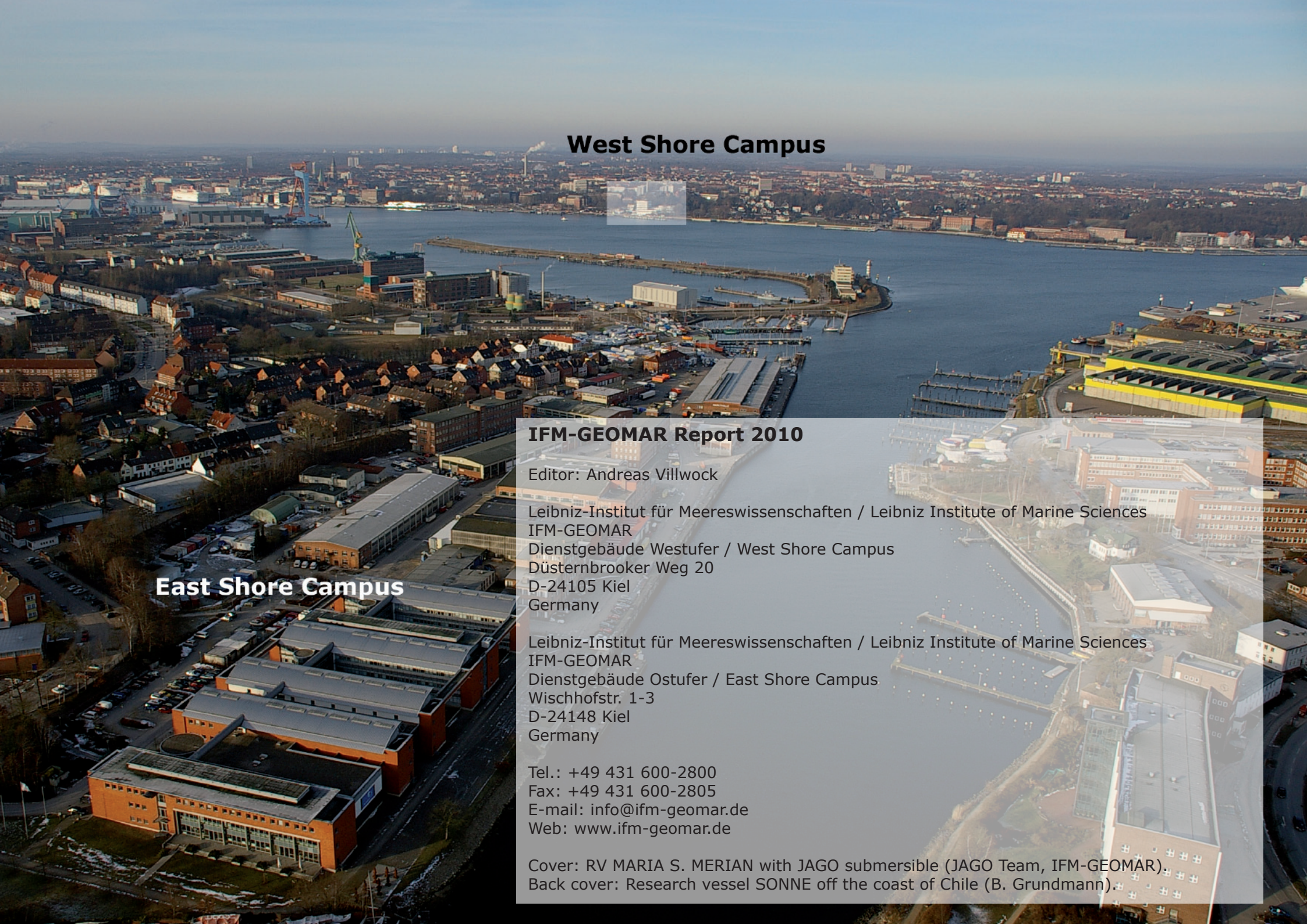
IFM-GEOMAR

IFM-GEOMAR Annual Report 2010

From the Seafloor to the Atmosphere

- Marine Sciences at IFM-GEOMAR Kiel -



IFM-GEOMAR Report 2010

Editor: Andreas Villwock

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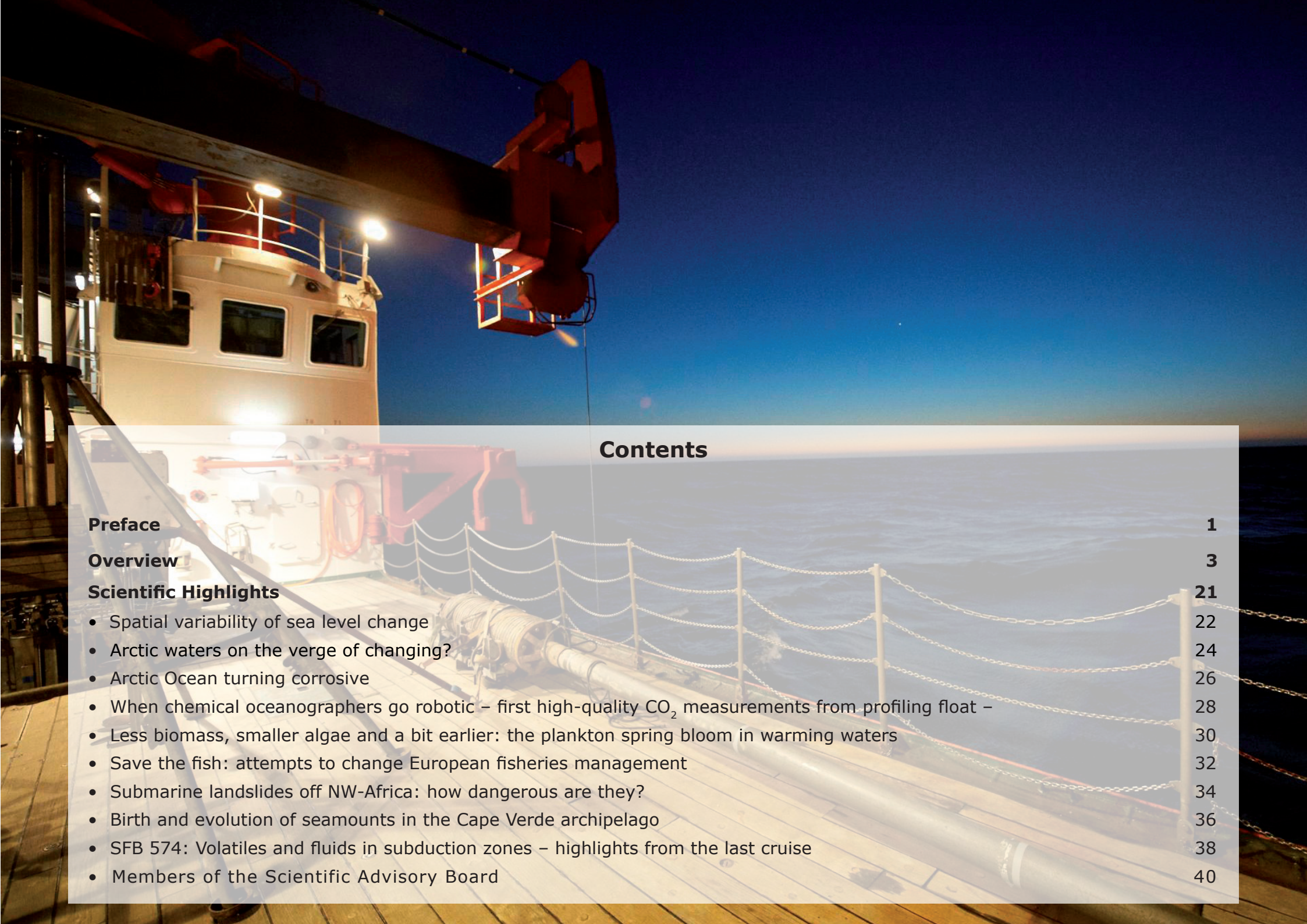
Cover: RV MARIA S. MERIAN with JAGO submersible (JAGO Team, IFM-GEOMAR).
Back cover: Research vessel SONNE off the coast of Chile (B. Grundmann).



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Preface

Humans often prefer continuity to change, but leaving the established tracks often offers new opportunities. That is how we regard the transition envisaged for 2012 of the Leibniz Institute of Marine Sciences into a research centre of the Helmholtz Association. Although this change has come about very unexpectedly and has generated many questions there will also be many new opportunities for further dynamic development offered by the new Helmholtz Centre for Ocean Research Kiel (GEOMAR), as we will be know from January 2012. The Helmholtz Centre for Ocean Research Kiel will complement the existing Earth system research being carried out within in the Helmholtz Association by our new partners, namely the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, the German Research Centre for Geosciences in Potsdam, and the Helmholtz Centre Geesthacht. The closer co-operation with these and other partners within the Helmholtz Association will allow many of the open questions in marine sciences to be addressed even more comprehensively, and I am very optimistic that, building on the success of the past years, the new research centre will quickly establish its position in the Helmholtz Association.

