctic coastal region is the transition zone between onshore and offshore permafrost and the degradation of permafrost, which can be connected with the release of permafrost-bond methane, is concentrated on the coastal zone.

The objectives are to identify and to understand the key processes controlling Arctic coastal dynamics, to decipher and quantitatively assess the recent role of the coasts and the coastal lowlands in the entire Arctic system and to establish models to predict the future behaviour of the Arctic coastal region in response to climatic and sea level changes concerning estimations of coastal retreat, material flux, methane emission and the development of onshore and offshore permafrost.

Implementation
The proposed studies will focus on the coastal zone of the Laptev and East Siberian Seas. During ship-based and terrestrial expeditions key locations along the coastline will be investigated in respect of the composition of the coastal sediments and coastal morphology and change rates in order to quantitatively assess the material fluxes and methane emission from eroded permafrost coasts. In the frame of international projects and based on remote sensing and GIS technologies the studies will be extended to cover the entire Arctic.
The investigations will be accompanied by studies on critical processes controlling Arctic coastal change, such as sea-ice processes and sea-level changes, as well as studies on landscape and relief forming periglacial processes and their consequences for hydrology and sedimentation. Special attention will be paid to the transformation of onshore to offshore permafrost under the influence of saline sea-water, which will be investigated in a coastal drilling transect. Based on the results, models for the prediction of the near future behaviour of the Arctic permafrost-affected coasts will be developed, which will finally be incorporated into regional and global models in the form of a coastal component

Deliverables
- Quantitative assessments of recent and near future dynamics of arctic coasts and their role in the entire Arctic system concerning material fluxes;
- Models of the onshore/offshore permafrost distribution in the coastal region of the Siberian Arctic and projections of its development under future climate scenarios.

Methane Budgets in Terrestrial and Marine Polar Environments

Objectives
The objective of this Programme is to study formation, pathways and fate of methane in different Arctic terrestrial and marine environments and to assess their contribution to the global CH_4 cycle. For this purpose we will study microbial CH_4 sources and sinks, sediment-water and soil-air exchange, entrapment of fossil atmospheric CH_4 in ice cores, sequestration in biogenic calcite via oxidation to CO_2, and stability of gashydrates in permafrost and ocean margin sediments. The complexity of this task comes from the coexistence of different phases of CH_4 in polar environments as: dissolved gas, free gas, and CH_4 in gashydrate. Furthermore, the interwoven microbial cycles in production and consumption of CH_4, and the different focused and diffuse transport pathways linking marine and terrestrial environments with the atmosphere represent major challenges to the understanding of the budgets of this relevant greenhouse gas.

Implementation
For integrated research of these objectives this project is handled by a group of terrestrial and marine geologist, geochemists, glaciologists, and microbiologists. Techniques and concepts include isotope and flux studies, microbiological and molecular ecological investigations, system oriented research at selected target areas, and spatial analysis and modelling. Terrestrial and marine target areas are the Eurasian Arctic, the Laptev and East Siberian Seas, sites off Spitzbergen, and focused sources at continental margins (e.g., Haakon Mosby Mud Volcano) and shelf seas.

The first period of the project implementation includes: (1) landside studies of gas fluxes using high resolution micrometeorological techniques (Eddy-correlation), remote sensing and GIS, (2) characterization of the function and diversity of marine and terrestrial microbial communities, (3) assessment of methane emission from eroded permafrost along coasts, (4) studies on the release of methane from coastal sediments, formation of plumes and CH_4 decomposition and transport in the water column, (5) quantification of fluid flow through sediments and its effect on CH_4 emission to bottom water; and (6) the role of biological

communities as barriers for oceanic CH_4 emission. Field and laboratory measurement and conceptual models will be combined with numerical modelling of the climate-driven formation and degradation of permafrost sequence and gas hydrates and transport-reaction modelling of sediment inventories and sediment-water fluxes.

Integrated research on the CH_4 cycle of terrestrial and marine permafrost as well as coastal and marine environments allows balance and assessment of major source and sink regions, estimation of large scale spatial budgets, and sensitivity studies about areas were the CH_4 cycle might be significantly affected by natural and man-made changes; e.g., release of CH_4 from drowned permafrost or continental margins.

Deliverables

- Quantification and spatial distribution of production, oxidation and release of CH_4 from soils to the atmosphere as well as from sediments to the water column/atmosphere; Identification of major pathways and microbial communities within the polar CH_4 cycle;
- Modelling of climate-driven formation and degradation of gas hydrates in permafrost and sediments and numerical modelling of reactions, transport and thermodynamics considering microbial pathways and transfer across sediment-water or soilatmosphere boundaries;
- Understanding the regulation of microbial activity relevant for the turnover of methane and linked element cycles (e.g. sulfur).

Benthic diversity and fluxes in the polar deep-sea

Objectives

The aim of this project is to identify key factors governing functional benthic biodiversity in the polar deep-sea. There, fluxes of organic matter fuelling the benthos are strongly seasonal and influenced by ice cover, thus the benthic ecosystem is rather vulnerable to possible changes of the ice regime. Besides the flux of organic matter also bottom currents, substrate properties, and natural disturbances are important for the interactions between deep-sea organisms and their environment. Our work, conducted at long-term stations in the Fram Strait, will focus on the zone between the lower bottom water and upper sediment (~ 10 m above to 1 m below seafloor). Many species live in this environment characterised by large physical and chemical gradients. Life strategies of organisms and physical processes affect the resuspension, settling and burial of particles, whereas respiration and formation of biomass cause fluxes of dissolved oxidants and exchange of nutrients across the sediment-water interface. From a biological, geological and geochemical perspective this complex system acts as a filter for burial of particles and as a source and sink for dissolved and gaseous components affecting bottom water chemistry. The hypothesis we follow is that small-scale biogeochemical and physical gradients at the sediment-water interface, to a yet unknown extent either influenced or generated by large motile organisms (*biogenic engineering*), lead to a persistent mosaic of microhabitats allowing coexistence of numerous species even at small spatial scales.

Implementation

To reach this goal we focus our interdisciplinary research efforts at long-term deep-sea stations. In addition to studies on the natural variability in quantity and quality of particulate organic matter flux into the deep sea, processes affecting transformation and transport of the material will be investigated. Implementation includes *in-situ* measurements of fluxes and respiration rates by free falling lander systems, as well as long-term experiments and observations with ROVs and AUVs.

Deliverables

- Quantification of the interactions between macro- and meiofauna, bottom current regime, sediment properties, food availability and water chemistry;
- Linking conceptual and numerical models of remineralisation and exchange processes across the sediment-water interface to species distribution.

Additional funding

Personnel	Institutional funding			Third party funding		
2002	Scientists	PhD Students	Technicians	Scientists	PhD Students	Technicians
AWI	5	3	3			
GKSS	0	0	0			
total number	5	3	3			

New keys to polar climate archives

Objectives

The urgent societal questions with regard to future climate development require enhanced efforts for understanding natural climate variability as well as natural rates of change. We need to resolve natural processes resonsible for change and we need to expand our capability of reading climate archives. Inline with this we must find links between observed change with their respective signatures in archives. Polar climate archives as evidenced by results from polar ice cores are the ones which not only contain the most complete and highly resolved records of global and regional change, but also yield climate change signals with larger amplitude than those from lower latitudes. Since these signals can be dated exactly and are highly resolved in time they allow direct linkages with actually measured changes which will lead to an enhanced definition of processes. In order to fully exploit this approach we need to develop methods for the determination of a number of higly resolved parameters from the archives and apply them to available and new samples from key locations. This will yield time series of new, process relevant, climate change indicators.

Implementation

We intend to enhance our efforts on the analyses of gas samples, especially with respect to their isotopic composition, from ice cores in conjunction with studies on the gas entrapment process, which is dependent upon physical property changes of the ice. We will further develop new methods on multielemental analyses for reconstruction of atmospheric aerosol load and transport pathways. Existing ice cores will be reanalysed and new ices cores from key locations will be drilled with particular emphasis being put on two time frames, firstly the last 2 millenia and secondly the last interglacial, the Eemian. In addition the observations of very recent and ongoing changes such as advance and retreat of outlet glaciers, surface elevation changes and changes in permafrost area will be widened in scope by increased use of remote sensing methods in conjunction with ground truthing.

Deliverables

- Increased precision in stable isotope analysis of gases occluded in the ice;
- New higly resolved multiparameter time series of climatic indicators from North and South and linked to observed change;
- Palaeo precipitation rates;
- Retrospective of solar activity changes;
- New ice cores from key locations spanning the last 2 millenia.

Portal for Earth and Environmental Sciences of Polar Regions

Objectives
Recently at AWI a prototype was developed for a portal system targeted at expeditions carried out by the research vessels “Polarstern” and “Heincke”. In this portal, not only detailed ships’ schedule of past and future expeditions are displayed, but, also related AWI publications and datasets, trackline maps, scientific summary of the expeditions’ goals, on-board newsletters and press releases. Because such a portal system is of great value to the scientific community in terms of providing a connection between scientific investments (resources) and output, we propose to expand its scope so as to serve other German, and, possibly, European research institutes involved in polar studies. Our goal is to foster cross-institutional cooperation in polar studies within Europe and to improve the scientific planning of future expeditions. The latter will certainly help us to avoid data redundancy and to decrease data gaps.

Implementation
LDAP directory technology, implemented at AWI since 1998, will be used as an innovative catalogue engine for metadata archival. For a European-wide portal research vessels, submersibles, aircraft and long term observatories will initially be considered.

Deliverables
- Central repository for data (meta, published and primary) collected in polar regions by European research platforms information targeted to schools and the general public;
- Central repository for academic information of general interest to the scientific community.

3.4 Programme Topic I: Infrastructure
(Spokesman: Prof. Dr. Heinz Miller)

Personnel	Institutional funding			Third party funding		
2002	Scientists	PhD Students	Technicians	Scientists	PhD Students	Technicians
AWI	20	0	18	1	0	0
GKSS	0	0		0	0	0
total number	20	0	18	1	0	0

Effective research in Ocean, Coastal and Polar Sciences requires an efficient and specialized suite of research platforms and infrastructure. This includes ice breaking research vessels, year round stations, both in the Arctic and Antarctic, with attached observatories, aircraft and vehicles specially adapted for the polar environment and also medium sized and small research vessels capable for multidisciplinary research in shelf seas and coastal regions. These instruments for field research must be matched by appropriate laboratory facilities, ranging from cutting edge analytical tools to labs for controlled experiments simulating natural conditions. Increasingly important are the availability of high performance computational facilities and knowledge base information systems. Reaching the goals of this programme with its inherent longterm engagement requires the continuing availability of this research infrastructure including its continuous modernisation.

Development and Implementation

Large Scale Infrastructure
Next to carrying out original research in various fields, which requires long-term commitment and large infrastructures, it has been one of the principal tasks of Helmholtz-Centers to provide large science infrastructures for use by the national and international scientific community.

With the changeover to programme oriented funding this task will be the responsibility of appropriate programmes. This has the additional advantage that, by coordinating the use of large scale infrastructures within programmes, most efficient usage can be achieved. At the same time this facilitates the development of joint research programs between the Helmholtz-Programmes and those designed by scientists at universities and other institutions thereby enlarging the overall scope and effectiveness.

When the German Antarctic Research Program was established in 1978 it was clear that especially marine polar research could only effectively be carried out by providing appropriate infrastructure for the program. As this program developed and widened in scope to include the Arctic as well, demands on infrastructure grew and over the years it developed to its present status, which is described further below and in the Annex. In order to meet the scientific challenges ahead as described in this programme, the available infrastructure must be kept in top condition, adapted to ever changing requirements posed by new scientific experiments and field observations. Furthermore as new technologies emerge and can be brought into use for research, the existing infrastructure must be widened in scope with new units added.

Keeping large-scale infrastructure in top condition and efficient use is a mayor and not only financial challenge. Next to financial resources it requires dedicated and experienced staff

able to understand science requirements and merge them with technical possibilities. This is particularly important for research in the polar and ocean regions, which impose very special and sometimes very harsh environmental conditions, where not only issues of remote operations but also issues of personal safety have to be considered.

Mobile Research Platforms

Research and supply vessel RSV ”Polarstern”
The research and supply vessel RSV ”Polarstern” commissioned in 1982 is the major research tool for German polar activities. She provides ideal working conditions for almost all compartments of marine sciences and atmospheric as well as glaciological research.

“Polarstern” is a unique research tool. She can break ice up to 2 m continuously, can operate up to 90 days at sea and thus is ideally suited for the often long cruise legs to the remote regions. Polarstern was designed to staying winter over in the packice and therefore can operate even during polar winters, which already has led to two year round deployments to the Antarctic and late winter expeditions to the Arctic facilitating studies of seasonalities. Due to its unique combination of ice breaking capability and design for research use research time on “Polarstern” is always heavily overbooked with applications for ship time coming from AWI and to a higher degree from other national and international research groups. “Polarstern” has pioneered 2 ship expeditions to the deep interior of the Arctic Ocean. Applications for ship time are reviewed by a panel of experts from the wider community; allocation is made on the basis of scientific merit.

RV “Heincke”
RV “Heincke” is a medium sized multipurpose research vessel and can be used for a broad range of biological, hydrographic, and smaller scale geoscientific research activities. In addition to serving as a research platform RV “Heincke” is used for University courses having a mixture of class and fieldwork. Ship time allocation is managed the steering group for medium sized German research vessels.

Aircraft “Polar 2” and “Polar 4”
These aircraft are well suited and adapted for missions in the polar regions. The combined wheel and ski gear enables take-off and landing at gravel strips and even unprepared snow surfaces. The slow flight speed makes it an effective tool for survey missions. “Polar 2” is mainly used for airborne geophysical and glaciological survey missions as well as meteorological studies. “Polar 4” is used for logistic tasks, SAR operations, but also for in-situ air chemistry and radiation measurements.

During the last years major missions were focussed within the European EPICA program pre-site reconnaissance over Dronning Maud Land, logistics for Kohnen Station as well as aero-magnetic, aero-gravimetric and glaciological radar surveys in the Antarctic and Arctic. Additionally some missions were dedicated to tropospheric aerosol studies and sun-photometer measurements, as well as meteorological (e. g. catabatic wind) studies over Greenland, Fram Strait and Svalbard.

Polar Research Stations

Neumayer Station (70°39‘S, 08°15‘W, 40 m a.s.l.)
The Neumayer Station is the permanently occupied German research station located at the Eckstrøm ice-shelf close to Atka Bay. The station was commissioned in 1992 and replaced the former Georg von Neumayer station established in 1981.

The station operates scientific observatories for Meteorology, Atmospheric Chemistry, Geomagnetics and Seismology. Due to their location in the Southern Hemisphere data from all observatories close important gaps in global coverage and are routinely fed into the respective international networks. At the same time they allow research of a more regional nature by providing high quality datasets for regional circulation studies, aerosol transport modelling or local seismicity and hence investigations of present day tectonic regime. The designs and operational characteristics of the observatories have served as models for similar installations in Antarctica. Furthermore Neumayer is used as the operational base for aircraft missions and deep field traverses with the polar vehicle fleet during the summer season.

Kohnen Station (75° S, 00° E, 2892 m a.s.l.)
Kohnen station is a summer base on the inland ice plateau of Dronning Maud Land. It was established in 2000 primarily as base for the deep ice core drilling within the EPICA program, but has already been used for EPICA associated programs. This base will serve at least for the next decade for EPICA but also allow a number of summer only investigations, respectively facilitate automatic observatories augmenting the one at Neumayer and thus extending the scope of the ongoing regional studies.

Dallmann Laboratory (62°14‘S, 58°14‘W, 15 m a.s.l.)
The Dallmann Laboratory is located at the Argentinean Jubany station at King George Island. It was established as an international laboratory funded by the Instituto Antartico Argentino (IAA), The Netherlands Council of Earth and Life Sciences (NWO) and AWI in 1994. Since then it has been occupied each year during the summer season. About 25 to 35 scientists from Germany, Argentina and The Netherlands are working in the laboratory during each season. Research is focussed on marine and terrestrial biological studies, solar UV and ecophysiological investigations as well as geological field work. German research projects include investigations, which are in parallel carried out at Koldewey Station in the Arctic.

Koldewey Station (79°N, 12°E, 50 m a.s.l.)
The Koldewey Station in Ny Ålesund (Svalbard) is the German Arctic research station, serving two main tasks. It serves as a multi-disciplinary platform for a wide range of atmospheric, marine-biological and geophysical science. It also serves as an observatory for long-term measurements, particularly for climate and atmospheric research. Balloon-borne observations and ground-based remote sensing techniques are applied to study dynamical and chemical processes up into stratosphere. Because of its location, appropriate scientific equipment and data quality the station contributes as the Primary Arctic Site to the global Network for Detection of Stratospheric Change (NDSC). Meteorological and radiation programmes are run similarly to those at Neumayer. Data are also fed to networks of WMO (GTS, GAW, BSRN) and NDSC. An automatic seismological station completes long-term observations. The Koldewey Station became attractive as the Arctic site for international campaigns as well as a crucial reference site for validation of remote sensing instrumentation e.g. on satellites or airborne platforms.

General Infrastructure

Besides the large scale infrastructure mentioned above there is further specific infrastructure necessary available for achieving the goals of the programme topics. This infrastructure mainly serves the programme topics MAR, CO and POL but is also shared with the wider scientific community where appropriate. Examples are cold room laboratories for ice core processing and analysis, a sea water circulation system, polar condition

aquaria, and ice and sediment core storage and curating facilities. Analytical laboratories are well equipped and instruments range from NMR-systems for in vivo experiments through mass spectrometers, electron microscopes to general analytical instruments. For sea going research AWI additionally operates a number of smaller research vessels and motor boats, adapted for work in coastal areas and which serve as daily workhouses: “Uthörn”, “Mya”, “Aade” and “Diker”. GKSS operates the “Ludwig Prandtl” as platform for research and monitoring purposes mainly in the German bight.

Information Resource Centre / Computer Centre
The services provided by the AWI Computer Centre cover a broad range of items: from basic user support and network interconnections between AWI locations to high performance scientific computing facilities used in climate studies The scientific databases and information systems maintained by the Computer Centre form the core of the AWI Information Resource Centre. Preserving scientific data and information on a long-term basis is essential for the discovery of long term changes in nature and for interdisciplinary scientific cooperation. The Computer Centre maintains central facilities for data management and gives support to the scientific community of the AWI. In addition to technical support, the computing Centre also provides guidance for the scientific use of these tools, facilitating interdisciplinary research.

Another key element in the support of scientists working with numerical models comes from the Scientific Computing Group of the Computer Centre, which is mainly concerned, with the growing need of high performance computer systems and efficient numerical algorithms. The group members work in close connection with several research groups at the AWI. Ocean and sea-ice models, often used at AWI, are parallelized for the use on the massively parallel computer CRAY-T3E at the Computer Centre.

In addition we operate seismic processing packages (Disco, Focus, Landmark) on a multiprocessor computer (SGI, Origin 2000).

PANGAEA - Network for Geological and Environmental Data
The information system PANGAEA - Network for Geological and Environmental Data is aimed at archiving, publishing and distributing georeferenced data from research on climate variability, solid earth, and the marine environment. Data is stored with meta-information in a relational database, which is accessible through the Internet (http://www.pangaea.de). The system is used by the World Data Centre for Marine Environmental Sciences (WDC-MARE) to archive and distribute data from publications and projects.

The challenge of managing the heterogenic and dynamic data of environmental and geological research was met through a flexible data model, which reflects a strictly generalized 'world' of scientific data.

The system can be used by any scientific project related to geological or environmental science to collect and share data, to make the data available to the community via the Internet and to store data in a long-term operated archive. The institutes AWI & MARUM are responsible for the operation of the system and give support for the members and data curators of the projects. Organization of data management includes quality control and publication of data and the dissemination of metadata according to international standards. For the visualization of data freeware tools are provided, which can be used either with a direct link to the system or as standalone applications.

Additional funding

Personnel	Institutional funding			Third party funding		
2002	Scientists	PhD Students	Technicians	Scientists	PhD Students	Technicians
AWI	1	0	1			
GKSS	0	0	0			
total number	1	0	1			

Marine geophysical instrumentation pool

We plan to expand our Helmholtz mission oriented services of providing infrastructure to the wider community by establishing and operating a pool of marine geophysical instrumentation. This will initially consist of a pool of ocean bottom seismometers and other marine geophysical as well as oceanographic equipment and should later grow as community demand requires.

Objective
Present models of structure and composition of the Earth's interior are lacking in resolution, both with respect to the spatial definition of structures and to the values of physical properties. This is mainly due to the fact that the location of observing systems such as seismological networks is heavily biased towards a continental distribution. Appropriate observing systems operable on the ocean floor have now been developed since required technology became available and must be used to close the gaps in the areal distribution. As evidenced by many national and international projects there is large interest within the scientific community to use such ocean bottom systems for studies of

- structure and processes into the lower crust and mantle,
- seismogenic zones along subducting margin,
- active crustal seismology across continental margins,
- continental stabilities and mass transport,
- submarine volcanisms.

Implementation
It is beyond the capability of any single interested German research group to acquire and maintain a larger number of ocean bottom seismometers but it falls well within the Helmholtz-Centers remit to provide such infrastructure. Initially it is planned to acquire 50 such systems as core of the pool and to update the existing systems of different German research groups to the same standard so that for a start approximately 80 systems will be available for community use. Basic service of instruments will be part of the pool, whereas costs of deployment shall be borne by the projects. An agreement is in preparation whereby the systems presently owned by other institutions will be brought into the pool.

The research topics identified within the German marine geophysical community also need active seismic equipment, consisting of a 3 km 512-1024 channel digital streamer system and a high volume array of G-Guns as active source.

4 Annex – Competence of participating centres

4.1 Programme related Information

MARCOPOLI undertakes research in important components of the earth system. It is organized in four Programme Topics:

Ocean and Global Climate (**MAR**),
- Coastal Areas (**CO**),
- Polar Regions (**POL**),
- Infrastructure (**I**),

the latter describing the foundation for accomplishing the scientific goals.

The tasks will be to
- investigate the oceans role in global climate
- evaluate natural and anthropogenic processes within coastal regions and define knowledge based management tools
- assess the role of the polar regions within the earth system.