In 2010 IFM-GEOMAR continued its very successful track record, entering a phase of healthy consolidation after years of rapid growth. Staff numbers and budgets increased slightly and the proportion of funding allocated to projects remained at around 50% of the total funding. The past year has been characterized by a large number of scientific expeditions that have also included some land-based investigations. These activities have formed part of a number of large-scale projects through the Cluster of Excellence "The Future Ocean" and the two Collaborative Research Centres. An increase in the output of scientific articles can consequently be expected during the coming years.

With regard to research infrastructure, the working conditions for isotope analysis have been further improved by the opening of new "clean-air" laboratories on the east shore in the spring of 2010. In addition, a new remotely controlled underwater vehicle (ROV) with an operating depth down to 3,000 metres has been brought into service.

During the past year IFM-GEOMAR has put an increasing amount of effort into communicating scientific topics and results to both the general public and to decision makers. In addition to the usual communication channels through the media, comprehensive exhibitions have been organized in cooperation with the "Future Ocean" Cluster of Excellence, and internet videos have been increasingly utilized.

This report summarises the main activities of the institute during 2010 and highlights a number of important research topics. All relevant documentation and statistics can be found in the appendices.

I hope that you will enjoy reading the "IFM-GEOMAR Annual Report for 2010".

Prof. Dr. Peter M. Herzig
Director

IFM-GEOMAR at a Glance

Overview

The Leibniz Institute of Marine Sciences (IFM-GEOMAR) is one of the world's leading institutions in the field of marine sciences. The institute investigates the chemical, physical, biological and geological processes of the seafloor, the oceans and their interactions with the atmosphere. This broad spectrum makes IFM-GEOMAR unique in Germany and one of the three leading institutes in Europe. Additionally, the institute has successfully bridged the gap between basic and applied science in a number of research areas.

IFM-GEOMAR has identified four overarching research themes:

- Role of the Ocean in Climate Change
- Human Impact on Marine Ecosystems
- Living and Non-Living Marine Resources
- Plate Tectonic Processes and Geological Hazards.

In cooperation with the University of Kiel, the institute is responsible for the Excellence Cluster "The Future Ocean" and two long-term Collaborative Research Centres (SFBs) that are funded by the German Research Foundation (DFG).

Four research vessels, large-scale sea-going equipment such as the manned submersible JAGO, the unmanned deep-sea robots ROV KIEL 6000 and AUV ABYSS, as well as state-of-the-art laboratories, analytical facilities, and a hierarchy of numerical models provide a unique basis for cutting-edge marine research. With a number of curricula offered in English, the institute actively contributes to the education of young scientists in the field of marine sciences.

IFM-GEOMAR is a member of the Leibniz Association, the German Marine Research Consortium (KDM), the Marine Board of the European Science Foundation and the Partnership for Observation of the Global Oceans (POGO).

Director and CEO

Prof. Dr. Peter M. Herzig

Head of Administration

Ursula Frank-Scholz

Public Relations

Dr. Andreas Villwock

Staff

762 including 388 scientists (end 2010)

Budget

60,8 million Euros:
- 27,9 million Euros research funding
- 32,9 million Euros institutional funding