Thus the programme will work towards deciphering processes in the polar regions relevant to global climate, their coupling to lower latitudes and their variability in space and time by observation and modelling of the past and present. Furthermore the programme aims at the scientific evaluation of possible impacts of observed and expected changes by assessing ensuing scenarios. Whenever accumulated understanding leads to reliable assessments, then these findings are to be used in managing and monitoring of marine and associated ecosystems with strong emphasis on sustainable use of coastal regions, and enhancement of coastal protection.

The two centres joining in this programme have a long standing tradition in all aspects of the programme with particular complementarity in programme topic CO “Coastal Areas” and further synergies to be expected in the other topics. The programme has been developed towards achieving the above mentioned challenges based on existing expertise acquired during previous work.

This programme is well anchored in and contributes to large internationally agreed research efforts as defined within the newly formed Earth System Science Partnership, which consists of WCRP, IGBP, DIVERSITAS and IHDP or other scientific bodies such as ICSU through SCAR, SCOR, and ICSI. It is also linked into international governmental bodies such as the IOC and IASC. Results from this programme will be instrumental for increasing confidence in the projections of future scenarios undertaken by IPCC.

The very nature of this programme with its mix of observations and modelling necessitates actually very frequently that research efforts be undertaken in close international collaboration and coordination. This holds especially in the polar regions, where available resources have to be shared for most effective and environmentally benign use, or in coastal areas where institutions and agencies from border countries quite naturally collaborate.

Within Helmholtz this Programme has specially close ties within Research Field 2 “Earth and Environment” with Programme 1: “Geosystem: the Changing Earth”, and many contact areas with Programme 2: “Atmosphere and Climate”, Programme 5: “Sustainable Use of Landscapes”, and Programme 6: “Sustainable Development and Technology”.

Programme 1 and Programme 3 will together with Research Field 6 (Transport & Space) form a Helmholtz Network *Integrated Earth Observing System* thereby linking Research Fields 2 and 6 for resources with optimal results by pooling the expertise available for the space segment of global observing systems with that of earth centred scientific use.

Programme spokesman: Prof. Dr. Heinrich Miller *1944

Scientific career

University	University of Munich, Geophysics, Dipl.-Geophys	1963	-	1969
Ph.D. / M.D.	University of Munich, Geophysics, „Geophysical investigations on an Alpine glacier“	1969	-	1971
further Positions	Research Scientist, University of Munich	1971	-	1979
	Assistent, University of Munich	1979	-	1985
Current Position	Professor University of Bremen	1985		
	Head of section “Structure & Dynamics of the Lithospere & Polar Ice Shields, AWI	1986 2000		
	Deputy Director at AWI			

Five most important publications

Miller, H., Gebrande, H. und E. Schmedes (1977) Ein verbessertes Strukturmodell für die Ostalpen, abgeleitet aus refraktionsseismischen Daten unter Berücksichtigung des Alpen-Längsprofils, Geol. Rdschau, 66, 2, 283 - 308

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Johnsen, S. J, Dahl-Jensen, D., Gundestrup, N.,Steffensen, J. P., Clausen, H.B., Miller, H., Masson-Delmotte, V., Sveinbjörnsdottir, A.E., White, J. (2001), Oxygen isotope and palaeotemperature records from six Greenland ice-core stations: Camp Century, Dye-3, GRIP, GISP2, Renland and NorthGRIP. Journal of Quaternary Science, 16 (4), 299-307

Quantitative information on programme level

Science related information

Quantitative parameter	Type	Unit	1998	1999	2000	2001	2002
Publications	ISI-listed	no.	274	306	340	366	387
	Habilitations	no.	5	5	2	3	1
	PhD Thesis	no.	37	32	30	28	33
Full professorship offerings (C3/C4)		no.		1	2	2	7
Guest scientists		no.			63	79	98

Third Party Funding

Quantitative parameter	Unit	1998	1999	2000	2001	2002
Participation in DFG-Collaborative Research Centers, Priority Programs and Graduate Colleges	no.	5	5	5	8	9

Promotion of young scientists and proportion of women

Quantitative Parameter	Total number 2002	Proportion of woman
PhD Students	81	50
Post-Docs	97	35
Young group leaders	18	28
Group leaders	88	16
C3/C4 professorships	17	0

Innovation data

Quantitative Parameter	Unit	1998	1999	2000	2001	2002
Patents granted/issued	no.	1	6	7	10	10
Patents running	no.	23	23	24	28	41
Licences	no.	23	26	28	29	29
Licence revenues	10^3€	52	28	37	62	n.d.
Spin-offs	no.	1	2	2	0	1

4.2 Competence of participating centre – Alfred Wegener Institute for Polar and Marine Research (AWI)

The Alfred Wegener Institute for Polar and Marine Research (AWI) is a multidisciplinary scientific institution engaged in topics of scientific and public interest. AWI is the German national polar research institution and as such promotes and carries out polar and marine science to further our understanding of the variability and functions of the global environment and of the Earth System based on observations, modelling and applications. AWI carries out cutting edge science by focussing on an interdisciplinary research approach together with national and international partners to whom it also provides polar infrastructure and logistics. It develops new approaches, tools and methods and applies these to research topics of both basic and applied interest.

Living conditions on our Planet Earth depend on the physical condition and the chemical composition of the atmosphere, the oceans and the earth's crust, in particular influenced by the enlivened surface. The Earth System was in its history always subject to steady change. Reasons for this change are e.g. variations of physical and biogeochemical processes in the compartments atmosphere, hydrosphere, cryosphere and geosphere or impacts like continental drift, volcanic eruptions, change of solar radiation and human activity. These processes may result in considerable climate changes and striking interferences with the plant and animal world. Both relative slight but long lasting and short term changes of environmental conditions may put at risk the basis of our current form of living. These consolidated findings result in the demand for detailed investigations of all crucial processes in the Earth System in order to predict its development reliably by mathematic models. This is the only way to build a solid basis for efficient precaution measures to protecting the environment and in particular the human being.

The polar regions of our Planet Earth are a central issue in modern global change research and in the scientific assessment of potential climate change and its impact. German scientists have been participating in international polar research for many years, and since 1980 the Alfred Wegener Institute for Polar and Marine Research (AWI) has been representing Germany's interest in polar and marine sciences. As an interdisciplinary research institute, AWI scientists study the natural variability of the climate system over small and large time scales. The Arctic and Antarctic are climatically the most sensitive regions in the Earth System and in this context valuable sources of information on possible future global environmental change. Key data are obtained on present-day variability of ocean systems and climate, records of their historic variability in the recent geological past, and in the reconstructions of climate history. Methods which are applied in this research range from modern satellite-based remote sensing to deep sea drilling. A priority at AWI is to conduct research on the polar marine regions and their biotas. But AWI also carries out terrestrial polar research, making key contributions in the fields of atmosphere physics and chemistry, the palaeoclimatic history of periglacial regions, and their permafrost soils. Investigations on marine and terrestrial polar regions are linked up closely, to better understand the critical processes in these regions.

AWI provides a major contribution to global environmental research, in conjunction with other Helmholtz-Centers as well as university and non-university research institutions. Modern polar and marine research requires an intensive technical and personal effort, as well as close collaboration with other national and international research institutions. Hence AWI provides the necessary polar and marine infrastructure and logistics to its national partners and takes a leading role in the international network of polar and marine research, working together with numerous partners all over the world.

With the formation of the AWI Research Unit Potsdam in 1992, the scientific research spectrum of AWI was extended to periglacial and permafrost research in polar land areas. In 1998 the scientific profile of AWI has been further extended by the integration of the Biological Institute Helgoland (BAH) that has a centennial history in North Sea research. This development mainly strengthened the marine biological work in mid-latitude oceans and opened new research perspectives.

AWI has a programmatic internal structure; the different departments (Climate System, Pelagic Ecosystems, Benthic Ecosystems, and Geosystem) correspond with the topics of the research programme. This organisational structure may be easily adapted to new developments in its research programme. AWI has currently four research sites in Germany, it's headquarter in Bremerhaven, two marine research stations, one on Helgoland and one on Sylt, and the research unit in Potsdam, with its focus on terrestrial geoscience and investigations of atmospheric processes.

Key facilities for polar research are the permanently manned stations in the Antarctic (Neumayer Station) and in Ny Ålesund on Spitsbergen (Koldewey Station), as well as the research ships and aircraft managed for the German polar and marine research. The central resource is the research icebreaker "Polarstern". The RV "Heincke" enables marine research in sub-polar to tropical latitudes. The AWI survey aircraft are deployed in both the Arctic and the Antarctic, where they carry airborne measuring equipment for studies in glaciology, geophysics and meteorology. AWI scientists are conducting each year an extensive expedition programme reaching from the most northern parts of the Arctic Ocean and the Siberian tundra to the Southern Ocean and Dronning Maud Land, 2900 m high on the Antarctic continental ice shield.

Research collaborations among AWI staff und university colleagues are integral to our success as an institution, this is enhanced by the fact that the leading positions at AWI are joint appointments with universities, which also ensures a steady flow of students and young post-docs. These collaborations, the strength, variety, and frequency of our interactions with the university community provide metrics of the health of our programme. In addition AWI runs a visiting scientist programme, which provides unique opportunities for interactions among scientist from around the world,as do the frequent expedition to polar regions which usually enjoy the participation of a large number of international scientist.

Recently AWI faculty members at University of Bremen were active in the design of two new M.Sc. programmes at University of Bremen. Within the physics department the "Postgraduate Program in Environmental physics" was started in 2002 and within the earth sciences department a Master course in "Environmental and Marine Geosciences" will commence in 2003. In addition in autumn 2002 a joint International Graduate Program on Marine Microbiology (MARMIC) was opened at the MPI for marine Microbiology with contributions by AWI, IUB, and University of Bremen. The programme is interdisciplinary and spans biology, geology, physics and chemistry. Finally, AWI scientists are strongly involved with the DFG-Forschungszentrum Ozeanränder (Research Center Ocean Margins, RCOM) established at the University of Bremen in 2001.

Science related information

Quantitat. parameter	Type	Unit	1998	1999	2000	2001	2002
Publications	peer reviewed papers	no.	443	431	396	456	416
	thereof ISI-listed	no.	200	240	274	309	334
	Habilitations	no.	5	4	2	3	1
	PhD Thesis	no.	29	29	22	26	30
Full professorship offerings (C3/C4)		no.	-	1	2	3	7
Guest scientists		no.			44	50	63

Third Party Funding

Quantitative parameter	Unit	1998	1999	2000	2001	2002
Participation in DFG-Collaborative Research Centres, Priority Programs and Graduate Colleges	no.	4	4	4	5	6

Third Party Funding	1998 (10^3€)	1999 (10^3€)	2000 (10^3€)	2001 (10^3€)	2002 (10^3€)
total	7,634	8,686	10,100	11,753	13,598
public funds (%)				98	96
industrial funds (%)				2	4

Selected third party projects of AWI

Project Name	Funding Source*
European Project for Ice Coring in Antarctica (EPICA)	EU
DEKLIM-Junior Research Group "Climate Reconstruction using Polar Ice Cores" (RESPIC)	BMBF
Global implications of Arctic climate processes and feedbacks (GLIMPSE)	EU
Silicious Microfossiles in the Ochotsk Sea- ecological and biogeochemical aspects for paleooceanographic reconstructions in marine polar areas (KOMEX)	BMBF
Arctic Deep Sea (ARKTIEF)	BMBF
Climate Variability and Predictability (CLIVAR)	BMBF
Sea Level Change - An Integrated Approach to Its Quantification (SEAL)	HGF
Methane fluxes in ocean margin sediments: microbiological and geochemical control (METROL)	EU
Siberian River Run-Off (SIRRO)	BMBF
Ocean – sea ice coupling and atmospheric variability in the Arctic (ACSYS)	BMBF
Bottom-up and top-down control of population dynamic of copepods (GLOBEC)	BMBF
Biodiversity of photo synthetics picoplankton in Marine Waters (PICODIV)	EU
Information system for biodiversity of terretrial algae (Alga Terra)	BMBF
Coastal Sands as biocatalytic filters (COSA)	EU
Biological effects of environmental pollution in marine coastal ecosystems (BEEP)	EU
Response of benthic communities and sediment to different regimes of fishing disturbance in European coastal waters (RESPONSE)	EU
Concomitant ecological research on offshore wind power utilization on research platforms in the North Sea and Baltic Sea (BEOFINO)	BMU
Prevention and reduction of the impact of offshore wind power plants in the North Sea and Baltic Sea	UBA

*Abbreviations: EU = European Union, BMBF = Federal Ministry of Education and Research, BMU = Federal Environmental Ministry, UBA = Federal Environmental Agency

Promotion of young scientists and proportion of women

Quantitative Parameter	Total number 2002	Proportion of woman (%)
PhD Students	70	52
Post-Docs	62	46
Young group leaders	18	28
Group leaders	71	20
C3/C4 professorships	14	0

Innovation data

Quantitative Parameter	Unit	1998	1999	2000	2001	2002
Patents granted/issued	no.	1	6	7	8	8
Patents running	no.	9	13	18	25	33
Licences	no.	4	4	5	5	6
Licence revenues	10^3_	0	5	6	22	10
Spin-offs	no.	1	0	1	0	1

Honours and Awards

Scientist	Prize	Organisation	Year
U. Brathauer	Annette Barthelt Prize for marine research	Annette Barthelt Foundation	1998
A. Weisheimer	Michelson-Prize	University Potsdam	1999
K. Meissner	Annette Barthelt Prize for marine research	Annette Barthelt Foundation	1999
L. Medlin	Tyge Christensen Prize	International Phycological Society	2001
W. Arntz	Honorary doctor	University Punta Arenas, Chile	2001
H. Fischer	Kalkhof-Rose Gedächtnis Preis	Academy of Science, Mainz	2001
K. Riedel	Bremer Studienpreis	University Bremen	2001
K. Riedel	Förderpreis für junge Wissen-schaftler	Society of German Chemists	2001
G. Wehrle	Tiburtius- Prize	Senates Administration for Science, Research and Culture, Berlin	2002
H. Reinhardt	AMSEL- Prize	Society of German Chemists	2002
W. Geibert	Annette Barthelt Prize for marine research	Annette Barthelt Foundation	2002

Programme Topic MAR: Ocean and Global Climate

Important recent achievements showing acquired expertise
AWI is involved in investigations of physical and chemical processes in the system atmosphere-cryosphere-hydrosphere. In recent years we lead various expeditions in polar waters with ocean, ice and atmospheric research topics; we have developed and utilized models of the polar climate, and have performed manifold data oriented studies, partly on the basis of data acquired by ourselves and partly working on available data collections. We have participated in the main international research programmes, as WOCE, ACSYS, and CLIVAR. Our main expertise with respect to Topic MAR lies with in theoretical and numerical investigations and s underpinned by observational capability of the atmosphere-ocean-ice system, with the aim to develop dynamically consistent models for understanding the ingredients climate variations and prognose them.

A dynamically and statistically consistent picture of the thermohaline circulation of the global ocean has been gained from simulations carried out with a Large Scale Geostrophic (LSG) model, in which measured data are assimilated. The atmospheric forcing is represented by using COADS- and NCEP-data. The results are in satisfactory agreement with sea level data derived from altimeter measurements of the TOPEX/Poseidon satellites during the period 1993 to 2000.

A comprehensive ocean circulation model was coupled with simple sea ice and atmosphere models to make climate simulations of several thousand years duration. Interaction of the oceanic heat transport, sea ice distribution in the Labrador Sea and fresh water fluxes during freezing and melting lead to self-sustained, multi-decadal fluctuations in the system. With this climate model we simulated the onset of large-scale glaciation.

Feedback mechanisms between the atmospheric heat and moisture fluxes and the thermohaline circulation in the north Atlantic have been investigated using a coupled ocean - sea ice - atmosphere model. While processes in ocean and sea ice are described comparatively detailed in that model, the effect of the atmosphere is represented only in terms of a simple model for the energy and moisture budgets. Estimates of the decadal and multidecadal variability of the thermohaline circulation exhibit a dominant period of approximately 50 years.

To quantify the internally excited atmospheric climate variability, simulations have been performed with a hierarchy of climate models. This set comprises low-order spectral atmospheric models and coupled atmosphere-ocean-models of medium and high complexity. It has been proved on the basis of statistical analyses of model integrations over 1000 years that all models are able to simulate typical large-scale atmospheric circulation patterns (Northern Atlantic Oscillation, Pacific - North America - pattern) and to generate decadal scale climate variability resulting from nonlinear dynamical effects without external forcing factors.

Various investigations with numerical models tried to quantify the influence of the Arctic Mediterranean on climate and to understand the coupling processes between the regional arctic and larger scale conditions. Sea ice budget is a major component in this interaction, because it is controlled in the Arctic Ocean by the inflow of warm water of Atlantic origin and influences the stability of the water column in the formation areas of North Atlantic Deep Water. Numerical model experiments and field work have been carried out to better understand these interactions.

Different model approaches were employed to investigate the role of the Antartic Circumpolar Current (ACC) in the interhemispheric spreading of climate fluctuations. We

have developed a canonical view of the dynamical balance of the ACC, in which wind stress and buoyancy flux at the surface, eddy-induced transport of momentum and substances, and bottom form stress play a major role. We have developed models of the ACC at various levels of complexity and studied dynamical issues as well as links of the Southern Ocean currents and wave system to the global ocean.

For the first time in the region of the East Antarctic continental margin offshore spreading anomalies have been measured in high resolution with the aid of the polar aircraft Polar2 and over the open sea by a helicopter-based aero-magnetic survey. The sequence of magnetic anomalies, which were created in an early stage by the opening of the Weddell Sea and the South Atlantic, are now continuously evident. According to the new magnetic dating continental breakup started about 140 million years ago and not as previously suggested about 180 million years ago. Against commonly held assumptions, the separation of South America and Africa from East Antarctica was initiated at the same time but from different centres, with the Weddell rift propagating from west to east. Seismic investigations showed that the Agulhas Plateau was never an element of Gondwana but instead was created through the influence of the Bouvet Hotspot on the mid oceanic ridge leading to the deposition of thick sequence lava and the buildup to a topographic feature, which significantly influenced pathways of several water masses as could be proven by analysis of contourites imaged by high resolution seismics. The correlation of seismic data with the results of ODP Leg 175 led to dating of slide scarps in the area of the Orange Fan, Cape Basin. These slide scarps show a chronological motion indicating an East to West migration of the Benguela Current and suggests a northward evolution of the current with time.

Aerogeophysical data obtained by “Polar 2” have led to a clear definition of the plate boundary between Eurasia and North America in the region of Fram Strait and Lena Trough. North Greenland and the archipelago of Svalbard are separated from each other by an ancient branched system of spreading axes. Together with results from deep seismic soundings on- and offshore Svalbard, this yields a spreading model since late Miocene.

Upgraded 3-D ice dynamics models were used to produce the sea-level predictions from the polar ice sheets for the IPCC Third Assessment Report. Other numerical experiments concentrated on glacial cycle simulations and contributed to the EPILOG reconstruction of the Last Glacial Maximum ice sheets, and on deriving patterns of visco-elastic rebound and gravity anomalies required to interpret data from forthcoming satellite gravity missions (CHAMP, GRACE). Similar model studies were conducted within the framework of the Helmholtz-Strategiefonds project SEAL using improved climatic input derived from atmosphere-ocean coupled general circulation models. Within SEAL models were also set up to determine the glacier and ice cap contribution to sea-level change and to reconstruct the ice loading history on the northern hemisphere continents since the Last Glacial Maximum. The latter is required to constrain the current rate of isostatic adjustment needed to correct tide-gauge records of sea-level change.

As a baseline of Cenozoic paleoclimate reconstruction in southern high latitudes we developed siliceous microfossil biostratigraphic zonations that allow the dating of paleoceanographic events and thereby provide bounds on time frames of major climate and associated oceanic changes.

We have successfully developed a dual approach combining process models formulated by physicists with experimental hypothesis-testing by biologists to address the role of ocean biogeochemistry in regulating global budgets of climate-relevant trace gases. Mechanistic models of carbon uptake and calcification by phytoplankton, tested in laboratory and mesocosm experiments, have shown that increasing CO_2 levels can enhance primary

production. Further, concomitantly decreasing pH levels can suppress calcification rates of coccolithophorids and foraminifera in the future and thus increase the ocean's capacity to take up anthropogenic CO_2. Other research on isotope fractionation and nutrient uptake ratios by dominant plankton organisms is continuing to contribute to a better understanding of ocean biogeochemistry. The results are being fed into biogeochemical general circulation models to reconstruct palaeoclimate and project future climate scenarios.

Only two years ago previously unknown microbial life was discovered responsible for the efficient consumption of the aggressive greenhouse gas methane in the ocean. This new group of microbes is ubiquitous and abundant wherever methane occurs in substantial quantities. They exert a significant control on global climate by oxidizing methane to CO_2 which is subsequently sequestered into carbonate, sometimes forming extensive cements, chimneys or reefs. This process removes as much methane as terrestrial or atmospheric oxidation, however, knowledge on the key microbes, pathways and their regulation is still preliminary. In collaboration with the Max Planck Institute of Marine Microbiology, the University Bremen and other national and international institutes, a variety of interdisciplinary projects between geology, geochemistry, oceanography and microbiology are currently carried out spanning coastal seas, continental margins, ocean waters, the deep sea, subsurface sediments and permafrost areas. Significant advances in the reconstruction of glacial/interglacial changes in the global carbon cycle from CH_4 and CO_2 as well as $\delta^{13}C$ H_4 and $\delta^{13}CO_2$ in water bodies and ice cores, and the current development of the first combined biological and physical model of anaerobic methane oxidation put AWI into a leading position in ocean and global climate methane research.

Significant forthcoming changes

We expect to fill a C3-position for palaeoclimate modelling in 2003, thereby enhancing our capability in coupled climate modelling; we expect the successful applicant to also play an integrative role in driving both modelling as well as observational efforts.

The climate research community in Germany is in a planning stage to define and develop selected model components, which will be made available to the community and maintained by the Model&Data Group at MPI in Hamburg. AWI contributes to the development of the new atmosphere general circulation model (ICON). AWI also is volunteering within MARCOPOLI to lead the development of the new ocean general circulation model.

We expect significant new satellite missions in particular ICESAT and CRYOSAT as well as ENVISAT and JASON1 for mapping land and ocean surfaces but in particular ice surfaces to yield valuable new data sets on their temporal evolution. This will enhance our modelling efforts to implement observational data of the highest possible accuracy. The Helmholtz network: Integrated Earth Observing System, which is currently developed between AWI, DLR, GFZ and GKSS will be a valuable infrastructural element for enhancing data availability, quality and interpretation. We deem it necessary that for this as well as the very closely associated work package on "Ocean, Ice sheets and sea level in a changing climate", which has been started within the SEAL project, needs strengthening in fixed personyears.

In 2002 the AWI has joined the International Research Consortium on Continental Margins (IRCCM) coordinated at the International University Bremen to enforce integrative research and educational activities on continental margins focusing on surface and subsurface imaging, fluid flow and the methane cycle. Other partners are the DFG Research Centre RCOM, the Max Planck Institute for Marine Microbiology, GEOMAR, as well as several international universities and oil industries. The AWI will contribute to central research and education projects of the IRCCM such as methane transport and oxidation in the water

column, pathways of microbial carbon sequestration in sediments, and groundwater fluid flow.

Recently, large investments have been made to build up a state-of-the-art mass spectrometry laboratory for the detection of stable carbon isotopes in solid, liquid and gaseous phases. Stable isotope geochemistry is a major research tool in identifying and quantifying critical processes in the global carbon cycle, its evolution and its contribution to global change.

The technique of deep-sea drilling to investigate geological features of the ocean floor is used since the 1960^{s} and the obtained results have revolutionized our understanding of the Earth System. Following the Deep Sea Drilling Project (DSDP) and the Ocean Drilling Program (ODP) the Integrated Ocean Drilling Program (IODP) will start in fall 2003 with a ten years live time. IODP is the most ambitious program of ocean drilling ever conceived and its scientific goals are far beyond those of its predecessors. The new program will address basic questions of earth system science ('the deep biosphere and the subseaflor ocean', 'environmental change: its processes and effects', 'solid earth and geodynamics') using a fundamentally new multiple drilling platform approach to the science of ocean drilling. Partners in IODP are Japan, who are constructing a large drill ship that, being equipped with a riser, will be able to drill risky geological structures in deep-sea basins and continental margins, the United States that will provide a new drill vessel that is going to have similar technical facilities as the JOIDES RESOLUTION but with modernized technology and Europe that will make mission specific platforms available that enable drilling of sites that are not accessible by the other drill ships. European nations that decided to participate in IODP are organized in a consortium (ECORD) that will be the formal representative of the European contribution to IODP. ECORD will besides MEXT (Japan) and NSF (USA) be the third lead agency in IODP. The 'Deutsche Forschungsgemeinschaft' and the Federal Ministry for Education and Research (BMBF) decided to finance the annual financial contribution of Germany as formal member of ECORD in equal shares, as is the case for the membership fee of the current Ocean Drilling Program (ODP) that will be replaced by IODP in fall 2003. The German contribution to IODP will be administered by AWI.

Spokesman of Programme Topic MAR:

Prof. Dr. Dirk Olbers *1944

Scientific career

University	University of Hamburg, Dipl. Phys.	1964	-	1970
Ph.D. / M.D.	University of Hamburg, "On the energy balance of small-scale internal waves in the deep-sea"	1970		1973
Post-Doc	Woods Hole Oceanographic Institution, USA	1971	-	1972
	Institute of Geophysics, University of Hamburg	1972	-	1978
further Positions	Institute for Marine Research, Kiel	1978	-	1979
	Max Planck Institute for Meteorology, Hamburg	1979	-	1985
Current Position	University Professor (C4), University of Bremen Head of Department Climate System, AWI	1985		

Five most important publications

Rintoul, S., Hughes, C., Olbers, D. (2001). The Antarctic Circumpolar Current System, In: Ocean Circulation and Climate, Eds: G. Siedler, J. Church and J. Gould. Academic Press, New York, p. 271-302.

Olbers, D. (2001). A Gallery of Simple Models from Climate Physics, Stochastic Climate Models, Progress in Probability Vol. 49, Eds.: P. Imkeller and J. von Storch, Birkhäuser Verlag, p. 3-63.

Olbers, D., Ivchenko, V. O. (2001). On the meridional circulation and balance of momentum in the Southern Ocean of POP, Ocean Dynamics, Vol. 52, 79-93.
Olbers, D. J., Wenzel, M., Willebrand, J. (1985). The interference of North Atlantic circulation patterns from climatological hydrographic data, Reviews of Geophysics, 23, 313-356.
Olbers, D. J., 1983: Models of the oceanic internal wave field. Rev. Geophysics and Space Physics 21, 1657-1606.

Leading Scientists

Prof. Dr. Antje Boetius *1967

Scientific career

University	University of Hamburg and Scripps Institution of Oceanography, Biology, Diploma	1986 - 1992
Ph.D. / M.D.	University of Bremen, Biology, "Microbial Degradation of Organic Matter in Deep Sea Sediments"	1992 - 1996
Post-Doc	Institute for Baltic Sea Research Warnemünde, Biological Oceanography, Prof. K. Lochte	1996 - 1999
	Max Planck Institute for Marine Microbiology, Biogeochemistry, Prof. BB Jørgensen	1999 - 2000
further Positions	Adjunct Researcher, Max Planck Institute for Marine Microbiology	2001
	Assistant Professor for Microbiology, International University Bremen	2001
Current Position	Senior Scientist, Alfred-Wegener Institute for Polar and Marine Research	2001

Five most important publications

Boetius, A., Ravenschlag, K., Schubert, C., Rickert, D., Widdel, F., Gieseke, A., Amann, R., Jørgensen, B.B., Witte, U., Pfannkuche, O. (2000) A marine microbial consortium apparently mediating anaerobic oxidation of methane. *Nature* 407, 623-626
Michaelis, W., Seifert, R., Nauhaus, K., Treude, T., Thiel, V., Blumenberg, M., Knittel, K., Gieseke, A., Peterknecht, K., Pape, T., Boetius, A., Amann, R., Jorgensen, B.B., Widdel, F., Peckmann, J., Pimenov, N.V., Gulin, M.B. (2002) Microbial Reefs in the Black Sea Fueled by Anaerobic Oxidation of Methane, *Science* 297, 1013-1015
Boetius, A., Damm, E. (1998) Benthic oxygen uptake, hydrolytic potentials and microbial biomass at the Arctic continental slope. *Deep-Sea Research I* 45, 239-275
Boetius, A., Lochte, K. (1996) The effect of organic matter composition on hydrolytic potentials and growth of benthic bacteria in deep-sea sediments. *Marine Ecology Progress Series* 140, 235-250
Boetius, A., Felbeck, H. (1995). Digestive enzymes in marine invertebrates from hydrothermal vents and other reducing environments. *Marine Biology* 122, 105-113

Dr. Rüdiger Gerdes *1957

Scientific career

University	Kiel University	1976 - 1983
Ph.D. / M.D.	Institute for Marine Research at the University of Kiel: The role of density diffusion in numerical models of the North Atlantic circulation (in German)	1983 1988
Post-Doc	Princeton University, Princeton, NJ, USA	1988 - 1991
Current Position	Senior scientist, Climate System Department, AWI	1991

Five most important publications

Gerdes, R., Koeberle, C.(1995). Influence of DSOW on the North Atlantic general circulation, Journal of Physical Oceanography,25,2624-2642.

Lohmann, G., Gerdes, R.(1998). Sea ice effects on the sensitivity of the thermohaline circulation, Journal of Climate,11,2789-2803.
Gerdes, R., Determann, J., Grosfeld, K.(1999). Ocean circulation beneath Filchner-Ronne-Ice-Shelf from three-dimensional model results, Journal of Geophysical Research ,104,15827-15842.
Gerdes, R., Biastoch, A., Redler, R.(2001). Salt balance of the Gulf Stream in a regional model: Implications for climate variability, Climate Dynamics,18, 17-27.
Meissner K., Gerdes R.(2002) Coupled climate modelling of ocean circulation changes during ice age inception, Climate Dynamics, 18, 455-473.

Dr. Rainer Gersonde *1950

Scientific career

University	Univ. Kiel, Diploma (Geology and Palaeontology)	1969	-	1975
Ph.D. / M.D.	Univ. Kiel, Geology-Palaeontology Institute "Paläoökologische und biostratigraphische Auswertung von Diatomeenassiziationen aus dem Messinium des Caltanissetta-Beckens (Sizilien) und einiger Vergleichsprofile in SO-Spanien, NW-Algerien und auf Kreta"	1976	-	1980
Post-Doc	Univ. Kiel, Geology-Palaeontology Institute	1980	-	1982
further Positions	Scientist, Univ. Kiel, Geology-Palaeontology Institute	1975	-	1976
	Scientist, AWI	1982	-	1985
Current Position	Senior Scientist, AWI	1985		

Five most important publications

Gersonde, R., A. Abelmann, U. Brathauer, S. Becquey, C. Bianchi, G. Cortese, H. Grobe, G. Kuhn, H.-S. Niebler, M. Segl, R. Sieger, U. Zielinski, and D. K. Fütterer (2003). Last glacial sea-surface temperatures and sea-ice extent in the Southern Ocean (Atlantic-Indian sector) – A multiproxy approach. Paleoceanography (in press)
Bianchi, C. and R. Gersonde (2002) The Southern Ocean surface between Marine Isotope Stages 6 and 5d: Shape and timing of climate changes. Palaeogeography, -climatology, -ecology, 187, 151-177.
Frank, M., Gersonde, R., Rutgers van der Loeff, M., Bohrmann,G., Nürnberg, C. C., Kubik, P. W., Suter, M. and A. Mangini (2000). Similar glacial and interglacial export bioproductivity in the Atlantic sector of the Southern Ocean: Multiproxy evidence and implications for glacial atmospheric CO_2. Paleoceanography 15, 642-658.
Gersonde, R. and U. Zielinski (2000). The reconstruction of late Quaternary Antarctic sea ice distribution - The use of diatoms as a sea ice proxy. Paleogeography, -climatology, -ecology 162,263-286.
Gersonde, R, F.T. Kyte, U. Bleil, B., Diekmann, J.A. Flores, K. Gohl, G. Grahl, R. Hagen, G. Kuhn, F. J. Sierro, D. Völker, A. Abelmann, and J.A. Bostwick (1997) Geological record and reconstruction of the late Pliocene impact of the Eltanin asteroid in the Southern Ocean. Nature 390, 357-363.

Dr. Philippe Huybrechts *1962

Scientific career

University	Vrije Univ. Brussel, Physical Geography (specialisation Geophysics and Meteorology), Licenciate	1980	-	1984
Ph.D. / M.D.	Vrije Univ. Brussel, Ph.D., „The Antarctic ice sheet and environmental change: a three-dimensional modeling study"	1985	-	1991
Post-Doc	AWI Bremerhaven	1991	-	1995
	Vrije Univ. Brussel, Departement Geografie	1996	-	1998
Current Position	Senior Scientist, Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven	1999		

Five most important publications

Huybrechts, P. (2002). Sea-level changes at the LGM from ice-dynamic reconstructions of the Greenland and Antarctic ice sheets during the glacial cycles. Quaternary Science Reviews, 21, 1-3, 203-231.

Le Meur, E., and P. Huybrechts (2001). A model computation of the temporal changes of surface gravity and geoidal signal induced by the evolving Greenland ice sheet. Geophysical Journal International, 145, 835-849.

Huybrechts, P., and J. de Wolde (1999). The dynamic response of the Greenland and Antarctic ice sheets to multiple-century climatic warming. Journal of Climate, 12(8), 2169-2188.

Huybrechts P., A. Letreguilly and N. Reeh (1991). The Greenland ice sheet and greenhouse warming. Palaeogeograpy Palaeoecology Palaeoclimatology (Global and Planetary Change section) 89, 399-412.

Huybrechts P. (1990). A 3-D model for the Antarctic ice sheet: a sensitivity study on the glacial-interglacial contrast. Climate Dynamics, 5, 79-92.

Prof. Dr. Dieter Wolf-Gladrow *1953

Scientific career

University	University of Braunschweig, MS in Physics	1974	-	1980
Ph.D. / M.D.	Universities of Braunschweig and Köln, PhD in Physics	1980	-	1985
Post-Doc	University of Köln	1985	-	1987
	Alfred Wegener Institute for Polar and Marine Research	1987	-	1990
further Positions	Senior Scientist at AWI	1990	-	now
	Habilitation in Environmental Physics at the University of Bremen	1996	-	
Current Position	Prof. for Theoreth. Marine Ecology at the Uni. of Bremen	1999	-	now
	Senior Scientist at AWI			

Five most important publications

Riebesell U., Wolf-Gladrow D. and Smetacek V. (1993) Carbon dioxide limitation of marine phytoplankton growth rates. Nature 361: 249-251.

Völker C. and D.A. Wolf-Gladrow (1999) Physical limits on iron uptake mediated by siderophores or surface reduction. Mar. Chem. 65: 227-244.

Wolf-Gladrow D.A., J. Bijma and R. Zeebe (1999). Model simulation of the carbonate system in the microenvironment of symbiont bearing foraminifera. Mar Chem. 64: 181-198.

Wolf-Gladrow D.A. (2000) Lattice-Gas Cellular Automata and Lattice Boltzmann Models – An Introduction. Springer, Berlin, Lecture Notes in Mathematics, 1725, 308 pp.

Zeebe R.E., Wolf-Gladrow D.A. (2001) CO_2 in Seawater: Equilibrium, Kinetics, Isotopes. Elsevier Oceanography Book Series, 65, 346 pp, Amsterdam.

Prof. Dr. Victor Shahed Smetacek *1946

Scientifc carrer

University	Bachelor of Science, Agra University, India,	1962	-	1964
	Diploma in Biology, Kiel University, Germany	1964	-	1969
Ph.D. / M.D.	PhD in Biological Oceanography, Kiel University “The succession of phytoplankton in Kiel bight”	1969	-	1975
Post-Doc	Kiel Univ., Inst. Marine Res. Interdisciplinary Research Project: "Interaction Water Column/Sediments"	1971	-	1978
further Positions	Hochschulassistent Univ. Kiel	1978	-	1986
	Dr. habil. in Biological Oceanography, Kiel University	1986	-	
	Prof. of Marine Biology, Univ. Bremen and Head of Section Biological Oceanography at AWI	1986		
Current Position	Head of Division Pelagic Ecosystems at AWI	1999		

Five most important publications

Smetacek V., Baar H. J. W. de, Bathmann U. V., Lochte K., Rutgers van der Loeff M. M. (1997) Ecology and biogeochemistry of the Antarctic Circumpolar Current during austral spring a summary of Southern Ocean JGOFS cruise ANT X/6 of R. V. Polarstern, Deep-Sea Research II, 44,1-21

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Networking details

Most Important scientific cooperations

Topic of co-operation	Partners
Virtual Institute 'Pole Equator Pole' (PEP)	Research Center Karlsruhe FZK, Univ. Bremen, Potsdam, and Karlsruhe
Antarctic Scientific Drilling (ANDRILL)	Cape Roberts Project and SCAR
DFG Research Center Ocean Margins	Univ. Bremen, MPI Bremen, Center for Tropical Marine Ecology Bremen

Selected coordinator or leader function in programmes and networks

Scientist	Programme / Network	Function
P. Lemke	World Climate Research Programme (WCRP)	Chairman
P. Lemke	German national member organisation to 'The International Institute for Applied Systems Analysis'	Chairman
E. Fahrbach	CLIVAR/CLIC Southern Ocean Panel	Co-Chairman

Programme Topic CO: Coastal Areas

Previous work in the field of Programme
Expertise on biodiversity, spatial population dynamics and ecosystem processes in sandy beaches accumulated at the AWI - Wadden Sea Station on Sylt is at the forefront of international research. The adjoining tidal sandy beach is the only one in the world where the total number of eukaryote species has been assessed – a prerequisite to estimating resilience of the community to disturbance such as beach nourishment. Recolonization by these small organisms is fast, suggesting that this mode of coastal protection is sustainable. On the other hand, macrobenthic species colonize on average less than half of the suitable sites within the scale of local populations. Limitations to larval settlement and/or juvenile survival impacting on the event scale seem to be the primary cause of the observed habitat emptiness and shifting ranges. This finding has considerable implications for benthic monitoring and design of sampling strategies.

The physical stability of sedimentary shores can be strongly influenced by a few dominant species some of which stabilize and others disrupt the sediment. Consolidates sediments are sinks for organic matter and nutrients whereas bioturbating activity enhances nutrient cycling and shortens trophic pathways. Understanding the dynamic balance between these groups in relation to physical forcing factors is a prerequisite to predicting the response of coastal ecosystems to change.

At Helgoland, expertise on the principles guiding functional biodiversity has focussed primarily on a range of marine crustaceans. Studies of small-scale habitat segregation by related species have provided insights into the principles of competitive exclusion and resource partitioning in the context of changing environmental conditions. Comparisons of metabolic and digestive key enzymes across different species and climate zones have enabled identification of mechanisms regulating the response to temperature changes. Studies on reproductive processes in lobsters, carried out with an aim to boosting the near-depleted stocks on the island, have yielded insights currently being applied under field conditions. Life-history adaptations to regional and temporal variability in environmental key factors such as salinity are investigated experimentally. Considerable expertise has been acquired on the impact of enhanced UV radiation on macroalgae.

A functional set of biomarkers for monitoring biological effects in marine environments has been developed. Female flounders from the German Wadden Sea coast exhibit a threefold higher frequency of liver tumors than males. Malignant carcinomas were found in females only which we relate to a lower activity of energy producing enzymes, leading to an impairment of protective mechanisms against oxyradicals and xenobiotics. In addition, females display higher rates of energy consumption in liver tissue due to the production of lipid rich yolk precursor-proteins during reproduction. An EU-project was started in 2001 with an aim to establishing an integrated network to monitor parameters such as lysosomal stability in fish and mussels. Novel biomarkers to be developed using molecular biological tools in mussel and turbot include drug transporters of the ABC-gene.

Persistent organic pollutants (POPs) are distributed worldwide via the atmosphere. Organochlorine compounds were analysed in three fish species of differing feeding types. Hexachlorobenzene (HCB), p,p´- DDE and Mirex ranged highest in concentrations in regions remote from any source areas. POPs were predominantly bioaccumulated from the food rather than bioconcentrated from the water. The concentration patterns revealed distinct transfer routes. Chlordane components, some polychlorinated biphenyls and Mirex were mainly adsorbed on particulate matter and taken up by demersal fish via the benthic

food web. p,p´- DDE, a metabolite of p,p´-DDT, was preferentially accumulated in the pelagic food web, whereas HCB was taken up by the fishes directly from the water.

Research on marine natural products as potential sources of novel active substances has progressed rapidly in recent years. We have established biological test systems to screen chemical defence mechanisms in sessile organisms against predators and biofouling. The chemical structures of active components and their potential use in pharmaceutical applications are under study. Isolates of Arctic bacteria have also yielded unique cold adapted enzymes and compounds of pharmaceutical interest. Work on toxic phytoplankton, whose occurrence renders sea food unsafe for human consumption, has revealed occurrence of a toxin new to European waters.

Eutrophication by marine aquaculture can cause environmental problems. In the framework of an EU project coordinated by the AWI animal aquaculture was integrated with nutrient extractive seaweeds such that the wastes of one product become a resource for the others. The seaweeds are suitable for human consumption and animal feed. An outdoor aquaculture system, built to manipulate short-day and long-day conditions, has enabled us to maintain year-round high phytomass production in different species. The mechanism of such photoperiodic responses consists of a circadian (‘daily inner clock’) timer that measures the length of the night and triggers the photoperiodic response. A feasibility study has been conducted for open ocean aquaculture within ‘Offshore-Windparks’ and field experiments with promising results for seaweeds and mussels are in progress.

At present about two to three times more organic matter is produced and turned over in the Wadden Sea and the adjacent coastal zone than four decades ago. Despite decreasing phosphate levels productivity and remineralisation proceed at a high level suggesting that eutrophication is primarily caused by increased nitrogen concentrations. The time series at Helgoland and Sylt still show two to three-fold higher winter nitrate levels than during the sixties and early seventies.

The Wadden Sea has experienced a combination of sea level rise and progressive embankments during the last 1000 years. The gradual transition zone between the land and the sea became truncated and squeezed. Shore habitats became more fragmented, and a cascade of indirect effects has changed the entire coastal ecosystem. The artificial hard substrates provide a novel habitat, changing the species composition in the area. Shipping and aquaculture introduced about 40 species of algae and invertebrates of which some have the potential to dominate over native species and alter habitat structures and food webs. In particular, a Pacific oyster is taking over mussel beds in the Wadden Sea.

The ecological effects of the exceptionally severe winter 1995/96 have been compared to those of moderate and mild winters at the North Sea coast. In most cases, winter mortality is quickly compensated during the next summer, either by a density-dependent response of juvenile recruitment to decreased adult population size or by enhanced recruitment success due to diminution of predator populations by the severe winter. Recolonization by other species with a limited supply of pelagic larvae can be much slower.

Research on lugworm, eelpout and cod populations in a latitudinal cline along European shores showed that, despite wide windows of thermal tolerance in these species, individual populations are physiologically specialized to the specific climate and the inherent temperature fluctuations of the respective latitude. Genetic analyses revealed apparent differences between these populations. The adaptive flexibility of coastal marine invertebrates and fish under the effect of a changing climate will be subject of future efforts in ecological, physiological and genetic studies.

Significant forthcoming changes and developments

Building projects on the island stations on Helgoland and Sylt are in progress, albeit faced with serious financial uncertainties. In particular, dormitories for graduate students and guest houses for visiting scientists need to be extended. On Sylt, a new laboratory building is about to be erected as a relief from overcrowding in the existing facilities.

The newly created professorship "Marine Chemical Ecology" is about to be filled. The candidate's specific expertise lies in the field of toxic algae, their impact on marine food webs, aquaculture and the quality of human food. He will integrate existing expertise within the AWI with the steadily proliferating international research effort in the field of harmful algal blooms. At a more general level, commensurate with the candidate's broad knowledge base, he will organise organic chemists, molecular and field ecologists working at Bremerhaven and Helgoland by coordinating and focussing research activity on common interdisciplinary goals.

Research on the physiology and culture of marine macroalgae is planned to be concentrated at Helgoland and Bremerhaven. With the retirement of a leading scientist in 2006, the experimental algal cultures presumably will be moved from Sylt to Helgoland. At Sylt it is intended to focus more on shellfish culturing which is commensurate with the benthic field research carried out at the Wadden Sea Station. There is an intention to use the existing aquaculture facilities at Sylt for a new focus on coastal fish ecology.