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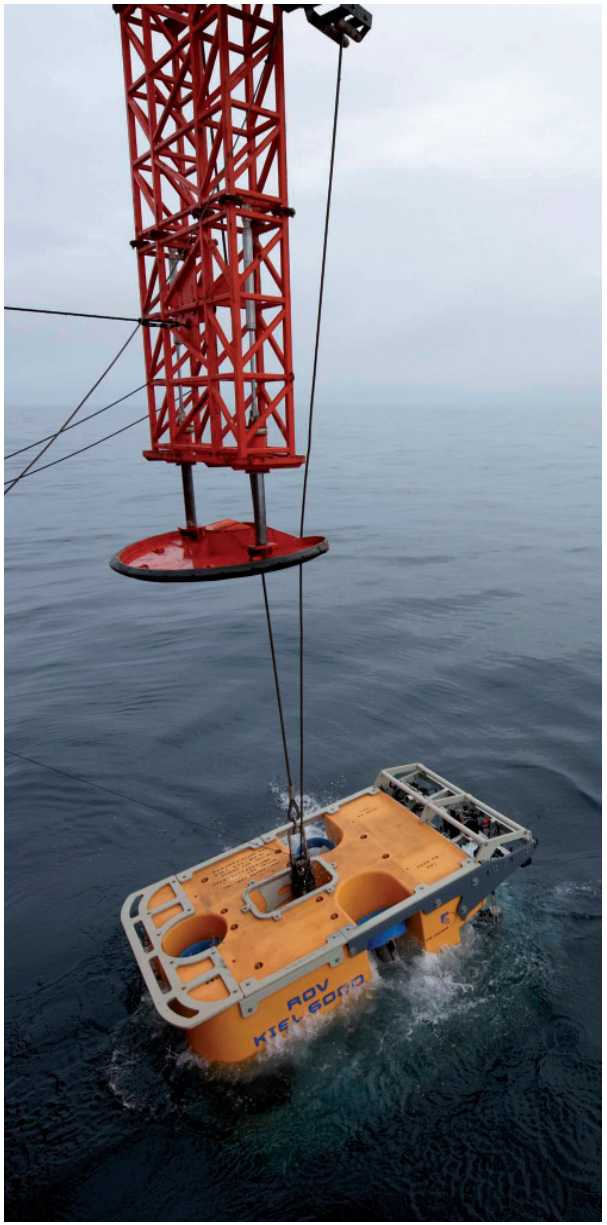
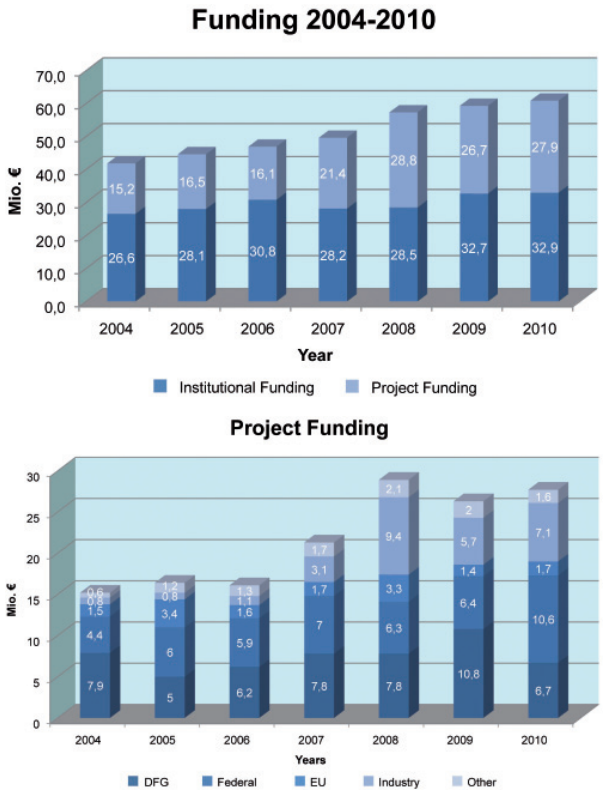


1. Introduction

The most important development with respect to IFM-GEOMAR during the past year has been the decision announced on July 8, 2010 to transfer the institute from the Leibniz Association to the Helmholtz Association. With effect from January 1st, 2012 IFM-GEOMAR will become the 18th centre within the Helmholtz Association. This decision taken jointly by the State of Schleswig-Holstein and the Federal Government has serious consequences, not only for IFM-GEOMAR but also for German marine research as a whole. Apart from the resulting changes to the institution's funding, from 50:50 (Federal / Provincial) to 90:10, the decision will have far-reaching consequences, particularly with regard to the ability to apply for funding from the German Research Foundation (DFG). Amongst several financial questions discussed by the various working groups was the special cooperation between the institute and Kiel University. The continuation of the so-called "Kiel Model" was a fundamental requirement for both IFM-GEOMAR and the university; it involves joint implementation and operation of curricula, joint professorships, and large interdisciplinary research projects such as the Cluster of Excellence "The Future Ocean" . Most of the negotiations for the new Helmholtz Centre for Ocean Research Kiel (GEOMAR) were finalised by the end of the year and major benchmarks defined for the future budgets

As a result of these changes the planning process for the extension building has also been affected, in particular with regard to the development consultant and the financing of the project. The first important step was taken at the end of 2010 with the purchase by the State of Schleswig-Holstein of the former seafood market (Seefischmarkt) site for this development, but construction is not expected to start before end of 2012. The Federal government will now cover 90% of the 90 million Euro total cost.