Research on sediment dynamics in the tidal basins of the Wadden Sea and the coastal zone has been started by a new appointment. Together with geologists from Wilhelmshaven, Denmark and the Netherlands a joint effort on sediment transport in the eastern North Sea is in preparation. Studies on sediment dynamics will be combined with biogeochemical process analyses of permeable sand in the coastal zone which serves as a biocatalytic filter in the cycling of organic matter and hazardous chemicals.

Leading Scientists

Prof. Dr. Karsten Reise *1946

Scientific career

University	Universities of Kiel, Würzburg and Göttingen, zoology, botany, biochemistry and chemistry; diploma	1968	-	1972
Ph.D. / M.D.	Univ.of California and Washington (US); Univ. of Göttingen, "Predation pressure on the tidal flat fauna of the North Sea"	1972		1976
Post-Doc	Univ. of Göttingen, Institute of Zoology	1976	-	1982
	Habilitation 1982; Heisenberg Stipend	1982	-	1985
further Positions	Scientist; Biolog. Anstalt Helgoland (BAH); Prof. Univ. Gött.	1985	-	1987
	Senior scientist, head of dept. at BAH; Prof. Univ. Hamburg	1987	-	1998
	Senior scientist at AWI; Prof. Univ. Hamburg	1998	-	1999
Current Position	Head of section 'coastal ecology' and of Wadden Sea Station Sylt; prof. Univ. Kiel	1999		

Five most important publications

Reise K. (1985) Tidal flat ecology. Ecol Stud 54. Springer Berlin 191 pp

Reise K. (1987) Spatial niches and long-term performance in meiobenthic Plathelminthes of an intertidal lugworm flat. Mar Ecol Prog Ser 38:1-11

Reise K. (1994) Changing life under the tides of the Wadden Sea during the 20th century. Ophelia Suppl. 6:117-125

Reise K., Gollasch S., Wolff W.J. (1999) Introduced marine species of the North Sea coasts. Helgoländer Meeresunters. 52:219-234

Reise K. (ed) (2001) Ecological comparisons of sedimentary shores. Ecol Stud 151. Springer Berlin 384 pp

Dr. Karen Hellen Wiltshire

Scientifc career

University	Bachelor of Science, University of Ireland, Dublin	1980	-	1984
	Master of Science, Trinity College Dublin, Ireland	1984	-	1986
Ph.D. / M.D.	Inst. of Fish. Sci. Hydrobiol., Univ. Hamburg, "Influence of microphytobenthos on nutrient exchange between sediments and water in the Tide-Elbe "	1986	-	1992
	Dr. habil. in Limnology, Kiel University	2002		
Post-Doc	Institute for Chemistry, GKSS Geesthacht	1992	-	1994
further Positions	Research Fellow, Gatty Marine Laboratory, University of St. Andrews, Scotland, UK	1994	-	1996
	External Research and Teaching Associate at the University of Groningen, Netherlands	1997		
	Research Scientist at the Max Planck Institute for Limnology, Plön, Germany	1997	-	2001
Current Position	Senior scientist and deputy head of section Shelf Sea Ecology at the Biologische Anstalt Helgoland, AWI	2001		

Five most important publications

Lass, S., Boersma, M., Wiltshire, K. H., Spaak, P., Boriss, H. (2001). Does trimethylamine induce life-history reactions in Daphnia?, Hydrobiologia, 442, 199-206,

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Boriss, H., Boersma, M., Wiltshire, K. H. (1999). Trimethylamine induces vertical migration in Daphnia, Nature, 398, 382.

Networking details

Most Important scientific cooperations

Topic of co-operation	Partners
BIOMARE- Implementation and Networking of Biodiversity research in Marine areas of Europe	Netherlands Institute of Ecology, Centre for Estuarine and Coastal Ecology Yerseke, Centre for Coastal and Marine Sciences, Plymouth Marine Laboratory
Effects of climate induced temperature change on marine coastal fishes (CLICOFI)	Universities Bremen, Bergen, Antwerpen, Rome

Programme Topic POL: Polar Regions

Important recent achievements showing acquired expertise
Concerning processes in atmosphere sea ice and ocean in polar regions AWI has in recent years significantly improved its capabilities of observing and modelling the polar system.

A new project has been started to investigate the physics of clouds and precipitation as well as their influence on polar atmospheric processes. For these investigations, the high resolution weather forecast model LM (Lokal-Modell) of the Deutscher Wetterdienst is available. This model is characterised by a comparably sophisticated parameterisation of cloud microphysical processes with special emphasis placed on the ice phase. With respect to the polar boundary layer we studied atmospheric meso- and micro-scale processes and developed parameterisations of energy and momentum fluxes for climate models of different scales. Observations of the campaign ARTIST, carried out 1998 in the area around Svalbard, were analysed and used as a basis for model studies of polar processes in the marginal sea ice zone. Applications of the three-dimensional model METRAS clarified the strong influence of small variations of sea ice cover on the energy fluxes in the boundary layer. Using a regional climate model for the Arctic, which is driven by data from a global climate model, it has been shown that the Arctic model climate varies between two circulation states. The centre of the circulation is positioned either in the West- or in the East Arctic region, and these configurations influence the synoptic storm tracks into the Arctic.

Radiative effects of tropospheric aerosols on the radiation budget in the Arctic atmosphere have been investigated in the Arctic Study on Tropospheric Aerosol and Radiation (ASTAR) 2000 campaign on Svalbard. In addition, the longest data set of lidar observations of polar stratospheric clouds over the Arctic has been collected at the AWI station on Spitsbergen. Together with other European stations a climatology of Arctic PSCs was established. It reveals a remarkable uniformity of PSC type above Spitsbergen. In winter 1999/2000 the AWI participated in the THESEO 2000 / SOLVE campaign - a large co-operation of European and US scientists and so far the largest effort to explore the wintertime Arctic stratosphere. AWI contributed with a Match experiment, a method to measure stratospheric ozone loss rates in-situ, which has been developed since 1994.

A variety of near-coastal processes in high latitudes, as e.g. the formation and melting of sea ice, the interactions with ice shelves (including the melting of icebergs), and the wind driven circulation (including the near coastal negative buoyancy force) has been studied with the BRIOS (Bremerhaven Regional Ice Ocean Simulations) model system, which has been developed during the last years. The studies comprise e.g. the interpretation of the model results with respect to the formation rates, the formation areas and the propagation paths of the bottom water.

This model was applied as part of our involvement in the international DOVETAIL program (Deep Ventilation Through Antarctic Intermediate Layers) which was designed to estimate the volume transport of deep and bottom waters out of the Weddell Sea and to study their pathways through the gaps of the South Scotia Ridge system. In combination with hydrographic measurements of various “Polarstern” cruises (ANT-X/4, ANT-XV-4) the variation and modification of outflowing water masses as well as the estimation of interannual variability in the physical system of new formed bottom waters could be estimated.

The Weddell Sea is known to be the major area of water mass modifications in the Southern Ocean. More than 60% of the Antarctic Bottom Water is formed in the Atlantic sector. Therefore water mass formation processes in the Weddell Sea are the major drivers

of the southern component of the global deep thermohaline overturning circulations. Initially in the framework of WOCE and later in CLIVAR cruises with Polarstern have been carried out from 1989 to 2003 to obtain measurements with CTDs, moored instruments, floats and drifters on icebergs, to quantify the Weddell gyre circulation and the water mass formation. With transects across the western Weddell Sea and along the Greenwich Meridian, it could be shown, that both, the inflowing Warm Deep Water as a source water and the Weddell Sea Bottom Water as a product of the water mass modifications, changed their properties on a decadal time scale. It is speculated that the observed changes are related to variations in the atmospheric driving forces which affect the inflow of source water from the Antarctic Circumpolar Current into the water mass formation areas. The Antarctic Circumpolar Wave has the potential to trigger those variations. To validate the hypothesis measurements were extended into the eastern boundary of the Weddell gyre by the deployment of profiling floats within the ARGO programme and a Polarstern cruise in austral summer 2002/2003. A particular effort aimed to use vertical profiling floats in seasonally ice covered areas. Measurements of the bottom water outflow in the northwestern Weddell Sea and the net sea ice formation in the formation area indicate, that freshwater from precipitation and continental melt strongly modulate the bottom water formation induced by salt release during ice formation. Therefore strong emphasise is given in the study of the role of ocean-shelf ice interaction and input of icebergs.

In the Arctic, a mooring program for the long-term observation of the fluxes through Fram Strait was started in 1997 within the EU program VEINS (with the University of Hamburg, the Norsk Polar Institutt and other partners), and this program was continued during “Polarstern” cruises in 2000, 2001 and 2002. At the end of the 90s the heat flux to the Arctic Ocean had increased considerably. Warmer Atlantic Water contributed to the increase to a similar extent as stronger flow of the West Spitsbergen Current. Hydrographic measurements (ARK-XIV/2, 1998 and ARK-XV/1, 1999) in the central Greenland Sea show that the decadal trend of the Greenland Sea deep water towards higher temperatures was interrupted only during 1996/97. In that winter, convective mixing reached depths of 1000 m in the entire Greenland Sea. In the preceding autumn 1996, warm saline Atlantic Water had penetrated the central Greenland Sea. Besides the processes in the central Greenland Sea, the deep water contribution from the shelf seas was investigated. The flow of dense brine-enriched winter water from the Storfjord, (western Barents Sea) towards the Greenland Sea basin was studied with ship-borne (ARK-XIV/2, 1998 and ARK-V/3, 1999) and moored instruments.

During "Polarstern" cruise ARK-XVII/2 (2001) to the North Pole extensive ice thickness measurements were performed. They revealed a reduction of mean ice thickness of 20% compared with measurements in the same region in 1991. A helicopter-borne sea ice thickness sensor ("HEM-Bird") was successfully operated for the first time, yielding extensive data of very good quality.

A stand-alone sea ice model was improved by using monthly mean ocean heat fluxes from an Arctic Ocean model (NAOSIM). With the new heat fluxes particularly the accuracy of the ice edge was improved, e.g. in the Greenland Sea north of Iceland. The sea-ice model was extended to enable assimilation of satellite derived ice concentration fields. This will be used to run the model in forecast-mode. In an AWI coordinated international activity (the WCRP/ACSYS Sea Ice Model Intercomparison Project) this sea ice model has been determined to be the most realistic sea ice model to date.

In the past years AWI has successfully developed several instruments for climate research. The autonomous profiling deep sea mooring (Jojo-CTD), which allows daily profiles from the surface to 4000 m for 1 year), is now operationally used. For calibrations of oceanographic field instruments a non static temperature bath has been realized that performs according to

the accuracy requirements of polar regions. The same holds for a prototype of a reference conductivity meter which overcomes the serious shortcomings of available equipment. A breakthrough in UV instrument techniques is given by the design of a UV-spectrometer that measures simultaneously over the entire spectrum instead of scanning it. The related illumination chambers for the precise simulation of solar radiation, including the UV range, are broadly applied by different work groups. Furthermore, a number of line-scanners for the visible and infrared range is used together with its specialized evaluation software package mainly for remote sensing of sea ice.

A series of interdisciplinary cruises carried out in different seasons by AWI scientists in close collaboration with partners from other countries has demonstrated the overriding role of mesoscale physics in shaping biogeochemistry and ecology of the Antarctic Circumpolar Current. The research has yielded a number of significant insights into frontal dynamics, iron limitation of primary production, coupling between silica and carbon cycles, seasonality of grazer control of plankton species assemblages, amongst others. These field observations have been applied to interpretation of biological proxies in the underlying sediments and revealed robust evidence for much higher carbon sequestration by the ACC during the last glacial as compared to the Holocene. The in situ iron fertilization experiment EisenEx was a further significant achievement that demonstrated the feasibility of this approach for the study of ocean ecology but also for assessing the impact of iron fertilization as a geo-engineering option.

AWI pelagic ecologists and modellers are at the forefront of research identifying quantitative links between ocean biogeochemistry and the biology of key species belonging to various functional groups including sea-ice biota. A conceptual framework in which the predator/prey “arms race“ plays a central role in guiding the evolution of plankton has been published. For example we have shown that the silica shells of the diatom species contributing most to the ooze accumulating under the ACC are extremely strong and have evolved to withstand grazing pressure. Progress has also been made in understanding the biology and functional roles of key zooplankters. These include mechanisms of adaptation of different life cycle stages of krill to the sea-ice habitat and also the role of an ubiquitous copepod genus in significantly retarding the vertical flux of organic carbon. Selective grazing by protists and zooplankton in shaping pelagic ecosystem structure was demonstrated during EisenEx. We have also developed and applied methods to trace terrestrially derived dissolved organic matter in the sea.

Considerable experience has been accumulated in comparing the impact of various disturbants on marine ecosystems in different latitudes and evaluating succession. In polar regions, iceberg scour was identified as an important disturbant in a system formerly considered largely undisturbed. Shelf breakoff of icebergs and magnitude of ice impact were quantified. Iceberg scour leads to local destruction of benthic communities and to complex small-scale community patterns because of reduced competition, but increases diversity at larger scales due to the co-existence of different successional stages.- Another field of competence is the impact of UV radiation on shallow-water communities of polar macroalgae. AWI is a pioneer in the study of these seaweeds and able to cultivate their life cycles in the laboratory. UV-B impact is species, habitat and depth specific.- Former ecological, ecophysiological and community related work in the context of various SCAR programmes has identified specific polar traits on the different levels of organismic and communitarian hierarchy. This baseline knowledge will enable us to determine the effects of disturbance in polar areas from the species level to large-scale biogeography and biodiversity, and to deduce polar principles to be compared in a worldwide context.

Comparisons of marine animals from various climate zones have revealed some key physiological mechanisms that determine temperature dependent success from a bio-

energetic point of view. The limits of both cold and heat tolerance in several Antarctic and temperate fish and invertebrate species were found to be related to a mismatch in oxygen demand and supply and, finally, the onset of anaerobic metabolism. Oxygen limitation seems to represent a hitherto ignored unifying principle in animals and man. This discovery was supported by the use of non-invasive NMR spectroscopy and imaging techniques. Additionally it was discovered that reptant benthic decapods are excluded from extremely cold areas by a combined effect of magnesium anaesthesia and low temperature. – Molecular techniques have been implemented in studies of gene expression, comparing the processes of thermal adaptation in stenotherms and eurytherms. Mitochondrial densities and their energetic capacities , together with the adjustment of membrane properties, were identified to reflect a high cost of functional adaptation to fluctuating temperatures in the cold. On evolutionary scales, oxygen limitation at extreme temperatures, the cost of eurythermy and the interdependent evolution of enhanced eurythermy and performance levels with climate change appear as very important principles affecting metazoan evolution.

Gradients have been identified in species richness and composition, indicating that life in the cold is not a difficult task for most taxa, and in reproductive traits and life cycles which reveal increasing adaptation towards higher latitudes. Close to the Antarctic continent, eurybathy seems to have favoured a large number of taxa during glacial ice shelf advances.

Studies on the trophic role of Antarctic benthos, zooplankton, fish, and seals have shown that many benthic suspension feeders seem to subsist on tiny plankton and resuspended matter, that small copepods are much more important in the food web than thought previously, and the foraging strategies of Weddell and elephant seals revealed close links with the migrations of their fish prey and food concentrations, respectively.

Feeding was found to be mostly connected to life strategies such as hibernation in certain copepods and reproductive season in benthic animals, but coupling to the short season of fresh primary production differs strongly among taxa. In particular the Southern Ocean benthic food web has been shown to be more complex than anticipated; several taxa formerly considered less important were identified as important links. The distance from phytoplankton to pelagic top predators (seals) is abt. 2.5 trophic levels whereas to benthic top predators (nemerteans) it is abt. 3.5 levels.

Based on benthic distribution and measurements of primary production it was shown that the deep Arctic basins are richly colonized only in areas where food particles are advected from highly productive shelf regions. Aiming at a better understanding of functional principles of a deep-sea ecosystem at high northern latitudes, modern sensor platforms such as benthic landers and the French ROV „Victor 6000“ were used at a deep-sea, long-term station. In the frame of optical and acoustical imaging with the ROV and a towed „Ocean Floor Observing System“, a variety of *in-situ* experiments were carried out over the past years. A novel autonomous scanning sonar system, for example, allowed detection and quantification of bentho-pelagic organisms at long distances. Microsensors with the ROV measured biological, geochemical, and physical gradients expected to govern benthic diversity at the sediment-water interface, whereas benthic respiration and interfacial solute exchange was quantified under consideration of bottom current profiles, using newly developed current metres designed for ROV manipulation.

Based upon data and samples collected in the river basins and deltas and along the coastline of the Laptev Sea during eight expeditions, the following results were obtained: (1) Riverine fluxes were quantitatively assessed. (2) The transport of the fluvial material to the central Arctic Ocean was fingerprinted through the application of geochemical and mineralogical tracers. (3) The genesis and the role of the large river deltas in the sediment

balance could be deciphered. (4) It was shown that the sediment input resulting from the erosion of permafrost-affected coasts exceeds the riverine flux.

Using magnetic susceptibility of marine sediments as tracer for Yenisei river discharge we were able to show that it varies with periods between 300 to 700 years. Reduced discharge correlates well with cooling events in the North Atlantic and Greenland, more severe sea ice cover off Northern Iceland as well as advance of glaciers in western Norway.

Based on organic-geochemical bulk parameters and detailed biomarker studies, detailed budget calculations for marine and terrigenous proportions of organic matter in the Arctic Ocean and its marginal seas could be performed for the first time. The high proportion of terrigenous organic carbon (OC) in Arctic Ocean sediments may explain the high burial efficiency for OC. Taking the average Holocene global burial rate of OC, the Arctic Ocean accounts for about 7 to 11% of the global burial budget. This number is disproportionately high considering that the Arctic Ocean accounts for only 2.5% of the global ocean area.

First results from a deep ice core drilled to the basal moraine in a joint AWI-AARI project on Akademic Nauk Icecap, Severnaya Semlya, we can deduce that contrary to earlier work, the ice core record does not extend back to the younger Dryas, but that oldest ice most likely is ca. 5000 years old. Hence this icecap is not a glacial age remnant but has grown to its present thickness of 800 m during the cooling since Holocene Climatic Optimum.

In Russian-German cooperation and joint expeditions since 1993 paleoenvironmental changes have been studied in the Eurasian Arctic using lake sediment cores and permafrost sequences with a multidisciplinary approach. The changes of climate, ecology and landscapes as derived from various indicators revealed surprising facts i.e. that, quite contradictory to accepted theories, summer temperatures were higher during the last glacial maximum than today, which opens quite novel lines of research. For the first time, the use of stable isotopes in permafrost ground ice together with quantitative temperature reconstruction using bioindicators allowed to obtain a refined view of past climate and environmental states.

Using modelling as well as measurement techniques the problem of present day mass balance of polar ice sheets is being investigated. Three-dimensional thermomechanical models of the Greenland and Antarctic ice sheets have been upgraded by incorporating improved ice-dynamic and isostatic treatments, revised input datasets on 20 kilometre horizontal resolutions, and refined climatic treatments based on newly calibrated transfer functions between ice core records and climatic perturbations

AWI has by now obtained either through participation in international ice core drilling projects or by its own drilling activity a large bi-polar archive of ice samples. During the final stage of the Helmholtz-Strategiefonds project KIHZ ice core data with minimum yearly resolution from North Greenland as well as from Dronning Maud Land, Antarctica, were used for intercomparison with each other and with the results of climate modelling for the past millennium showing antiphase behaviour in the period ranges greater than 30 years. This phase signal has only become evident, because of the large areas sampled by many icecores, which by averaging allows signal noise reduction. From detailed studies of aerosol variations in Dronning Maud Land teleconnection patterns pointing to links with El Nino events were derived.

New terrain has been entered with isotopic studies on trace gases (e.g. CO_2, CH_4, N_2O) enclosed in air bubbles in polar ice cores. To this end a new gas chromatography isotope ratio mass spectrometry (GC irm MS) method has been developed within the junior scientist group RESPIC within the framework of DEKLIM. This method reduces necessary

sample sizes by two orders of magnitude, making feasible for the first time isotopic investigations on air trapped in ice cores. In addition significant advances have been made in multielemental ICP-MS analysis by laser ablation from solid ice allowing not only routine analysis of time series, but also very basic studies on the location of impurities within the ice matrix.

AWI has also taken the lead role in drilling the ice core in Dronning Maud Land within the framework of EPICA.

After the development of new proxies we generated Pleistocene and Holocene climate records at millennial to centennial resolution from sediment cores recovered in the Atlantic Southern Ocean that document an early response of Southern Ocean surface temperatures and sea ice extent on orbital and sub-orbital time scales. This and the tight relationship between changes in Southern Ocean physical environment and productivity regimes and changes in climate relevant atmospheric parameters (e.g. CO_2) call for the fundamental role of this ocean in global climate development. The observation of millennial to centennial scale climate variability during glacial and interglacial periods denotes the presence of internal, e.g. ice-ocean related transfer/feedback mechanisms but also points to the impact of external forcing related to changes in solar activity. The interaction between the physical environment and the biological productivity regimes is only poorly understood. To generate new insight in this climate relevant field we recently started to use and develop proxies based on the measurement of siliceous microfossil stable isotopes that provide information on changes in biological productivity and salinity. An important breakthrough was made by the first successful measurement of radiolarian stable isotopes that provide information on upper water column structure and significantly improve the dating of biosiliceous deep-sea sediments.

AWI scientists are particularly experienced to work in the difficult environments of the polar regions. They have developed techniques for particular applications, which make optimal use of the available infrastructure and which give them a lead role internationally. They are able to routinely carry out multichannel seismic surveys in heavy sea ice conditions, they go on research dives in both polar regions, they drill icecores and are able to cope with the different cultures they meet in the high Arctic.

Significant forthcoming changes

Prof. Dr. Dieter Fütterer, head of Geosystems dept. at AWI will retire in Summer of 2003. The position is announced and we are looking for a scientist in the field of marine palaeoclimatology. We hope to find a person capable of leading work at the border between proxy data and models.

The position previously held by Dr. H. v. Westernhagen will be used to further develop strategies to cultivate marine species and improve productivity in unfavourable climates, making use of the newly established animal maintenance facilities at the AWI in light of the increased understanding of the principles underlying the relationships between animal performance and climate change from short to evolutionary time scales.

A significant improvement in instrumentation will be the delivery of an Autonomous Underwater Vehicle (AUV) in autumn 2003. The modular concept of the *Odyssey III* type vehicle allows a variety of scientific disciplines and users the installation of payload modules for specific missions at maximum water depths of 3000 m. One of the first pilot projects will include methane sensors, side scan sonar, CTD and a camera as payload and is dedicated for a detailed survey across a cold-seep location at the Norwegian continental margin. Future missions will include investigations beneath the sea ice and, at a later stage, surveys into Antarctic iceshelf caverns.

AWI will play a major role in ground truthing CRYOSAT, which is now scheduled to go into orbit in 2004 and will be engaged in the GRACE and GOCE missions with respect to ice sheet applications.

Important tools for validating sea ice thickness retrieval algorithms from CRYOSAT will be the improved version of the HEM-Bird as well as the ASIRAS instrument developed with industrial partners under ESA contract and which is to be flown with our aircraft.

In the interior ocean determination of interannual signals require year-round observations. The main tool to obtain sustained ocean measurements is a moored and drifting automated system specially designed to operate in ice-covered oceans in combination with remote sensing. With HAFOS (Hybrid ARCTIC Float Observation System) a combination of moorings, sub-surface floats and ice floe-based drifters will be designed which transmit data acoustically from subsurface platforms to recoverable or surface-based listening stations.

The advent of “Aurora Borealis” will provide new opportunities and challenges for this programme opening polar regions to access for research dependent on seasonal data and from areas till then inaccessible for certain types of research.

Spokesman of Programme Topic POL: Polar Regions

Prof. Dr. Peter Lemke *1946

Scientific career

University	FU Berlin, Physics	1969	-	1972
Ph.D. / M.D.	University of Hamburg, Physics, Dipl.-Phys.	1972	-	1975
	University of Hamburg, Meteorology, Application of the inverse modelling technique to Arctic and Antarctic sea ice anomalies	1980		
Post-Doc	Princeton University (USA), Geophysical Fluid Dynamics Laboratory	1981	-	1983
further Positions	Scientist, Max Planck Institute for Meteorology, Hamburg	1975	-	1989
	Professor, University of Bremen, AWI Bremerhaven	1989	-	1995
	Professor, University of Kiel, Institute of Marine Research	1995	-	2001
Current Position	Professor, University of Bremen, Head of the Regional Circulation Section at AWI Bremerhaven	2001		

Five most important publications

Lemke,P. (1977) Stochastic climate models, part 3, Application to zonally averaged energy balance models. Tellus 29, 385-392.

Lemke,P. (1987) A coupled one-dimensional sea ice - ocean model. J.Geophys.Res. 92, 13164-13172

Lemke,P., W.B.Owens and W.D.Hibler, (1990) A coupled sea ice - mixed layer - pycnocline model for the Weddell Sea. J.Geophys.Res. 95, 9513-9525.

Lemke, P., W.D. Hibler, G. Flato, M. Harder and M. Kreyscher (1997) On the Improvement of Sea Ice Models for Climate Simulations: the Sea Ice Model Intercomparison Project, Ann. Glaciol. 25, 183-187.

Hilmer. M. and P. Lemke (2000) On the decrease of Arctic sea ice volume, Geophys. Res. Let., 27, 3751-3754.

Leading Scientists

Prof. Dr. Wolf Arntz *1942

Scientific career

University	Heidelberg, Tübingen (Natural Sciences, Languages)	1962	-	1963
	Kiel (Marine Res., Fisheries, Zoology, Limnology)	1964	-	1968
Ph.D. / M.D.	Kiel, Fisheries Biology (Nat.-Math. Fac.) „Macrobenthos of Kiel Bay in 1968 and its exploitation by dab (Limanda limanda)“	1968	-	1970
Post-Doc	Kiel Univ., Special Research Programme SFB/95	1970	-	1971
	„Interaction Sea-Sea Bottom“ (Dep. of Fisheries Biology)		-	1978
further Positions	Dir., Fisheries Develop. Proj. PROCOPA, Peru (GTZ)	1979	-	1983
	Head, Zool. Dep., Inst. for Marine Res. Bremerhaven	1984	-	1985
further Positions	Head, Biology Section (later Ecology & Ecophys.), AWI	1986	-	1999
Current Position	Head, Benthic Ecosystems Department, AWI	2000		

Five most important publications

Arntz, W. E., Rumohr, H. (1982). An experimental study of macrobenthic colonisation and succession, and the importance of seasonal variation in temperate latitudes. J. exp. mar. Biol. Ecol. 64: 17-45.

Arntz, W. E. (1986). The two faces of „El Niño“ 1982/83. Meeresforsch. 31: 1-46.

Arntz, W. E., Fahrbach, E. (1996). El Niño. Experimento climático de la naturaleza. Causes físicas y efectos biológicos. Fondo de Cultura Económica, Mexico: 312 pp.

Arntz, W. E., Ríos, C. (eds.) (1999). Magellan-Antarctic: Ecosystems that drifted apart. Scientia Mar. 63 Suppl. 1: 518 pp.

Arntz, W. E., Clarke, A. (eds.) (2002). Ecological studies in the Antarctic sea ice zone. Springer, Heidelberg: 277 pp.

Prof. Dr. Ulrich V. Bathmann *1954

Scientific career

University	University of Kiel	1979	-	1984
Ph.D. / M.D.	Dalhousie University, Halifax, Canada	1985		1986
	University of Kiel	1984	-	1986
Post-Doc	SFB 313 "Sedimentation im Europäischen Nordmeer", Kiel	1986 1989	-	1989
Current Position	Senior scientist at AWI			

Five most important publications

Dubischar C.D., Bathmann U.V. (2002) The occurrence of faecal material in relation to different pelagic systems in the Southern Ocean and its importance for vertical flux, Deep-Sea Research II, 49, 3229-3242.

Strass V.H., Bathmann U.V., Rutgers van der Loeff M.M., Smetacek V.(2002) Mesoscale physics, biogeochemistry and ecology of the Antarctic Polar Front, Atlantic Sector: An Introduction to and summary of cruise ANT-XIII/2 of RV Polarstern, Deep-Sea Research II, 49, 3707-3711.

Bathmann U., Priddle J., Treguer P., Lucas M., Hall J., Parslow J.(2000) Plankton ecology and biogeochemistry in the Southern Ocean: A review of the Southern Ocean JGOFS, In: The changing ocean carbon cycle : a midterm synthesis of the Joint Global Ocean Flux Study; Roger B. Hanson, Hugh W. Ducklow, John G. Field (Eds) - International Geosphere-Biosphere Programme Book Series 5 - pp. 300-337.

Bathmann U.(1998) Ecology and biogeochemistry in the Atlantic sector of the Southern Ocean during austral spring: The first JGOFS expedition aboard RV '"POLARSTERN"', Journal of Marine Systems 17: 77-85.

Bathmann U. V., Scharek R., Klaas C., Dubischar C. D., Smetacek V.(1997). Spring development of phytoplankton biomass and composition in major water masses of the Atlantic Sector of the Southern Ocean, Deep-Sea Research II, 44,51-67.

Prof. Dr. Klaus Dethloff *1950

Scientific career

University	University Rostock, Physics, Physicist	1968	-	1973
Ph.D.	Ac. of Sci., Cent. Inst. Solar-Terrest. Phys., Kuehlungsborn "The zonally symmetric circulation of the tropo-stratosphere on the basis of the sources of angular momentum and heat"	1974	-	1979
Post-Doc	Acad. of Sci., Centr. Inst. Solar-Terrest. Phys., Observatory for Ionospheric Research Kuehlungsborn	1979	-	1982
further Positions	Scientist, Acad. of Sci., Heinrich Hertz Institute of Atmospheric Research and Geomagnetism, Observatory for Atmospheric Research, Kuehlungsborn	1982	-	1991
further Positions	Scientist, Inst. of Atmospheric Physics, Univ. Rostock	1991	-	1992
	Head of atmospheric modelling group, AWI Potsdam	1992	-	1997
Current Position	Head of research section "Physical and chemical processes of the atmosphere", AWI	1998		

Five most important publications

Dethloff, K.,Rinke, A.,Lehmann, R.,Christensen, J. H.,Botzet, M.,Machenhauer, B.(1996). Regional climate model of the Arctic atmosphere, Journal of Geophysical Research, 101/D8, 23401-23422.

Dethloff, K.,Weisheimer, A.,Rinke, A.,Handorf, D.,Kurgansky, M.V.,Jansen, W.,Maass, P.,Hupfer, P.(1998). Climate variability in a nonlinear atmosphere-like dynamical system, Journal of Geophysical Research,103/D20, 25957-25966.

Rinke, A.,Dethloff, K.(2000). On the sensitivity of a regional Arctic climate model to initial and boundary conditions, Climate Research, 14(2), 101-113.

Dethloff, K.,Abegg, C.,Rinke, A.,Hebestadt, I.,Romanov, V.(2001). Sensitivity of Arctic climate simulations to different boundary layer parameterizations in a regional climate model, Tellus, 53, 1-26.

Dethloff, K.,Schwager, M.,Christensen, J. H.,Kiilsholm, S.,Rinke, A.,Dorn, W.,Jung-Rothenhäusler, F.,Fischer, H.,Kipfstuhl, S.,Miller, H.(2002). Recent Greenland accumulation estimated from regional climate model simulations and ice core analysis, Journal of Climate, 15, 2821-2832.

Dr. Hubertus Fischer *1966

Scientific career

University	University of Karlsruhe, Physics	1986	-	1989
	University of Oregon, Physics	1989	-	1990
	University of Heidelberg, Physics, Diploma	1990	-	1993
Ph.D. / M.D.	University of Heidelberg, Physics, "Spatial variability in ice core records from northeastern Greenland - Reconstruction of climatic and airchemical long term trends since 1500 A.D."	1994	-	1997
Post-Doc	Scripps Institution of Oceanography, University of California, San Diego, Wahlen Lab	1997	-	1998
Current Position	Young Scientist Research Group Leader, Alfred Wegener Institute for Polar and Marine Research	1999		

Five most important publications

Fischer, H., The imprint of large-scale atmospheric transport patterns on sea salt records in Northern Greenland ice cores, Journal of Geophysical Research, 106, D20, 23977-23984, 2001.

Fischer, H., Wahlen, M., Smith, J., Mastroianni, D. and Deck, B., Ice core records of atmospheric CO_2 around the last three glacial terminations, Science, 283, 1712-1714, 1999.

Indermühle, A., Stocker, T.F., Joos, F., Fischer, H., Smith, J., Wahlen, M., Deck, B., Mastroianni. D., Tschumi, J., Blunier, T., Meyer, R. and Stauffer, B., Holocene carbon-cycle dynamics based on CO_2 trapped in ice at Taylor Dome, Antarctica, Nature, 398, 121-126, 1999.
Smith, H.J., Fischer, H., Wahlen, M., Mastroianni, D. and Deck, B., Dual modes of the carbon cycle since the Last Glacial Maximum, Nature, 400, 248-250, 1999
Fischer, H., Werner, M., Wagenbach, D., Schwager, M., Thorsteinsson, T., Wilhelms, F., Kipfstuhl, J. and Sommer, S., "Little Ice Age" clearly recorded in northern Greenland ice cores. Geophysical Research Letters, 25, 1749-1752, 1998

Dr. Wilfried Jokat *1953

Scientific career

University	Free University of Berlin, Diploma	1976	-	1982
Ph.D. / M.D.	University Kiel, Geophysical Department, „Die Anwendung ausgewählter Filterverfahren auf synthetische und beobachtete seismische Weitwinkeldaten“	1983	-	1986
Post-Doc	AWI, Bremerhaven	1987	-	1990
further Positions	Merchant, Hewanco Bremen	1973	-	1973
	Geophysist, Prakla Seismos, Hannover	1982	-	1983
Current Position	Senior Scientist, AWI	1990		

Five most important publications

Jokat, W.; Uenzelmann-Neben,G.; Kristoffersen, Y.; Rasmussen, T. (1992). ARCTIC´91: Lomonosov Ridge - a double sided continental margin, Geology, v.20, 887-890
Jokat, W., Weigelt, E., Kristoffersen, Y., Rasmussen, T., Schöne, T. (1995) New insights into evolution of the Lomonosov Ridge and the Eurasian Basin, Geophys. J. Int., 122, 378-392
Jokat, W., Hübscher, C., Meyer, U., Oszko, L., Schöne, T., Versteeg, W., Miller, H. (1995). The continental margin off East Antarctica between 10°W and 30°W, in: Storey, B.C., King, E.C., Livermore, R.A. (eds), Weddell Sea Tectonics and Gondwana Break-up, Geological Society Special Publication No. 108, 129-141
Schlindwein, V. and Jokat, W. (1999). Structure and evolution of the continental crust of northern East Greenland from integrated geophysical studies, J. Geophys. Res., 104, 15227-15245
Jokat, W. (2003). Arctic-98: Seismic investigations along the western sector of Alpha Ridge, Central Arctic, Geophysical J. Int. , 152,185-201

Prof. Dr. Hans-Otto Pörtner *1955

Scientific career

University	Westfälische Wilhelms-Universität Münster	1973	-	1979
Ph.D. / M.D.	Univers. Münster / MPI Göttingen / Univers. Düsseldorf „Biochemische und physiologische Anpassungen an das Leben im marinen Sediment“	1979	-	1983
Post-Doc	University of Düsseldorf, MPI Göttingen, Physiology,	1983	-	1986
	Dalhousie U., Acadia U. Canada, Animal Physiology	1986	-	1987
further Positions	Assistant Professor, University of Düsseldorf	1987	-	1992
	Heisenberg fellow, DFG: Lovelace Medical Found, Albuquerque,USA, UTMB, Marine Biomedical Institute Galveston USA, AWI Bremerhaven, FRG	1992	-	1995
Current Position	Professor at University Bremen, Section head at AWI	1995		

Five most important publications

Pörtner H.O. (2002) Climate change and temperature dependent biogeography: systemic to molecular hierarchies of thermal tolerance in animals. Comp. Biochem. Physiol. 132A, 739-761.
Mark, F.C., Bock, C., Pörtner, H.O. (2002) Oxygen limited thermal tolerance in Antarctic fish investigated by MRI and 31P-MRS. Am J Physiol 283 (5), R1254- R1262

Pörtner H.O. (2001) Climate change and temperature dependent biogeography: oxygen limitation of thermal tolerance in animals. Naturwissenschaften 88, 137-146

Pörtner, H.O., B. Berdal, R. Blust, O. Brix, A. Colosimo, B. De Wachter, A. Giuliani, T. Johansen, T. Fischer, R. Knust, G. Naevdal, A. Nedenes, G. Nyhammer, F.J. Sartoris, I. Serendero, P. Sirabella, S. Thorkildsen, M. Zakhartsev (2001) Climate induced temperature effects on growth performance, fecundity and recruitment in marine fish: developing a hypothesis for cause and effect relationships in Atlantic cod (Gadus morhua) and common eelpout (Zoarces viviparus). Continental Shelf Research 21, 1975-1997.

Frederich, M., H.O. Pörtner (2000) Oxygen limitation of thermal tolerance defined by cardiac and ventilatory performance in the spider crab Maja squinado. Am. J. Physiol 279, R1531-R1538.

Dr. Volker Rachold *1964

Scientific career

University	Göttingen, Mineralogy, Diploma	1986	-	1991
Ph.D. / M.D.	Göttingen, Geochemical Institute, Geochemistry of Lower Cretaceous Sedimentary Sequences of NW-Germany: Cycles and “Events”	1991	-	1994
Post-Doc	AWI, Research Unit Potsdam	1994	-	1998
further Positions	Habilitation, Potsdam University, Sediment Pathways and Budgets of the Laptev Sea Region, Siberian Arctic - Implications for Arctic Land-Ocean Interactions	1994	-	2002
Current Position	Senior scientist, AWI, Research Unit Potsdam	1998		

Five most important publications

Rachold, V. (1999). Major, trace, and rare earth element geochemistry of suspended particulate material of East Siberian rivers draining to the Arctic Ocean, Land-ocean systems in the Siberian Arctic: Dynamics and history (H. Kassens, H. A. Bauch, I. Dmitrenko, H. Eicken, H.-W. Hubberten, M. Melles, J. Thiede, L. A. Timokhov, eds), Springer, Berlin, 199-222

Rachold, V., Grigoriev, M. N., Are, F. E., Solomon, S., Reimnitz, E., Kassens, H., Antonow, M. (2000). Coastal erosion vs riverine sediment discharge in the Arctic Shelf seas, International Journal of Earth Sciences, 89, 450-460

Levasseur, S., Rachold, V., Birk, V., Allegre, C. J. (2000). Osmium behavior in estuaries: the Lena River example, Earth and Planetary Science Letters, 177, 227-235

Rachold, V., Brumsack, H.-J. (2001). Inorganic geochemistry of Albian sediments from the Lower Saxony basin, NW German: paleoenvironmental constraints and orbital cycles, Palaeogeography, Palaeoclimatology, Palaeoecology 174, 123-144

Schwamborn, G., Rachold, V., Grigoriev, M.N. (2002). Late Quaternary sedimentation history of the Lena Delta, Quaternary International, 89, 119 –134

Dr. Ursula Schauer *1951

Scientific career

University	Freie Universität Berlin	1970	-	1971
	Christian-Albrechts-Universität Kiel, Diploma Physical oceanography	1971	-	1977
Ph.D. / M.D.	Christian-Albrechts-Universität Kiel, Institute of Marine Research “Zur Bestimmung der Schubspannung am Meeresboden aus der mittleren Strömung“	1978	-	1982
Post-Doc	German Hydrographic Institute, Hamburg	1983	-	1987
	Institute of Marine Research, University Hamburg	1988	-	1989
further Positions	Fellow of the "Summer Research Assistant programme" Saclant ASW Research Centre, La Spezia, Italy	1980	-	1980
	Chair in Arctic marine science, Naval Postgr. Sch., Monterey (USA)	2000	-	2001
Current Position	Senior scientist, AWI Bremerhaven	1989		

Five most important publications

Schauer U, H. Loeng, B. Rudels, V. K. Ozhigin, W. Dieck, 2002,
Atlantic Water flow through the Barents and Kara seas, Deep-Sea Research I, 49, 12, pp. 2281-2298.

Schauer, U., B. Rudels, E. P. Jones, L. G. Anderson, R. D. Muench, G. Björk, J. H. Swift, V. Ivanov, A.-M. Larsson, 2002, Confluence and redistribution of Atlantic water in the Nansen, Amundsen and Makarov basins. Annales Geophysicae 20, (2), 257 – 273

Gerdes, R. and U. Schauer, 1997, Large-scale circulation and watermass distribution in the Arctic Ocean from model results and observations, J. Geophys. Res., 102, 8467-8483.

Schauer, U., 1995, The release of brine-enriched shelf water from Storfjord into the Norwegian Sea, J. Geophys. Res., 100, 16,015-16,028.

Schauer, U., 1987, Determination of bottom boundary layer parameters at two shallow sea sites using the profile method. Continental Shelf Research, Vol.7, No. 10, 1211-1230.

Networking details

Most Important scientific cooperations

Topic of co-operation	Partners
Australian ACE-CRC	Antarctic CRC and CSIRO Marine Research Hobart, Australian Antarctic Division Kingston, etc.
Southern Ocean GLOBEC-Krill Study	Bundesamt für Fischeibiologie, Hamburg, BAS Cambridge, etc.
European Project of Ice Coring in Antarctica (EPICA)	Partners from nine European Countries
Otto-Schmidt Laboratory	Arctic-Antarctic Research Institute St. Petersburg, Russia
Investigations on benthic biodiversity and evolution in the Antarctic and the Magellan Region. (EASIZ and EVOLANTA)	ICM Barcelona, Universities Hamburg, Gent, Kiel, Punta Arenas, IRSNB Brussels, CADIC Ushuaia, IAA Buenos Aires, etc.

Selected coordinator or leader function in programmes and networks

Responsible scientist	Programme / Network	Function
J. Thiede	Scientific Committee on Antarctic Research (SCAR)	President
J. Thiede	European Polar Board	Chairman
H. Miller	European Project for Ice Coring in Antarctica Phase III (EPICA)	Coord. and Chairman Steer. Committee
D. Fütterer	International Arctic Science Committee (IASC)	Dep.-Chairman of ExCom

Programme Topic I: Infrastructure

Important recent achievements showing acquired expertise
Best evidence for acquired expertise is that large scale infrastructure provided by AWI has been operating smoothly over the last years. There were no serious difficulties which actually hindered planned research. Even under the sometimes quite difficult conditions imposed by external factors, such as storms, sea state or thick sea ice performance of infrastructure and logistic operations was excellent. Whether it was a successful voyage of "Polarstern" to the North Pole together with USCGS "Healy" or the initial start of the EPICA deep drilling in Dronning Maud Land after a 5 year scientific presite survey phase expeditions usually are on time and with excellent scientific return. AWI aircraft have performed well this past season within the DROMLAN air network, serving national and international needs; the AWI hot water drilling equipment succeeded in penetrating Ross Iceshelf twice enabling hydrographic measurements and as a first to recover sediments from the seafloor beneath an iceshelf with relatively small effort andrill; the deep-sea ROV Victor6000 was successfully deployed from "Polarstern" in the high North – a first deployment of Victor6000 apart from its mothership.

All of these achievements give evidence not only of the technical capabilities, but also for the extremely high qualification and experience of the crews involved. AWI has been highly successful in building solid partnerships with the companies responsible for operating the ships and aircraft.

Based on its local infrastructure, AWI was selected to host the first ICSU World Data Centre (WDC Mare) in Germany. The central core of the Data Centre is the information system PANGAEA (Network for Geological and Environmental Data), which was developed by the AWI and MARUM over the last 10 years. Aside from the data holdings of participating institutions there are additional data from over 25 national, European, and international projects available on a long-term basis. The information systems for the AWI field research facilities (Neumayer Station, Koldewey Station, RV "Polarstern") are leading examples of fast developing, modern information technology. To date, 20 years of AWI meteorological data from weather observations, radiosonde casts, and solar radiation measurements of the research ships and stations are available on the Internet. Likewise, oceanographic data from flow meters and profile probes (CTD, XBT) can be accessed directly. State of the art Geographical Information Systems allow the production of charts and maps and the interpretation of geo-referenced data.

Significant forthcoming changes
The Dronning Maud Land Air Network (DROMLAN) has been established under the auspices of the European Polar Board with the aim to ease access for scientists to East Antarctica and make research more effective. Germany is partner in this multinational effort and shares responsibilities to install the necessary local infrastructure and for the inner-Antarctic feeder flights. The main airlink from Capetown will be by chartered high load capacity aircraft such as IL76 to Novolazarevskaya station or Troll station.