The total IFM-GEOMAR budget for 2010 came to 60.8 million Euros, of which about 33 million Euros came from institutional funding and about 28 million Euros from third party funding for specific projects. Apart from ongoing large-scale projects such as the Cluster of Excellence "The Future Ocean" and two collaborative research projects, a number of new projects have also been funded (see Section 2 for a selection and Appendix 3.2 for a complete list).

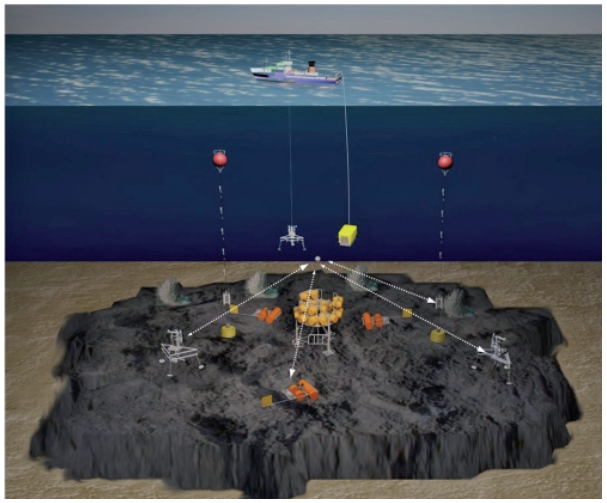


Institutional and project funding 2004 - 2010

2. New Research Projects

2.1 "MoLab"

The "MoLab" ("Modular multi-disciplinary seafloor laboratory") will be able to measure different biological, physical, chemical, and geological parameters within an area of several square kilometres over a period of several months. It will be designed by IFM-GEOMAR and will be partly built by local companies within the state of Schleswig-Holstein. The system will consist of a suite of different instruments that can be assembled



Schematic diagram of a MoLab configuration

in a very flexible manner to suit specific requirements. A major advantage of the "MoLab" will be that it can be installed, maintained, and recovered using medium sized research vessels such as RV POSEIDON. It can also be easily adapted to suit new areas of investigation and different scientific tasks. Thus "MoLab" will fill a crucial gap between planned spatially-fixed and cable-connected observatories that are extremely expensive, and traditional ship-based methods. The Ministry for Science and Education (BMBF) is providing 3.16 million Euros to fund this project. A second remotely operated vehicle, the ROV PHOCA (which has a maximum operating depth of 3,000 metres) has been purchased for this project, to be used for installing the instrumentation on the sea floor (see also Section 6 on infrastructure). The first applications of "MoLab" are planned for autumn 2011 in the fjords of northern Norway, where it will be used to investigate climate-related environmental changes in the vicinity of cold water coral reefs.

2.2 TRION

This project makes use of stable isotopes of strontium as a new proxy for continental weathering, pedogenic processes, and seawater temperatures, providing a new method to reconstruct former temperatures from corals in the Red Sea as well as dealing with questions related to ocean acidification and chemical weathering. It is coordinated by IFM-GEOMAR and receives financial support of 700,000 Euros from the German Research Foundation (DFG). This project is unique because it is a cooperation between German, Israeli and Palestinian scientists and thus, apart from its scientific objectives, may also contribute to the peace process in this politically unstable region in the Middle East.

2.3 The Jeddah Transect Project

The Jeddah Transect Project will perform multidisciplinary marine research off the coast of the Saudi-Arabian port of Jeddah. A total duration of nine years is envisaged for the project, divided into three phases of three years each. The first phase, which involves four sub-projects, started on July 1st, 2010 and will be completed by July 2013. It will involve joint biological, geological, and geophysical studies performed within an area that extends from the Saudi Arabian coast to the axis of the 2 km deep Red Sea trench. A large range of subjects will be covered, such as coastal protection, the ecology of fish and coral communities, and the venting of gas and fluids on submarine slopes. The deep basins in the central Red Sea, which contain vast resources in the form of mineral-rich solutions, will also be examined.
The first phase of the cooperation comprises investigations into:

- Fluid and gas emanations in the Red Sea, off the Saudi Arabian coast - a window into sub-seafloor hydrocarbon formation and degradation processes
- Volcanism and hydrothermalism in and around the Atlantis II Deep in the Red Sea
- Nutrient gradients in the Red Sea: how they correlate with plankton abundance and diversity, and with interactions between macroalgae and corals
- Development of a coastal monitoring system for sustainable environmental planning along the Jeddah coastline, Saudi Arabia

The total budget for the initial three-year period is approximately 6.4 million Euros. The first series of voyages are planned for early 2011, using the RV POSEIDON research vessel.