Neumayer base has a finite lifetime and will have to be replaced by a new base, which is currently in the planning stage and which will have to be built between 2006 and 2008. In 2003 an infrasound array was installed near Neumayer base as one of the German contributions to the global observing systems within the Comprehensive Test Ban Treaty. It will be commissioned in 2004 and must have data availability better than 99 %.

Together with ESA AWI will install a bistatic radar system on POLAR 2 as a flight testbed system for the radar altimeter to be flown on CRYOSAT. This system will be employed for satellite system verification and ground truthing.

Although POLAR2 and POLAR4 have recently received certification for continued operation we must face the fact that they are heavily strained during polar operations and within this programmes period we must start to look for replacement.

AWI is also driving European plans for building a new ice breaking research vessel (Aurora Borealis), which will be capable of carrying deep sea drilling equipment for recovering sediments and hence palaeoclimate information from ice infested regions, even the central Arctic Ocean and in that capacity will serve central goals of IODP and will be a European contribution to that program. This new ship will be able to operate year round in the Arctic and then “Polarstern“ will be deployed for year round operation in the Antarctic.

Leading Scientists

Prof. Dr. Heinz Miller *1944

Scientific career

University	University of Munich, Geophysics, Dipl.-Geophys	1963	- 1969
Ph.D. / M.D.	University of Munich, Geophysics, „Geophysical investigations on an Alpine glacier“	1969	- 1971
further Positions	Research Scientist, University of Munich	1971	- 1979
	Assistent, University of Munich	1979	- 1985
Current Position	Professor University of Bremen Head of section “Structure & Dynamics of the Lithospere & Polar Ice Shields, AWI Deputy Director at AWI	1985 1986 2000	

Five most important publications

Miller, H., Gebrande, H. und E. Schmedes (1977) Ein verbessertes Strukturmodell für die Ostalpen, abgeleitet aus refraktionsseismischen Daten unter Berücksichtigung des Alpen-Längsprofils, Geol. Rdschau, 66, 2, 283 - 308

Angenheister, G., Gebrande, H., Miller, H., Weigel, W., Goldflam, P., Jacoby, W., Palmason, G., Björnsson, S., Einarsson, P., Zverev, S., Loncarevic, B. und S. Solomon (1977) First results from the Reykjanes Ridge Iceland Seismic Project, Nature, 279, 5708, 56 - 60, 1979

Miller, H., Henriet, J.P., Kaul, N. & Moons, A., (1990), A fine-scale seismic stratigraphy of the eastern margin of the Weddell-Sea, in: Bleil, U. & Thiede, J. (eds.), Geologic History of the Polar Oceans: Arctic versus Antarctic, Kluwer Academic Publishers, Dordrecht, pp. 131 - 162.

GRIP Project Members, (1993), Climatic Instability during the last Interglacial revealed in the Greenland Summit ice-core, Nature, 364, 203-207.

Johnsen, S. J, Dahl-Jensen, D., Gundestrup, N.,Steffensen, J. P., Clausen, H.B., Miller, H., Masson-Delmotte, V., Sveinbjörnsdottir, A.E., White, J. (2001), Oxygen isotope and palaeotemperature records from six Greenland ice-core stations: Camp Century, Dye-3, GRIP, GISP2, Renland and NorthGRIP. Journal of Quaternary Science, 16 (4), 299-307

Dr. Eberhard Fahrbach *1947

Scientific career

University	Heidelberg, Physics, Vordiplom	1968	- 1970
	Kiel, Physical Oceanography, Diplom	1971	- 1974
Ph.D. / M.D.	Kiel, Transport processes in the central equatorial Atlantic and their influence on the heat budget, Ph. D.	1980	1983
Post-Doc	University of Miiami, CIMAS	1984	- 1984
	Oregon State University, Department of Oceanography	1984	- 1984

further Positions	Project scientist, Kiel, Institut für Meereskunde	1975	- 1979
	Project scientist, Kiel, Institut für Meereskunde	1984	- 1986
Current Position	Senior scientist	1986	

Five most important publications

Fahrbach, E. and J. Meincke, 1978: High-frequency fluctuations near the bottom over the continental slope. "Meteor"-Forschungs-Ergebnisse A, 20, 1-12.

Fahrbach, E., C. Brockmann and J. Meincke, 1986: Horizontal mixing in the Atlantic Equatorial Undercurrent estimated from drifting buoy clusters, Journal of Geophysical Research 91, 10 557-10 565.

Fahrbach, E., G. Rohardt, M. Schröder and V. Strass, 1994: Transport and Structure of the Weddell Gyre, Annales Geophysicae 12, 840-855.

Fahrbach, E, S. Harms, G. Rohardt, M. Schröder and R. A. Woodgate, 2001, The flow of bottom water in the northwestern Weddell Sea, Journal of Geophysical Research (Oceans): 106, C2, 2761-2778.

Fahrbach, E., Meincke, J., Osterhus, S., Rohardt, G., Schauer, U., Tverberg, V.,
Verduin, J. (2001). Direct measurements of volume transports through Fram Strait, Polar Research 20 (2), 217-224.

Dr. Hartwig Gernandt *1943

Scientific career

University	University Rostock, Physics, Diplom	1962	- 1967
Ph.D. / M.D.	University Rostock / German Academy of Science		- 1971
	Ionospheric Research / Faculty of Physics	1967	
	Title: Ionospheric anomalies at high geomagnetic southern latitudes		
Post-Doc	Meteorological Service of East Germany / Aerological Observatory Lindenberg,	1972	- 1975
further Positions	Leader of the East-German Antarctic Expedition Group construction of the East-German Research Base, later Georg Forster Station	1975	- 1977
further Positions	Station leader at Georg Forster	1982	1990
	Meteorological Rocket Sounding Station at Zingst of the Aerological Observatory Lindenberg		
	Head of Working Group	1992	- 1997
	Physics and Chemistry of the Atmosphere		
	AWI (Postdam)		
Current Position	Head of Logistics Department, AWI (Bremerhaven)	1998	-

Five most important publications

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General description Research Platforms and Polar Logistics

Mobile Research Platforms

Research and supply vessel RSV ”Polarstern”
The research and supply vessel RSV ”Polarstern” was commissioned in 1982. She is designed as a high class ice breaking vessel (GL 100 A 5 ARC3 / MC ARC3 AUT). The overall-length is 118 m and maximum beam 25 m. Displacement and draught are 17.300 tons and 11.2 m, respectively. Propulsion is performed by 4 diesel engines providing approximately 14.000 KW. Maximum speed is 16 and cruising speed is 12 knots. The ship is able to sail through 2 m thick fast ice with a speed of 5 knots and it breaks fast ice up to 3 m thickness and more. Bow and stern thrusters assist to manoeuvre the ship for work on stations or for unloading operations at the ice shelf margin.

The overall capacity is 124 persons with 38 to 44 berths for crew. About 50 to 70 scientists can be accommodated and provided with working facilities on board. The demand for using the ship has been permanently high during the years. Altogether about 5.500 scientists have been working on board until 2001. Since commissioning RSV ”Polarstern” has sailed more than 1 million nautical miles with an average of 320 days at sea each year. Until now she completed 20 Antarctic and 17 Arctic expeditions, each comprising a number of cruise legs. Highlights of Arctic expeditions have been joint operations with the Swedish icebreaker ”Oden” when the North Pole was firstly reached in September 1991. In 1998 she has been working with the Russian nuclear icebreaker ”Arktika” in the heavy accessible Alpha Ridge region. The latest co-ordinated operation was together with the icebreaker USCGC ”Healy” when after a detailed survey of the western Gakkel Ridge she completed her second visit to the North Pole in September 2001. Antarctic cruises were performed to the Weddell, Bellingshausen and Amundsen Sea as well as waters around the Antarctic Peninsula and the supply of Neumayer Station is a regular task each year. Twice “Polarstern” made winter voyages to the Antarctic, with important contributions to the understanding of seasonal cycles. “Polarstern” also has been instrumental in a number of SAR-operations, which have solved lives. She has assisted ships endangered by sea ice.

In order to maintain the ship's standard at a continuously high scientific and technical level after almost 20 years of permanent operation a comprehensive conversion and modernization was commenced in 1998 and completed in 2001. The shipyard work was focussed on installation of advanced scientific and navigation technology, fibre optic data network and communication systems as well as improvement and reconstruction of lifting gears, cranes, winches, laboratories and other facilities.

The reconstructed bridge with advanced navigation aids and electronic charts, the partially strengthened hull and other technical measures improve manoeuvring in heavy ice conditions.

Appropriate cranes support onshore loading. Lifting gears and scientific winches are designed for launching and recovery of devices and sensors, fishing and deep sea sediment probing. Hydro-acoustic survey systems such as Hydrosweep, Parasound and fishery sounders can be continuously operated. The fibre optic network connects bridge, winch control room, laboratories and all scientific working places with several servers and distributes information of the central data acquisition system. Altogether 24 scientific laboratories, aquarium and refrigerating rooms are placed at disposal. Additionally up to 15 mobile laboratory containers can be installed.

Facilities such as flight control, hangar, helideck, tanks and refuelling facilities are available for two helicopters BO 105 CBS 5 used for sea ice reconnaissance, transport of personnel

and slingload as well as for scientific observations. The weather station collected meteorological data provides forecast information and satellite imagery on sea ice distributions. Recently technical facilities and hydro-acoustic navigation aids have been installed to deploy the remotely controlled underwater vehicle VICTOR 6000 for deep sea missions.

RSV ”Polarstern” offers excellent working conditions. The advanced scientific and technical equipment and ability to navigate in heavy ice conditions in almost all regions of the Arctic and Antarctic oceans make her a leading platform of the international polar research fleet.

RV “Heincke”
RV “Heincke” was first commissioned in 1990. The overall length is 54 and beam is 12.5 meters. Displacement and draught are 999 tons and 4.2 m, respectively. RV “Heincke” is a low noise ship with a range of 7500 nautical miles and can spend approx. 30 days at sea. She is at sea for approximately 200 days a year with its main operational areas being the Baltic Sea, North Sea and Atlantic.

The laboratories on board (wet, dry, thermal and multipurpose) provide virtually vibration-free workplaces for up to twelve scientists, as well as excellent computing facilities. The laboratories are supplied with seawater, compressed air and a UPS power supply. Thanks to its versatile equipment (winch systems, crane facilities, radio communications equipment and sounding equipment), the “Heincke” can be used for a broad range of biological and hydrographic research activities.

Aircraft “Polar 2” and “Polar 4”
Both aircraft of type Dornier 228-101 have been specially adapted for polar operations. As STOL type aircraft equipped with combined wheel and ski landing they can operate from small gravel strips and even from an unprepared snow surface. Their slow flight speed makes them an effective tool for survey missions. The aircraft’s high wing layout and large windows offer excellent conditions for visual observations and an unpressurised cabin with rectangular cross-section and a level floor facilitate mission equipment. On mission aircraft can operate up to 3600 m altitude with a minimum speed of 250 km/h. The cruise altitude on ferry flights is 7500 m with oxygen masks. On scientific missions the crew consists of 2 pilots, 1 technician and 2 scientists. Maximum transport capacity is 15 Pax. Maximum endurance with an average scientific load is 6 hours.

During Antarctic seasons both aircraft are operated from Neumayer Station and also from Halley or E-Base. Mobilisation and demobilisation from Europe via South America for Antarctic missions is performed with support provided by the British stations Halley and Rothera. Arctic missions are usually based at station North or other airfields in Greenland, at temporary camps on the Greenland icesheet or Longyearbyen airport on Svalbard.

Since 1983 “Polar 2” has flown about 6700 hours and Polar 4 about 5000 hours since 1985 on scientific and logistic missions.

Details about research vessels an aircraft

	Availability (days / year)	Internal Use AWI (%) in 2002	External Use (%) in 2002	remaining life time
RV POLARSTERN	326	34.2	65.8	13
RV HEINCKE	194	25.2	74.8	3
Aircraft Polar 2, Polar 4	600 flight hours	46	54	5 - 6

	number of users				
year	1998	1999	2000	2001	2002
RV POLARSTERN	291	254	573	477	333
RV HEINCKE	184	120	141	198	286
number of campaigns					
Aircraft Polar 2, Polar 4	3	2	2	2	2

Polar Research Stations

Neumayer Station (70°39‘S, 08°15‘W, 40 m a.s.l.)
The station is constructed on ice. The central facility is a steel tube system consisting of two main tubes (eastern tube 82 m, western tube 92 m in length), a 92 m long cross tube and a garage for polar vehicles. The tube diameter is between 8 and 8.4 m. The total area is 3420 sqm. The tube system accommodates 56 containerised modules such as sleeping rooms, laboratories, mess, hospital, social rooms, kitchen, snowmelter, power plant with two diesel generators (100 KW each) and 1 emergency generator (50 KW), air-condition and ventilation control system, workshop, warehouse and other technical facilities, such as a biological sewage treatment plant. The cross tube accommodates tank containers and food store. Other structures on steel platforms are the Radom with dish antenna, balloon launching shed, wind generator and air chemistry laboratory.

Scientific and technical equipment is at a high level standard. The local computer network serves laboratories and the data acquisition systems of the observatories and measurement sites. Communication, data transfer and Internet connection is performed via a permanent satellite link (64 kbit/s). Further communication equipment is Inmarsat A, VHF and HF facilities.

The key wintering staff is 1 station leader/physician, 4 scientists, 3 technicians, 1 cook. During summer season about 30 to 60 scientists and technicians are temporarily at the station. These are scientists and technicians for maintenance works at the station, aircraft missions and traverses departing for Kohnen Station. Outdoor facilities are set up such as modules for accommodation of personnel, aircraft landing strip, fuel tank containers, track vehicles and transportation facilities.

Supply is regularly performed by RSV ”Polarstern” until the middle of December each year. At the end of February or beginning of March other ships are usually requested to perform the resupply operation. Currently SANAP provides assistance by SA ”Agulhas” in the frame of logistic co-operation.

Kohnen Station (75° S, 00° E, 2892 m a.s.l.)
Kohnen station was commissioned in January 2001.It consists of a 32 m long and 8 m wide platform on steel pillars where 11 prefabricated container modules are mounted. The

functions of these modules are radio room, mess room, kitchen, sanitary facilities, two sleeping rooms, snowmelter, store, workshop and power plant. Food store containers on sledges and additional sleeping modules can be parked beside the platform and hitched to the central energy supply. Up to 20 persons can be accommodated. Communication facilities are Inmarsat B for data transmission, phone and fax. The power plant provides 80 kW with an average fuel consumption of 250 ltr. per day. The fuel depot consists of specially certified tank containers mounted on sledges. A marked and groomed landing strip for small ski-equipped aircraft like Dornier 228 or Twin Otter completes logistic facilities.

The distance between Neumayer and Kohnen is 757 km. Supply is mainly based on traverses. Design and power of towing vehicles meet the conditions, which are encountered at the inland ice plateau. The vehicle fleet consists of 6 towing vehicles, 12 sledges carrying piece goods and containers, and 5 sledges with tank containers and accommodation facilities. GPS navigation is used. Depending on weather conditions a traverse takes 9 to 14 days. Two traverses with up to 6 sledge trains are performed each field season carrying about 200 tons of construction material, scientific equipment, consumables and fuel.

Antarctic vehicle fleet
The vehicle fleet used around Neumayer Station and for expeditions into the interior comprises 10 Käßbohrer “Pisten-Bully” tracked vehicles specially adapted to Antarctic conditions. They have a strengthened frame in order to withstand the stress of pulling heavy loads during supply or research traverses. They are equipped with GPS navigation appropriate communication equipment and can operate year around allowing serving of deep field observatory installations. Under prevailing conditions their average lifetime is 8 to 10 years. This backbone of deep field logistics is augmented by an appropriate number of smaller vehicles (Skidoos), sledges for heavy and light loads and sundry other equipment necessary to ensure optimal working conditions for scientists as well as their personal safety.

Dallmann Laboratory (62°14‘S, 58°14‘W, 15 m a.s.l.)
The facility, which is in operation since 1994 as a joint base shared by Argentina, Germany and the Netherlands consists of one building with laboratories, workshop, store, social rooms, 12 berths and several container modules with aquarium and wet laboratories. AWI, NWO and IAA provide support for new technical and scientific installations. In 1998 a biological sewage treatment plant has been installed to improve the sewage disposal at Jubany station. In 2001 a new building has been constructed to currently accommodate facilities for Scuba diving. Logistics and supply of the laboratory is mainly performed in co-operation between AWI and IAA. On site support is provided by the technical staff of Jubany station.

Koldewey Station (79°N, 12°E, 50 m a.s.l.)
The Koldewey Station consists of several buildings and laboratories situated in the village Ny-Ålesund. The central building, the so-called ”Blue House”, is established with offices and accommodation for guest scientists. Spectroscopic and laser remote sensing instrumentation is installed in special laboratories in the so-called ”NDSC laboratory building”. A balloon launching shed, chemical laboratory and store complete the facilities. The station is equipped with a local computer network. Communication, data transfer and Internet connection is performed via satellite link.

Key wintering staff consists of a scientific station leader and an engineer, who are running the meteorological and stratospheric observatories. They are also responsible for on-site station management.

Ny-Ålesund is easy accessible by regular airline flights throughout the year. This access advantage and the high level research equipment make the station favoured for various scientific projects. Thus about 80 scientists and technicians are working here with an average of about 1100 man days each year. Amongst these 600 man-days fall to AWI activities and station management.

Ny-Ålesund as an international research site consists of several research stations and bases operated by Norway, Germany, UK, Japan, Italy and France. Logistics and support is provided by Kings Bay A/S to all research stations on a contractual basis.

Details about Research Stations and Polar Logistics

	Availability (days / year)	Internal Use AWI (%) 2002	External Use (%) in 2002	remaining life time
Koldewey*	365	55.1	44.9	10 - 15
Jubany	160 - 180	43.7	56.3	10 - 15
Neumayer*	70 - 80	33.3	66.7	5
Kohnen**	60 - 70	62.5	37.5	10 - 15

	number of users				
Year	1998	1999	2000	2001	2002
Koldewey*	61	49	33	60	65
Jubany	17	16	19	20	23
Neumayer*	6	5	4	8	6
Kohnen**	-	-	-	19	16

* Numbers are calculated for research projects, scientific personnel for observatories is not considered.

** Constructed and used in the frame of the European Project on Ice Coring in Antarctica (EPICA) by international funding, numbers are calculated for scientific personnel. This summer only station is to be further used when EPICA will have been completed.

International Collaboration and Logistic Management

Logistic infrastructure in Bremerhaven is tasked to ensure the technical operation of stations and mobile research platforms, which can only be achieved with the assistance of national and international co-ordination. A close logistic collaboration has been established with the United Kingdom, the Republic of South Africa, Norway and Argentina. New agreements have been signed with Japan, The Netherlands and France to further develop co-operation in polar operations and polar technology. Beside the joint Russian-German expeditions for Siberia the collaboration with Russia also covers logistic operations in Antarctica.

Logistics management comprises extensive administration tasks and briefing of personnel as well as procurement and management of equipment for expeditions. Each year about 500 to 700 participants scheduled for various expeditions and logistic missions are assisted in their preparations to head for the Arctic and Antarctic. AWI logistic performed on-site maintenance and repair works at Neumayer as well as preparation of and missions with the Antarctic onshore vehicle fleet. Support is obtained by contractual agreements with aviation and shipping companies to operate research vessels RSV ”Polarstern” and RV ”Heincke”, to perform aircraft missions and to technically run polar stations.

All Antarctic operations by ship, aircraft, vehicles as well as station performance are in line to COMNAP/SCALOP guidelines and recommendations. At Neumayer Station new

technologies are applied such as biological sewage treatment and complementary power supply by wind generator.

Selected coordinator or leader function in programmes and networks

Responsible scientist	Programme / Network	Function
H. Miller	Environmental Coordinating group of COMNAP/SCALOP	Chairman
H. Gernandt	Ships Operation group of COMNAP/SCALOP	Chairman

Additional remarks

Major Investments

	Large Scale Infrastructure	Costs (10^3€)	Investment period
1	Marine geophysical instrumentation pool	5,000	2003-2004
2	AUV and ROV	5,000	2004-2005
3	Midlife Conversion “Heincke”	5,000	2006
4	Vehicles for “East Antarctic Ice Divide”	4,000	2005-2006
5	Construction “Neumayer III” / disassembly “Neumayer II”	up to 30,000	2005-2008
6	Succession Dallmann-Laboratory	7,000	2008-2009
7	Substitution of “Mya”	6,000-7,000	2008-2009
	General Infrastructure		
8	Digital Streamer System	2,500	2003-2004
9	Compute Server (replacement CRAY T3E)	4,000	2004
10	North Sea Observatory Network	3,000	2004-2005
11	Portable NMR	2,500	2004-2005
12	New buildings	45,982	2003-2005

1) Marine geophysical instrumentation pool

We plan to expand our Helmholtz mission oriented services of providing infrastructure to the wider community by establishing and operating a pool of marine geophysical instrumentation. This will initially consist of a pool of ocean bottom seismometers and other marine geophysical as well as oceanographic equipment and should later grow as community demand requires.

2) Autonomous Underwater Vehicle (AUV) and Remotely Operated Vehicles (ROV)

Autonomous Underwater Vehicles (AUV) are self propelled, unmanned submersibles with own energy supply and control systems for navigation. Without requiring cable connection to a surface vessel these vehicles are excellent sensor platforms for long survey missions at the marginal sea ice zone and under the ice. As most AUVs support modular concepts in payload configuration they can be equipped with different sensors and prepared for a variety of pre-programmed missions. One example is the simultaneous measurement of zooplankton biomass under the sea ice and the ice thickness itself. Furnished with various sonar systems, optical devices, temperature and salinity sensors they are the only instruments to get data with high spatial coverage in shelf ice caverns, which are too dangerous to enter for manned submersibles and unreachable for cabled systems. Underway an AUV can sample data on seabed topography, animals living there, current speed and direction, ice thickness and sediment properties. This kind of data is needed to validate existing models on water mass modification or the mass balance of large Antarctic ice sheets. Envisaged missions will benefit from advances in sensor technology. The 4-dimensional description of methane plumes across cold seeps becomes possible, if using an AUV equipped with methane, temperature and salinity sensors at different water depths along transects.

Remotely Operated Vehicles (ROV) are connected by a cable to a surface vessel, which supports the ROV with power. Ultra short baseline navigation systems became more reliable over the past years and support exact navigation of the ROV in geo-coordinates. Apart from the power supply the modern fibre optical cables also allow the transmission of huge amounts of data from the vehicle to the vessel. This is used for transferring optical data, which enables the operator to navigate the vehicle safely. Working class deep-sea

vehicles are equipped with one or two manipulator arms, which serve for sampling or manipulating in the water column or at the seafloor. Because power supply is almost unlimited, these vehicles can be operated constantly over days for targeted sampling of water, sediments, rocks and organisms. ROVs can also be used to lift and manoeuvre scientific instruments deployed at the seafloor to other locations for further measurements. Professional deep-sea camera systems and innovative data processing software allow real-time video-mosaicking along transect surveys.

3) Midlife Conversion "Heincke"

"Heinke" was commissioned in 1990 and is still a modern, multifunctional and efficient ship. In particular her reduced vibrations and the possibilities for biological experiments on board of the ship have been proven invaluable. Since "Heincke" is part of the pool of medium sized research vessels the demands concerning ship time and operating areas drastically increased and with this also claims for modernizations. A technical commission, that still has to be established, shall work out a concept for her midlife conversion.

4) Vehicles for "East Antarctic Ice Divide" project

From 2007 to 2011 East Antarctica shall be traversed during the next International Polar Year and on the occasion of the 50th anniversary of the Antarctic treaty. For the project "East Antarctic Ice Divide" a special fleet of vehicles is needed. In this program, scientists from Japan, China, Russia, France, USA and other countries work together with scientists from AWI.

5) Construction Neumayer III / Disassembly Neumayer II

Neumayer-Station is the central German research station in Antarctica and an important logistic prerequisite for all activities on the Ekström ice shelf and in Dronning-Maud Land, in particular for EPICA. The station has to be renewed in 2007/2008. AWI scientists develop a science plan for the coming decade in cooperation with their external partners. Neumayer III also is necessary for running the CTBT infrasound station.

6) Succession Dallmann-Laboratory

The building for the Dallmann-Laboratory was constructed in 1994 at the Argentinean station Jubany. Ever since then German, Dutch and Argentinean scientists used the laboratory each season. By 2007/2008 the fundament and building will be worn and a new building will be necessary.

7) Substitution of "Mya"

The research catamaran "Mya" (built in 1978) should be replaced by 2009 by a new ship for coastal research in the North Sea. In 2001 a workshop developed specifications for the replacement of "Mya": It should not be a catamaran but a bigger and faster ship with two winches for nets and probes, possibilities for overnight stays for the crew and three scientists, a mess room, storage for scientific equipment, shower for divers, A-frame for small geological equipment, jollyboat.

8) Digital Streamer System and Air gun array

Research topics of this programme as well as topics of other German marine geophysical programs require the availability of a modern 1024 – 2048 channel digital streamer system and a high volume G-Gun array. The streamer system should be configurable to different length and hydrophone group spacing in order to allow high resolution sedimentary cover studies as well as deep penetration crustal investigations.

9) Compute Server (replacement CRAY T3Y)

The AWI computer center needs a replacement for the local computer server CRAY T3 in 2004. Main users are the Climate System (including atmospheric physics) and the

Geosystem department at AWI. This replacement is a prerequisite for use and participation on national high-end computing networks such as DKRZ or HLRN. The new server will be used e.g. for the development of new numerical algorithms and data processing of the extremely high data amounts from model runs.

10) North Sea observatory network
Currently AWI investigates the possibility of installing an automated network of observatories in the North Sea that will take over all long term measurements conducted currently off the coast Sylt and Helgoland. This network shall provide online data on the physical, chemical and biological situation of the North Sea. A reliable estimation of investment costs cannot yet be given.

11) Portable NMR
The in-vivo NMR-laboratory at AWI uses a 4.7T MR tomograph and a 9.4T spectrometer with a microscopy unit. These units enable e.g. the non-invasive investigation of living animals metabolism and the appraisal of their physiological status. In order to investigate the physiological status of animals in their biotope a portable NMR for use on a ship or station would be necessary. With such a system, measurements with Arctic and Antarctic organisms, coming directly from their natural habitat, could be performed. Besides biological experiments, glaciological experiments could also be performed with a portable NMR.

12) New buildings
New research building in Bremerhaven
In Bremerhaven, a new research building with more than 21,000 m^2 effective area is under construction, The new building considers the increased requirement for laboratory and office space due to the steady growth of the institute, The new building will be finished end 2003.

New building of a lecture hall in Bremerhaven
The building of a lecture hall is planned adjacent to the main building in Bremerhaven, The present lecture hall with a capacity of approximately 100 persons is far to small to fulfil the requirements for the organisation of national and international meetings, Since there are no convenient rooms for large scientific events available in Bremerhaven a new building is necessary.

New building for the Wadden-Sea station Sylt
The current course building (built in the thirties of the last century) is under use since 1949 and since than widely unchanged. Modern sensitive technical equipment cannot be used there anymore. Due to the age of the building increasing maintenance costs have to be considered. The construction of a new main building will create modern, up to date working and course rooms and lay the foundations for successful research projects and an expansion of course services.

Rebuilding of the naval accommodations in Helgoland
Due to the unsatisfactory living situation for AWI co-workers on Helgoland, it became necessary to create new housing space. By taking over the former naval accommodations the situation could be mitigated. These accommodations have to be renovated to fulfil the requirements of the future users.

4.3 Competence of participating centre –GKSS Forschungszentrum (GKSS)

Profile

The Institute for Coastal Research (IfK) at GKSS Research Centre has developed an applications-oriented, interdisciplinary research programme addressing the dynamics, state, change and utility of the coastal environment. The institute's mission is - in cooperation with his partner institutes on national and European level - to provide the scientific foundation for the implementation of effective and sustainable coastal management practices. Research results are used in advising public authorities and society at large on environmental issues and in developing efficient and economical methods and technologies for environmental monitoring.

The research programme "The Coastal Environment" deals specifically with the topics "Anthropogenic and Natural Regional Changes", "Environmentally Relevant Substances of the Future", "Monitoring Methods for Coastal Management" and "The Prognosis and Control of Coastal Processes". Physical processes such as ocean waves, currents, morphodynamics, the regional transport of substances and their influence on the coastal ecosystem are addressed, as well as the analysis of medium and long-term trends with the help of environmental statistics and simulations and the development of operational monitoring and forecasting methods. The relevance of "new substances is assessed and adequate analytical procedures are developed.

The work done at the Institute for Coastal Research is based on the expertise provided by the "Systems Analysis and Modeling", "Development of Operational Systems" and "Physical and Chemical Analysis" groups. The International BALTEX Secretariat has been established at GKSS Research Centre as a focal support point for the Baltic Sea Experiment (BALTEX) within the global context of GEWEX.

Recent developments

The Institute for Coastal Research was founded in 2001 via the merger of three of the formerly independent institutes at the GKSS Research Centre: The Institutes for Atmospheric Physics, Hydrophysics, and Physical and Chemical Analysis. In 1999 an external advisory board had suggested that the environmental research activities at GKSS be focussed on applied aspects of coastal research. Following this advice, a joint research programme "Water and Climate in the Coastal Zone" with the research themes "Substances Relevant to the Future of Coastal Regions", "Monitoring Strategies for Coastal Management", "Anthropogenic and Natural Regional Changes" and "Prognosis and Management of Coastal Processes" was established in 2000. This programme was reviewed positively by an external board in September 2001 and the institute's profile has subsequently progressed to the current research programme with the title "The Coastal Environment" ("Lebensraum Kueste").

Prior to 2000, the three former individual institutes made contributions to several of the "Sections" within the former HGF structure, amongst others "Climate Systems", "Soil and Water", "Biological Systems" and "Environmental Technologies". Following critical comments made during the review of HGF-Section 1 in 1998, it was decided to discontinue research activities in the field of "atmospheric physics" after the retirement of the director responsible. Instead, the former Institutes for Hydrophysics and Atmospheric Physics were reorganized according to the advice of the external advisory board, with one division being dedicated to "Monitoring Systems" and the other to "Systems Analysis and Modelling" (including climate in the coastal zone). The broad spectrum of analytical methodologies in

the former Institute for Physical and Chemical Analysis was significantly reduced and today, the activities of the corresponding division are devoted to applied and project-orientated research with a strong focus on the coastal environment.

The leadership of the Institute for Coastal Research and the responsibility for the three divisions lies with Prof. Franciscus Colijn (Operational Systems), Prof. Bernd Neidhart (Physical and Chemical Analysis) and Prof. Hans von Storch (Systems Analysis and Modelling). One of these directors represents the combined institute as the speaker on a rotational basis. Following this reorganization, all major activities of the institute have now become integrated consistently into the MARCOPOLI programme.

The external review board as well as the external advisory board have suggested the need for additional competencies in the areas of socio-economics and ecology. Within the scope of financial resources, these suggestions have been considered and realized, in particular via new appointments of leading scientists. In addition, discussions are underway with nearby Universities aimed at further improvements in joint research and education in the fields of ecosystem modelling, socio-economics, bio-geochemistry and eco-toxicology.

Science related information

Quantitative parameter	Type	Unit	1998	1999	2000	2001	2002
Publications	ISI-listed	no.	51	46	40	37	32
	Habilitations	no.	0	1	0	0	0
	PhD Thesis	no.	8	3	8	2	3
Full professorship offerings (C3/C4)		no.	0	0	0	0	0
Guest scientists		no.	28	24	23	29	35

Third Party Funding

Quantitative parameter	Unit	1998	1999	2000	2001	2002
Participation in DFG-Collaborative Research Centers, Priority Programmes and Graduate Colleges	no.	1	1	1	3	3

Third Party Funding	1998 (10^3€)	1999 (10^3€)	2000 (10^3€)	2001 (10^3€)	2002 (10^3€)
total	4,224	4,300	6,090	5,707	7,100
public funds (%)				97	not available
industrial funds (%)				3	not available

Selected third party projects of GKSS

Project Name	Funding Source
Ferry Box	EU
Maximum Waves (MaxWave)	EU
ENVISAT Operational Oceanograpy (ENVOC)	HGF
Hind cast of dynamic processes of the ocean and coastal areas of Europe(HIPOCAS)	EU
Wirkungsbezogene Analytik	BMBF
Hydrographic Monitoring of the Neva (HYMNE)	EU
Operational Radar and Optical Mapping (OROMA)	EU

Promotion of young scientists and proportion of women

Quantitative Parameter	Total number 2002	Proportion of women
PhD Students	22	10 (45%)
Post-Docs	35	6 (17%)
Young group leaders	0	0%
Group leaders	17	0%
C3/C4 professorships	3	0%

Innovation data

Quantitative Parameter	Unit	1998	1999	2000	2001	2002
Patents applied for	no.	14	10	6	3	8
Patents granted	no.	0	0	0	2	2
Licences	no.	19	22	23	24	23
Licence revenues	10^3_	51,524	22,984	31,166	39,989	not available
Spin-offs	no.	0	2	1	0	0

Honours and Awards

Scientist	Prize	Organisation	Year
Erhard Raschke	Georgi-Award	Alfred-Wegener-Stiftung	2001
Claus Weitkamp	Lifework Award	International Coordination-group on Laser Atmospheric Studies (ICLAS)	2002

Programme Topic MAR: Ocean and Global Climate

Important recent achievements showing acquired expertise

The climate community model ECHO-G, provided by the Model & Data Group at the MPI for Meteorology /German Climate Computer centre, is extensively used to reconstruct the climate of the past 1000 years. This topic was addressed, even if this topic is not an integral part of the spectrum of the Institute for Coastal Research, after the need for such activities arose in the HGF strategy project KIHZ (a joint effort with AWI, GFZ, FZJ and others), and the only suitable expertise was, mainly by chance, in the ICR (where Hans von Storch had just taken over responsibility, who had an excellent background in global climate modelling from his time at the MPI for Meteorology). The model runs are forced by prescribed solar, volcanic aerosol and greenhouse gas forcing, and dynamically downscaled to the European theatre. A methodology to enforce consistency with paleoclimatic proxy evidence (DATUN) is presently prepared.

The model simulations are done in a network of national and international institutions, and receives funding through several national and international projects.

Significant forthcoming changes

The activities in this field will not change significantly during the next few years; it is expected that the presently developed methodology, in particular with respect to assimilated proxy evidence, will pay off in the next years.

Leading Scientists

Prof. Dr. Hans von Storch *1949

Scientific career

University	University of Hamburg, Mathematics, physics and Danish, Diploma in Mathematics	1969	-	1976
Ph.D. / M.D.	Hamburg, Meteorological Department, PhD Degree in Meteorology	1977	-	1979
Post-Doc	University of Hamburg, Meteorological Department	1980	-	1986
further Positions	Senior Scientist and leader of "Statistical Analysis and Modelling"-group at the Max Planck-Institute for Meteorology (Hasselmann division).	1987	-	1995
Current Position	Director of the Institute of Hydrophysics at the GKSS Research Centre and professor at the Meteorological Department of the University of Hamburg;	1996		
	Speaker of Environmental Research at GKSS	2000		

Five most important publications

von Storch, H., and F.W. Zwiers, (1999) <http://w3g.gkss.de/staff/storch/sz.htm>Statistical Analysis in Climate Research, Cambridge University Press, ISBN 0 521 45071 3, 494 pp.

WASA, (1998) Changing waves and storms in the Northeast Atlantic? - Bull. Amer. Met. Soc. 79, 741-760

von Storch, H., H. Langenberg and F. Feser, (2000) spectral nudging technique for dynamical downscaling purposes. Mon. Wea. Rev. 128: 3664-3673

von Storch, H., E. Zorita and U. Cubasch, (1993) Downscaling of global climate change estimates to regional scales: An application to Iberian rainfall in wintertime. - J. Climate 6: 1161-1171

von Storch H., G. B¸rger, R. Schnur, and J. von Storch, (1995) Principal Oscillation Pattern: A review. - J. Climate 8, 377-400

Networking details

Most Important scientific cooperations

Responsible scientist	Topic of co-operation	Partners
Hans von Storch	Klima in historischen Zeiten (KIHZ)	Geoforschungs-Zentrum (GFZ), HGF-Strategieprojekt
Hans von Storch	Simulation, observation & paleoclimatic data: Climate variability over the last 500 years (SO&P)	CRU Norwich and others

Selected coordinator or leader function in programmes and networks

Responsible scientist	Programme / Network	Function
Hans von Storch	Deutsches Klimarechen-Zentrum (DKRZ)	Chairman Scientific Steering Committee
Hans von Storch	DFG Senatskommission	Member
Hans von Storch	Intergovernmental Panel on Climate Change – Task Third Assessment Report (IPCC-TAR)	Lead Author
Franciscus Colijn	International Council for the Exploration of the Sea (ICES)	Chairman Oceanography Committee
Franciscus Colijn	Steering Committee – Global Ocean Observation System (SC-GOOS)	Member Steering Committee

Programme Topic CO: Regional Coastal Areas

Important recent achievements showing acquired expertise

With the foundation of the GKSS Institute for Coastal Research further development of its expertise has been focused on (1) the determination and analysis of inorganic and organic trace substances and their effects, (2) on monitoring techniques including remote sensing and autonomous measurement systems and (3) on modelling and system analysis of the coastal environment and climate.

Organic and inorganic trace substances

Recommendations for optimized future concentration monitoring concepts of elements and organics have been derived from a number of externally funded projects such as the BMBF/UBA funded project “Elbe 2000”. An integrated evaluation and assessment of the pollutant research in the river Elbe and its tributaries has been carried out. Currently measured element concentrations were assessed on a geochemical basis from natural regional background values. The results and recommendations have been adopted partly by German and Czech water authorities, such as the Povodi Labe in Hradec Kralove and the Wassergütestelle Elbe in Hamburg.

The strong interplay between measurements and modelling within the Institute for Coastal Research (IfC) is a well established pre-requisite in order to parameterise and validate numerical schemes and, on the other hand, to identify chemical key species that have to be targeted in field and laboratory measurements.

Development of analytical techniques for the determination of the temporal and spatial variability of atmospheric mercury has been completed. Our methods have been adopted by OSPARCOM in the Sampling Guidelines for Monitoring Networks. GKSS data sets serve as

experimental reference data for an international model inter-comparison under the UN-ECE Convention on Long-Range Transport of Air Pollutants (CLRTAP).

For a more effect-orientated assessment of potential pollutants, the concept of Bioassay-Directed Chemical Analysis has been successfully established and applied to sediments and water samples with emphasis on acute toxic, genotoxic and more recently endocrine active substances.

Spatial monitoring techniques
For continuous monitoring of water quality indicators along fixed transects, an autonomous measurement system has been developed for online and in-situ water quality observations on board of ships of opportunity (e. g. Ferry Box), which significantly improves the spatial and temporal availability of routine data. Using this system we have started to build up a dense time series of hydrographic and bio-geochemical variables for the transect Cuxhaven - Harwich, which will be complemented by satellite data, mainly of ENVISAT. Within the framework of the EU funded Ferry Box project, which is coordinated by GKSS, a network of ferry boxes has been established.

Recent achievements have also been made in the spatial and temporal resolution of nutrient measurements in the Wadden Sea, which show that even without main discharges from land eutrophication effects occur along the sea-land gradients. This sheds a different light on the causes of eutrophication in the Wadden Sea, which is probably a phenomenon related to the hydrodynamic characteristics of the area , but which also depends on organic mater input from the North Sea.

High-precision detection of seabed structures by means of a multibeam echosounder system is now a well understood technique and regularly applied to study the coastal sediment movements in great detail. Another fruitful side application is the identification of ancient coastal structures for underwater archaeology in combination with divers. The latest finding was a 8000 year old settlement off the coast of Mecklenburg in the Baltic Sea which sheds some light on the climate changes during that time.

For monitoring tidal flat areas of the Wadden Sea the combination of detailed analysis by sampling along transects, aerial surveys using multispectral video technology and high resolution satellite data (Thematic Mapper, Spot) has opened new potentialities to study changes in sediment composition and transport, surface morphology and benthos communities.

For the Medium Resolution Imaging Spectrometer MERIS, which is one of the core instruments of the Earth Observation satellite ENVISAT (launch March 2002), a new procedure has been developed to retrieve properties of coastal waters, such as the concentrations of suspended matter, phytoplankton pigment and dissolved organic substances as well as parameters of the light climate for the determination of primary production. This procedure is based on inverse modelling and neural network methods. It has been developed at GKSS as Expert Support Laboratory of ESA and is now implemented in the ENVISAT data processor. For this development extensive measurements of the optical properties of coastal waters and it substances as well as radiative transfer simulations with Monte Carlo photon tracing techniques have been performed, partly within the context of the EU funded projects COASTLOOC, COLORS, NAOC and REVAMP. Methods for the operational application of ENVISAT data have been developed in the BMBF funded projects MAPP (Meris Application and regional Product Project) and ENVOC (ENVISAT Operational Oceanography), where in particular the synergy of ENVISATs optical and microwave instruments has been investigated for

applications such as suspended matter transport, primary production in coastal waters and wind and wave forecast.

Under the co-ordination of GKSS the HYMNE project (EU) brought together 4 West European and 4 Russian partners. The overall objective was to provide a low cost tool to the environmental administration of St. Petersburg to monitor and predict key parameters for the description of the environmental situation of the Neva Bight. Among others the following was achieved: The adaptation of remote sensing facilities for an operational monitoring of the regional hydrosphere with a high spatial and time resolution. Satellite optical, IR and radar instruments were used to demonstrate the monitoring of hydrographic parameters on a large scale whereas shore-based radar devices were used to observe the water transport rates, ice movements, wind, waves as well as small scale eddies on a local scale. Standard interfaces between the observation and prediction modules were defined and validated.

For the observation of coastal atmosphere and climate components calibrated remote sensing (cloud radar) and in-situ measurement capability has been set up and comprehensively tested in the field. The instrumentation served as a core for the activities in the EU-projects CliwaNet and CARL and will allow for detailed research on coastal cloud systems. Significant contributions have been made to international activities on the implementation of cloud observations from space (ESA, NASA).

Modelling and system analysis
In a continuous series of international projects, coordinated by GKSS-scientists, GKSS capabilities and scientific position were established within the European coastal research community. International EU projects under Mast 1 were started with the coordination of the Wadden Sea Project WASP, where a coupled current-wave- interaction model was created, which was calibrated by continuous automatic measurements. Work was continued with the coordination of the WASA-Project, which showed the climatological variability of wind-extremes by reconstructing for the first time 40 years of wind fields over the North-Atlantic. In the Pioneer-Project under Mast 3 the assimilation of biological data into the ecological model ERSEM, which was coupled to respective physical model to reproduce the pollution of the Baltic coastline from the Odra river flooding in 1997 was started.

The EUROROSE project of the EU dealt with the assimilation of ground based radar data into numerical models and the most recent project MAXWAVE investigates the risk of offshore traffic from individual rogue waves. The idea behind the development was to become capable to hind cast and forecast oceanographic events from data driven numerical modelling. Especially aerial coverage from satellite borne, ship borne and ground based measurements of the environmental parameters to be assimilated, was an important working strategy.

The dissemination of new developments and research results to the responsible governemental agencies Deutscher Wetterdienst, Bundesamt für Seeschifffahrt und Hydrography und Bundesamt für Wasserwirtschaft is well established.

An array of different regional atmospheric and shelf ocean models have been extensively used, and adapted to the specific needs, such as HIRHAM, REMO/HRM and, more recently, LM (atmosphere), HAMSON and TRIM for North Sea hydrodynamics, and WAM and k-model for the sea state (waves). Mainly in the framework of the BALTEX program, process based models on the land hydrology and river run-off are constructed with short-term operational purposes as well as to serve as components in a Regional Environmental Model (REM). Activities to build a process-based morpho-dynamic model for the coastal sea are underway.

Models have been used for the reconstruction of atmospheric and oceanic states since about 1955, and scenarios of possible future changes have been constructed. These results have entered the IPCC process (Third Assessment Report). In particular, the problem of a changing storm climate has been successfully addressed. The problem of the fate of lead, emitted with gasoline in Europe since the 1950s, has been studied in space/time detail; a retrospective evaluation of the lead regulation policy was made possible by this reconstruction.