2.4 SOPRAN II

The second phase of the BMBF-funded SOPRAN project focuses on the impact of climate change on the upper ocean. The main area for this research is the subtropical eastern North Atlantic, around the Cape Verde islands. IFM-GEOMAR is the coordinator for the eleven partners in this joint project, for which the total funding is 4.2 million Euros over a 3-year period (2010-2012).

2.5 PLUMEFLUX

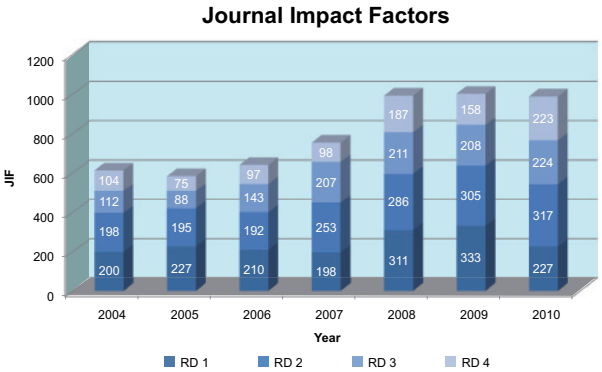
The PLUMEFLUX project, which is again funded by the BMBF (total budget 900,000 Euros), aims to investigate the distribution of Galápagos plume material in the equatorial East Pacific Ocean. Specific goals of this multidisciplinary research project involving volcanology, petrology, geochemistry, biology, and sedimentology are to:

- Further our understanding of the processes related to the transport and distribution of plume material in the upper mantle
- Characterize the compositional variation of material in the Central American trench (subduction zone)
- Reconstruct the geodynamic evolution of the Central East Pacific Ocean
- Record the biodiversity and zoogeography of the research area.

The project started with an expedition using the German research vessel SONNE (for details see Section 5.11).

3. Scientific Achievements

The scientific productivity of IFM-GEOMAR is impressively documented by the very large number of peer-reviewed scientific publications produced and the substantial amount of third-party funding provided, amounting to around 28 million Euros (see also Section 1 and Appendix 3.2). In 2010 more than 400 articles, books, and book contributions were published, of which 361 were in peer-reviewed journals (see Appendix 5). IFM-GEOMAR scientists also gave more than 450 scientific presentations at meetings, workshops, and symposia, of which more than 100 were invited talks (see Appendix 6). In addition, 220 posters were presented, some of which earned awards for their exceptional quality (see Appendix 7.7).



Journal impact factors by Research Division (RD), 2004-2010.

3.1 Scientific Meetings

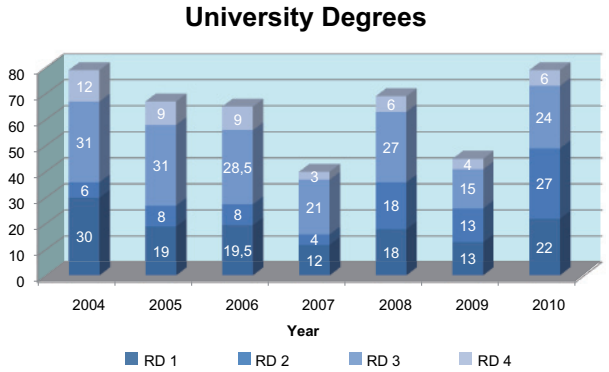
In 2010 more than 20 scientific workshops and meetings on various topics took place at IFM-GEOMAR. Amongst these the highlights were the final workshop of the DFG Aquashift project (200 experts from 18 countries), the 10th European Workshop on Laser-Ablation in Elemental and Isotopic Analysis, and the 3rd biannual scientific symposium of the Cluster of Excellence "The Future Ocean". In addition, scientists from IFM-GEOMAR were involved in the planning and organisation of a large number of meetings, workshops and individual sessions at international conferences. For details see Appendix 7.3.

4. Education and Curricula

In collaboration with Kiel University, IFM-GEOMAR is contributing significantly to the education in various areas of marine sciences. The most significant changes over the past years were the change-over to the Bachelor and Master degree system following the "Bologna-process" and the reduction of the teaching load for IFM-GEOMAR professors according to the recommendation of the evaluation by the Leibniz association in 2005.

The transfer to the Bachelor and Master degree system is now almost complete and the former diploma curricula are coming to an end. In 2010 24 bachelor's, 8 master's and 39 diploma theses were completed as well as 19 Ph.D. theses in various aspects of marine sciences, including marine geology and geophysics (see Appendix 5.6).

The master course "Biological Oceanography" currently has about 40 students in total, the bachelor's course entitled "Physics of the Earth system: Meteorology, Oceanography and Geophysics" has about 100 students, and there are about a dozen students enrolled in the master's course on "Climate



University degrees by Research Divisions, 2004-2010.

Physics: Meteorology and Physical Oceanography" which is still in the build-up phase. On overview of all courses with participation by IFM-GEOMAR staff, together with external courses, is provided in Appendix 8.

In addition, IFM-GEOMAR has reinforced its graduate training by two new Marie Curie Initial Training Networks, in the fields of paleo-oceanography (the Changing Arctic and Subarctic Environment - or "CASE" Initial Training Network) and physical oceanography (the "GATEWAYS" project), both funded by the 7th Framework Programme of the European Commission. For further information see:
http://caseitn.epoc.u-bordeaux1.fr/
http://www.gateways-itn.eu/cms/index.php

4.1 New Graduate School in Evolutionary Biology

In a joint project involving Kiel University, the Max-Planck Institute for Evolutionary Biology in Plön, and IFM-GEOMAR, a new graduate school has been established, known as the "International Max-Planck Research

School for Evolutionary Biology" (IMPRS). This graduate school provides Ph.D. candidates majoring in Evolutionary Biology with an interactive forum in which to exchange new ideas and research results. In addition, the IMPRS coordinates specialised courses, an internationally attended series of seminars, and annual meetings. A total of 42 Ph.D. grants are planned, each of six years duration, of which 24 will be located at the Max-Planck Institute, 16 at Kiel University, and 2 at IFM-GEOMAR.

4.2 Sixth Sino-German Summer School

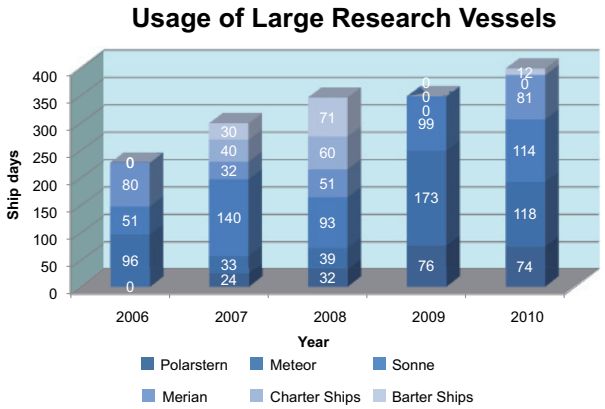
The sixth Sino-German Summer School was held from July 26th - 31st, 2010 at IFM-GEOMAR. Forty participants from Germany and Qingdao (PR China) were welcomed by the Mayor of Kiel, Mr. Torsten Albig. The group discussed the impact of global change on the oceans, i.e. possible reactions in the nutrient cycle, reactions in microorganisms within sediments, aspects of climate change, and the International Law of the Sea.

4.3 Integrated School on Ocean Sciences

The Integrated School of Ocean Sciences (ISOS) is part of the Cluster of Excellence "The Future Ocean". More than 120 Ph.D. candidates are members of the ISOS, which supports their Ph.D. training with a wide range of multidisciplinary talks, seminars, and workshops. Further information can be found under www.ozean-der-zukunft.de/ausbildung-isos/