Data assimilation methods are tested and used, in particular with respect to enforcing large-scale atmospheric information in regional atmospheric models, and sea level data in shelf sea and coastal sea models.

A network with social and cultural scientists has been established, which is addressing the problem of the perception of climate change and the perception of the utility of the coastal zone. Such an understanding of the public opinion and its dynamics is essential, when natural science wants to be a successful advisor of the political process. It is also an important prerequisite for the construction of holistic scenarios, as the future development depends to a large degree of public decisions, which are conditioned by public perception.

Significant forthcoming changes
Main forthcoming changes for our coastal research are expected from the synergy of the joint program of AWI and GKSS. In particular the combined expertises in the fields of biology, experimental ecology, new observation techniques for physical, chemical and biological variables and processes as well as modelling and system analysis will enable us to study coastal processes in the comprehensive way, which is the prerequisite for an optimized coastal zone management.

The holistic description of the regional environmental system, with emphasis on material transport and climate change, will be a major activity of the ICR. This activity includes the development of analytical methods, monitoring methods, documentation and analysis based on past measurements, modelling of environmental compartments, and coupling of these modules to a Regional Environmental Model.

In particular, as a follow-up of research on the emission, transport and transformation, and deposition of mercury and lead, future focus will be given to airborne organic substances with high persistence and bio-accumulation potential (POPs). It is intended to develop a system for short-term forecasting POP concentrations, as well as reconstructing past development and evaluating the prospects of further political regulations. The past and possible future changes with respect to the coastal wind-climate and its impacts will be emphasized.

Future research will increase the focus on the identification and assessment of potential risks induced by chemical contaminants. Considerable effort will be made in order to establish cause-effect relationships, as a consequent advancement from conventional concentration monitoring towards effect-monitoring. Therefore, a new concept for environmental analysis is currently established, based on bio-molecular recognition components such as DNA sequences, which are used for binding bio-effective substances.

The integration of different advanced observation tools into one system will be another major step forward in the field of operational systems for the support of coastal zone management. Such a system will include various remote sensing methods, autonomous measurement devices and dedicated in situ and laboratory analysis as well as tools for data

management, retrieval of information and visualisation. The core of the system will be based on models into which the various observational data will be assimilated.

A new activity focuses on strategies and rationale for the sustainable use of marine living resources with special emphasis on substances of potential value and methods of marine aquaculture. It aims to investigate natural substances in individual marine organisms and in complex biocoenoses with respect to their natural functions and their potential uses, e.g. as biopharmaceuticals and food supplements.

Research of the coastal zone in a holistic manner as outlined here can not be performed by single institute but requires the tight cooperation with other institutions. Main backbone for the IfC will be the cooperation with our partner of this program, the Alfred Wegener Institute for Polar and Marine Research. Further important cooperations will be continued or established with the neighbouring universities. Additional competence are necessary in a string of fields, such as socio-economy of the coastal zone, coastal geology, ecotoxicology and ecosystem modelling. So far, networks with other institutions mitigate the in-house limitations. To further improve the situation, specific cooperative arrangements (share of leading personnel) with neighbouring universities are instituted.

Agreements with the universities in Kiel and Hamburg have been, or are about to be, worked out with respect to ecology, climate, ecosystem modelling, coastal geology and socio-economy. Future research within the coastal research institute will encompass setting up links to the international LOICZ community, whereby GKSS/AWI should build the focal point for German coastal research. Strengthening will occur in the field of ecosystem modelling in a joint effort with the University in Kiel, biogeochemistry through cooperation with the University of Hamburg, and through developing new methods to monitor the health of organisms in the sea. This new direction is towards effect monitoring of contaminants and other stress factors on e.g. marine mammals. First steps into this direction have been made through a direct cooperation with the FTZ, a coastal research section of the Kiel university in Büsum. Also the causes of the recent seal mortalities, including the propagation and distribution of viral agents will be studied in detail to see whether mitigation can be reached if the causes are better understood. Most of the suggestions for additional funding are related to these joint efforts.

Leading Scientists

Prof. Dr. Hans von Storch *1949

Scientific career

University	University of Hamburg, Mathematics, physics and Danish, Diploma in Mathematics	1969	- 1976
Ph.D. / M.D.	Hamburg, Meteorological Department, PhD Degree in Meteorology	1977	- 1979
Post-Doc	University of Hamburg, Meteorological Department	1980	- 1986
further Positions	Senior Scientist and leader of "Statistical Analysis and Modelling"-group at the Max Planck-Institute for Meteorology (Hasselmann division).	1987	- 1995
Current Position	Director of the Institute of Hydrophysics at the GKSS Research Centre and professor at the Meteorological Department of the University of Hamburg;	1996	
	Speaker of Environmental Research at GKSS	2000	

Five most important publications

von Storch, H., and F.W. Zwiers, (1999) <http://w3g.gkss.de/staff/storch/sz.htm>Statistical Analysis in Climate Research, Cambridge University Press, ISBN 0 521 45071 3, 494 pp.
WASA, (1998) Changing waves and storms in the Northeast Atlantic? - Bull. Amer. Met. Soc. 79, 741-760
von Storch, H., H. Langenberg and F. Feser, (2000) spectral nudging technique for dynamical downscaling purposes. Mon. Wea. Rev. 128: 3664-3673
von Storch, H., E. Zorita and U. Cubasch, (1993) Downscaling of global climate change estimates to regional scales: An application to Iberian rainfall in wintertime. - J. Climate 6: 1161-1171
von Storch H., G. B¸rger, R. Schnur, and J. von Storch, (1995) Principal Oscillation Pattern: A review. - J. Climate 8, 377-400

Prof. Dr. Franciscus Colijn *1945

Scientific carreer

University	Groningen (NL), Biologie, Dr. (MSC) 1964-1971	1964	-	1971
Ph.D. / M.D.	Groningen, Marine Biology, Natural Sciences Facult., „Primary production of phytoplankton and microphytobenthos in the Ems-Dollard estuary“	1971		1983
Post-Doc	Groningen, Mar. Biol., Sen. Scientist	1983	-	1986
further Positions	Head of Research Departm. Biology, Rijkswaterstrat	1986	-	1994
	Prof., Coastal Ecology, Univ. of Kiel	1994	-	2001
Current Position	Director, FTZ-Büsum	1994	-	present
	Director, Institute for Coastal Research / GKSS	2001		

Five most important publications

Colijn & Cadée, (2003) Is growth of Wadden Sea phytoplankton light or nutrient limited? JSR, 32(1), 1-11
Tillmann, Hasse, Colijn, (2000) Planktonic primary production in the German Wadden Sea. J. Plankt. Res 22(7), 1253-1276
Peperzak, L., F. Colijn, W.W.C. Gieskes & J.C.H. Peeters, (1998) Development of the diatom-Phaeocystis spring bloom in the Dutch coastal zone of the North Sea: the silicon depletion versus the daily irradiance threshold hypothesis. J. Plankt. Res. 20(3): 517-537
Colijn, F., (1998) The temporal variability of plankton and their physico-chemical environment, Introduction. ICES J. of Mar. Science 55: 557-561
Wolfstein, K., F. Colijn & R. Doerffer, (2000) Seasonal dynamics of microphytobenthos biomass and photosynthetic characteristics in the northern German Wadden Sea, obtained by the Photosynthetic Light Dispensation system. Est. Coast. Shelf Sci. 51: 651-662

Dr. Roland Doerffer *1946

Scientific career

University	Hamburg	1966	-	1970
Ph.D. / M.D.	Dip. Biol.	1971		1972
	Dr. rer. nat.	1973	-	1977
Post-Doc	Uni Hamburg, Special research project Marine Research (SFB94)	1974	-	1978
further Positions	GKSS Institute of Chemistry	1978	-	1983
	GKSS Institute of Physics	1984	-	1994
	Institute of Hydrophysics, acting director	1993	-	1995
Current Position	Inst. f. Coastal Research, head remote sensing Lab.	2002		

Five most important publications

Schiller H, Doerffer R (1993) Fast computational scheme for inverse modeling of multispectral radiances: application for remote sensing of the ocean. Applied Optics 32:3280-3285

Doerffer R, Fischer J (1994) Concentrations of chlorophyll, suspended matter, and gelbstoff in case II waters derived from satellite coastal zone color scanner data with inverse modeling methods. Journal Geophysical Research 99:7457-7466

Schiller, Helmut & Roland Doerffer (1999) Neural network for emulation of an inverse model operational derivation of Case II water properties, International Journal of Remote Sensing, 9, 1735-1746

Gower, J. F. R.; R. Doerffer; G. A. Borstad (1999) Interpretation of the 685nm peak in water-leaving radiance spectra in terms of fluorescence, absorption and scattering, and its observation by MERIS, International Journal of Remote Sensing, 9, 1771-1786

Wolfstein, K., F. Colijn, R. Doerffer (2000) Seasonal Dynamics of Microphytobenthos Biomass and Photosynthesis Characteristics in the Northern German Wadden Sea, obtained by the Photosynthetic Light Dispensation System, Estuarine, Coastal and Shelf Science, 51, 651-662

Prof. Dr.-Ing. Bernd Neidhart *1941

Scientific career

University	Technical University of Darmstadt, Chemistry, Diploma in Engineering	1962	-	1967
Ph.D. / M.D.	PhD Degree at the Technical University of Darmstadt, Nuclear Chemistry „Radiochemical investigations of the spallation and fragmentation products of Tantalum“	1967		1970
Post-Doc	Technical University Darmstadt, Department of Inorganic and Nuclear Chemistry	1972	-	1978
further Positions	Head of the Central Scientific Unit for Analytical Chemistry in the Institute for Work Physiology at the University Dortmund (IfADo)	1978	-	1989
	Dep. Dir. Depart. of Occupational Toxicology (IfADo)	1981	-	1982
	Habilitation in Analytical Chemistry, Bergische Universität-Gesamthochschule Wuppertal	1984		
	Prof. for Analytical Chemistry at the University Ulm	1989	-	1990
	Speaker of Environmental Research at GKSS	1998	-	1999
	Dir. of the Institute of Physical and Chemical Analysis	1997	-	2000
Current Position	Prof. for Analytical Chemistry at the University Marburg	1990		
	Dir. of the Institute for Coastal Research/Physical and Chemical Analysis	2001		

Five most important publications

B. Neidhart, W. Mummenhoff, A. Schmolke, P. Beaven (1998) Analytical and legal aspects of the threshold limit value concept, Accred Qual Assur 3, 44-50

S. Bauerecker, B. Neidhart: Cold gas traps for ice particle formation, Science 282, 2211-2212 (1998)

O. Rohling, B. Neidhart (1999) Use of Erythrocyte ghosts for Preconcentration in Element Speciation, Anal. Chem. 71, 1077-1082

R. Eberhardt, B. Neidhart (1999) Acoustic levitation device for sample pretreatment in microanalysis and trace analysis, Fresenius J Anal Chem 365, 475-479

S. Rzepka, B. Neidhart (2000) Transport processes through track-etch membrane filters in a reagent delivery cell, Fresenius J Anal Chem 366, 336-340

Networking details

Most Important scientific cooperations

Responsible scientist	Topic of co-operation	Partners
Ralf Ebinghaus	Generation of observational data on Hg and POPs for model development and validation under the UN-ECE Convention on Long-Range Transport of Air Pollutants (CLRTAP)	EMEP Meteorological Synthezising Centre East, Moscow, RUSSIA
Ralf Ebinghaus	Mercury cycling in polar coastal ecosystems	Laboratoire de Glaciology et Géophysique de l´ Environment (LGGE), Grenoble, France
Franciscus Colijn	Operational Monitoring Systems	National Centre for Marine Research, Greece (NCMR), Southhampton Oceanographic Centre, UK (SOC), Norwegian Institute for Water Quality (NIVA), Finish Institute for Marine Research (FIMR)
Roland Doerffer	Development of neural network techniques	University Marie Curie, Paris
Andreas Prange	Water Quality of River Elbe	Internationale Kommission zur Reinhaltung der Elbe, IKSE (International Commission for the Protection of the River Elbe)
Roland Doerffer	Development of algorithms for ENVISAT	European Space Agency
Roland Doerffer	Synergy between ocean dynamics and ENVISAT (ENVOC)	Deutsches Zentrum für Luft- und Raumfahrt (DLR)
Hans von Storch	Social dimension of environmental change	Universities of Norkoping and Hawaii, Umweltforschungs-zentrum Leipzig (UFZ), Institut für Technikfolgeabschätzung (ITAS), Karlsruhe
Hans von Storch	Changing coastal climate	Meteo France, Swedish Weather Service (SMHI), Danish Weather Service (DMI), University Lund, Canadian Climate Centre for Modelling and Analysis in Victoria
Wolfgang Rosenthal	Ocean Wave Impact	Flensburger Schiffbaugesellschaft
Markus Quante	Simulation tools and algorithms for the EarthCare Satellite Mission	European Space Agency, Royal Meteorological Office of the Netherlands (KNMI); University of Reading, UK; Institut Simone Laplace, Paris F

Selected coordinator or leader function in programmes and networks

Responsible scientist	Programme / Network	Function
Franciscus Colijn	Comission Marine Facilities of the Netherlands	Chair
Roland Doerffer	ESA- Expert Support Laboratory	Member
Franciscus Colijn	European Catchments (EUROCAT)	Member, Work Package Leader

List of Abbreviations

4DVAR	4-Dimensional Variational Data Assimilation
AAO	Antarktische Oszillation
AARI	Arctic and Antarctic Research Institute, St. Petersburg
ACC	Antarctic Circumpolar Current
ACSYS	Arctic Climate System Study
ANDRILL	Antarctic Drilling
AO	Autonomous Okrug (northern Russia)
ARGO	Global Array of Profiling Floats
ARGOS	Automatic Remote Geomagnetic Observatory System
ARKTIEF	Arctic Deep Sea
ARTIST	Arctic Radiation and Turbulence Interaction Study
AUV	Autonomous Underwater Vehicle
AWI	Alfred Wegener Institute for Polar and Marine Research
BAH	Biological Institute Helgoland
BALTEX	Baltic Sea Experiment
BAW	Bundesamt für Wasserbau
BEEP	Biological effects on environmental pollution in marine coastal ecosystems
BFN	Bundesamt für Naturschutz
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe
BMBF	Bundesministerium für Bildung und Forschung
BRIOS	Bremerhaven Regional Ice Ocean Simulations
BSH	Bundesamt für Seeschiffahrt und Hydrographie
BSRN	Baseline Surface Radiation Network
CHAMP	Challenging Microsatellite Payload for Geophysical Research and Application
CLIC	Climate and Cryosphere
CLIVAR	Climate Variability & Predictability Programme
CLRTAP	Convention on Long-Range Transport of Air Pollutants
COADS	Comprehensive Ocean Atmospheric Data Set
COMNAP	Council of Managers of National Antarctic Programmes
COSA	Coastal Sands as biocatalytic filters
COSPAR	Committee on Space Research
CRYOSAT	Cryosphere Satellite
CTD	Conductivity-Temperature-Depth
DATUN	Data Assimilation through upscaling and nudging
DEKLIM	Deutsches Klima Forschungsprogramm
DIVERSITAS	International Programme of Biodiversity Science
DKRZ	German Climate Computing Centre (Deutsches Klimarechenzentrum)
DLR	German Aerospace Center
DNA	Deoxyribonucleic Acid
DOVETAIL	Deep Ocean Ventilation through Antarctic Intermediate Layers
DROMLAN	Dronning Maud Land Air Network
DWD	Deutscher Wetterdienst
ECHO-G	Gekoppeltes globales Atmosphäre-Ozean-Modell (MPI)
ECORD	European Consortium on Ocean Research Drilling
EIFEX	European Iron Fertilisation Experiment
EMEP	Environmental Synthesising Centre East, Moscow
ENCore	European Network Core
ENES	European Network for Earth System Modelling

ENSO	El Niño Southern Oscillation
ENVISAT	ESA's Environmental Satellite
ENVOC	ENVISAT Operational Oceanography
EPICA	European Project for Ice Coring in Antarctica
EPILOG	Environmental Process of the Ice Age: Land, Oceans, Glaciers
ERGOM	Baltic Sea Ecosystem Model
ERS	European Remote Sensing Satellite
ERSEM	European Regional Sea Ecosystem Model
ESA	European Space Agency
ESRI	Environmental Systems Research Institute
EU-FP 6	European Union Frame Programme 6
EUROCAT	European Catchments
EUROROSE	European Radar Ocean Sensing
FIMP	Finish Institute for Marine Research
FTZ	Forschungs- und Technologiezentrum Westküste der Universität Kiel
FZJ	Forschungszentrum Jülich
FZK	Forschungszentrum Karlsruhe GmbH
GAW	Global Atmospheric Watch
GBF	Gesellschaft für Biotechnologische Forschung mbH
GCM	Global circulation model
GEOMAR	GEOMAR Forschungszentrum
GEWEX	General Energy and Water Cycle Experiment
GEWEX-BALTEX	Global Energy and Water Circle Experiment – Baltic Sea Experiment
GFDL	Geophysical fluid Dynamics Laboratory
GFZ	Geoforschungszentrum Potsdam
GKSS	Forschungszentrum GKSS
GLIMPSE	Global Implications of Arctic climate processes and feedbacks
GLOBEC	Global Ocean Ecosystems Dynamics Research (US Global Change Research Program)
GOCE	Gravity Field and Steady-State Ocean Circulation Mission
GOOS	Global Ocean Observing System
GRACE	Gravity Recovery And Climate Experiment
GSA	Great Salinity Anomaly
GSF	Forschungszentrum für Umwelt und Gesundheit
GTS	Global Telecommunication System
HAFOS	Hybrid Arctic-Antarctic Float Observation System
HAMSON	Hamburg Shelf Ocean Model
HELCOM	Helsinki Commission, protection of Baltic marine environment
HEM	Hubschraubergestützte elektromagnetische (Sonde)
HGF	Helmholtz Gemeinschaft Deutscher Forschungszentren e.V.
HIRHAM	High Resolution Atmospheric Climate Model (Regional atmospheric climate model)
HLRN	Hochleistungsrechner Nord
HOPE	Hamburg Ocean Primitive Equation Model
HYMNE	Hydrographic Monitoring of the Neva
IASC	International Arctic Science Committee
ICES	International Coordination-group on Laser Atmospheric Studies
ICESAT	Ice, Cloud, and Land Elevation Satellite
ICSI	International Commission on Snow and Ice
ICSU	International Council of Scientific Unions
IGAC	International Global Atmospheric Chemistry Project
IGBP	International Geosphere – Biosphere Program

IHDP	International Human Dimensions Programme on Global Environmental Change
IKSE	Internationale Kommission zur Reinhaltung der Elbe
IOC	Intergovernmental Oceanographic Commission
IODP	Integrated Ocean Drilling Program
IOW	Institut für Ostseeforschung Warnemünde
IPCC	Inter-governmental Panel on Climate Change
IRCCM	International Research Consortium on Continental Margins
ISD	Ice Shelf Decay
ISPOL	Ice Station Polarstern Project
ITAS	Institut für Technikfolgenabschätzung
JASON	Ocean surface altemetry satellite
JGOFS	Joint Global Ocean Flux Study
KIHZ	Klima in Historischen Zeiten
KOMEX	Kurile-Okhotsk Marine Experiment
LGGE	Laboratoire de Glaciologie et Géophysique de l'Environment
LGM	Last Glacial Maximum
LM	Lokales Modell Atmosphäre
LOICZ	Land-Ocean Interactions in the Coastal Zone
LSG	Large Scale Geostrophic
MARCOPOLI	Marine, Coastal and Polar Systems
MARMIC	International Graduate Program on Marine Microbiology
MARUM	Zentrum für Marine Umweltwissenschaften der Universität Bremen
MAXWAVE	Maximum Waves Project
METRAS	Mesoskaliges Transport- und Strömungsmodell
METROL	Methane fluxes in ocean margin sediments
MEXT	Ministry of Education, Culture, Sports, Science and Technology (Japan)
MOM	Modular Ocean Model
MPI	Max Planck-Institut
NAO	North Atlantic Oscillation
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Prediction
NCMR	National Centre for Marine Research, Greece
NDSC	Network for Detection of Stratospheric Change
NIVA	Norwegian Institute for Water Quality
ODP	Ocean Drilling Program
OGCM	Ocean General Circulation Model
OGSA	Open Grid Service Architecture
OM1	Ocean Model 1 (MPI Hamburg)
OPA	Océan Parallélisé (French ocean Modelling project)
OROMA	Operational Radar and Optical Mapping
OSPARCOM	Oslo Paris Commission
PAGES	Past Global Changes (IGBP)
PANGEA	Network for Geological and Environmental Data (AWI)
PICODIV	Picoplankton Diversity
PIK	Potsdam Institute for Climate Impact Research
POP	Persistent Organic Pollutant
PRISM	Program for Integrated Earth System Modelling
RADARSAT	Radar Satellite (Canada)
RCOM	Research Center Ocean Margins
RDBMS	Relational Database Management system
REM	Raster Electron Microscope
REMO	Regional Model

REM	Regional Environmental Model
RESPIC	Research Group on Earth Climate System Reconstruction on Polar Ice Cores
RESPONSE	Response of benthic communities and sediment to different regimes of fishing disturbance in European coastal waters
ROV	Remotely Operated Vehicle
SCALOP	Standing Committee on Antarctic Logistics and Operations
SCAR	Scientific Committee on Antarctic Research
SCOR	Scientific Committee on Oceanic Research
SDE	Spatial Database Engine
SEAL	Sea Level Change (Helmholtz strategy fund)
SIRRO	Siberian River RUN-OFF
SOC	Southampton Oceanographic Centre, UK
SPARC	Stratospheric Processes and their Relation to Climate
SRES	IPCE Special Report on Emission Scenarios
TOPEX	Ocean Topography Experiment POSEIDON (USA/France)
TRACKS	Transporte und Chemische Umsetzung in Konvektiven Systemen
UBA	Umwelt Bundesamt
UFZ	Umweltforschungszentrum Leipzig-Halle GmbH
WASA	Waves and Stormes in the North Atlantic
WASP	Wadden Sea Project
WCRP	World Climate Research Programme
WDC	World Data Centre (ICSU)
WECCON	Weddell Sea Convection Control Project
WLA	Wissenschaftliche Lenkungsausschuss
WMO	World Meteorological Organization
WSP	Weddell Sea Polynya
XBT	Expendable Bathy Thermograph
ZIB	Zuse-Institut Berlin