5. Major Expeditions

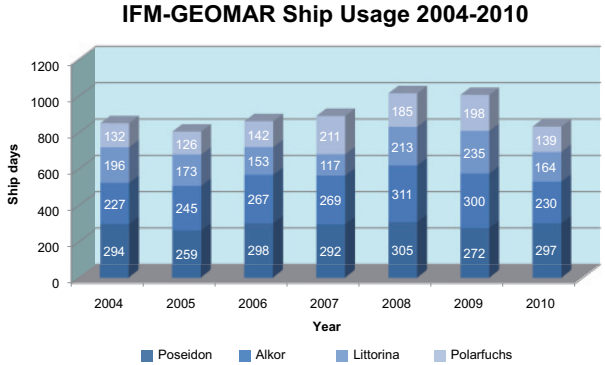
More than 20 major expeditions were conducted under the leadership of IFM-GEOMAR during 2010 (see Appendix 4). IFM-GEOMAR scientists used a total of 387 days of ship time on Germanys' four ocean research vessels (METEOR, SONNE, MERIAN and POLARSTERN). IFM-GEOMAR's four research vessels (ALKOR, POSEIDON, LITTORINA, and POLARFUCHS) provided a total of 830 days of service, of which 289 days were used by IFM-GEOMAR scientists. Chartered vessels were also used for some expeditions due to the limited availability of German research vessels. Some of the major expeditions are highlighted below.



Ship usage of large research vessels 2004-2010.

5.1 METEOR 80/3 expedition

The main objective of the third stage of the METEOR research vessel's M80 expedition (December 29th, 2009 – February 1st, 2010) was to achieve a better understanding of the evolution of the Cape Verde seamount



Ship usage of IFM-GEOMAR research vessels 2004-2010.

complex. One of the main areas of investigation was the Charles Darwin volcano complex that was discovered in 2005, which is located to the south of the San Antao Island in a water depth of 4,000 metres. During the expedition led by Dr. Thos Hansteen (RD[1] 4) the remotely operated ROV KIEL 6000 underwater vehicle was used to obtain the first samples ever to be collected from these underwater volcanoes. Preliminary results indicated explosive volcanism, which has not previously been reported at such great water depths.

5.2 POSEIDON 395 expedition

The research area for the POSEIDON research vessel's expedition No. 395 (February 4th - 21st, 2010) was the "Sahara slide complex", a submarine slide of enormous dimensions off the coast of north-west Africa. Submarine slides are a potential natural hazard because they can destroy infrastructure (e.g. submarine cables) and trigger tsunamis. With a length of 700 kilometres and a volume of about 600 cubic kilometres the

1. RD for Research Division

"Sahara slide complex" is one of the largest slides known. It occurred about 50,000 to 60,000 years ago. During the 17 day expedition with the POSEIDON research vessel, led by Prof. Sebastian Krastel (IFM-GEOMAR and the Cluster of Excellence "The Future Ocean"), the morphology and evolution of the trailing edge of the slide complex was investigated in detail using deep-towed side-scan sonar systems, bathymetric mapping, and seismic measurements.

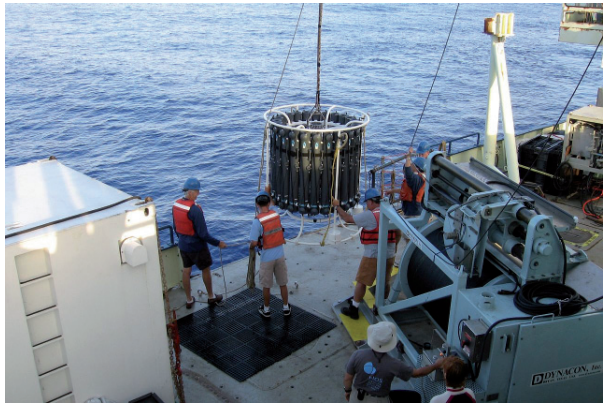
5.3 ABYSS AUV flight recorder search

IFM-GEOMAR's ABYSS autonomous underwater vehicle (AUV), together with two other identical vehicles from the Woods Hole Oceanographic Institution and the Waitt Institute (both in the USA), was used during a five-week search mission for the Air France Airbus (AF447) that crashed into the western tropical Atlantic Ocean during severe weather on June 1st, 2009. Although the equipment on the three AUVs functioned well the wreck of the aircraft and the flight recorders were not located. Another mission is planned for 2011.

AUV ABYSS loaded on an Airbus A380 for the transfer to Boston, USA. Photo: Sylvain Pascaud, Airbus.

5.4 METEOR 81/1 expedition

The first stage of the METEOR's M81 expedition (February 4th - March 8th, 2010) formed one of the first experiments of the GEOTRACES international research programme (http://www.geotraces.org/). The objective of this programme is to obtain a better understanding of the origin and distribution of trace elements and micronutrients such as manganese, aluminium, cadmium, copper, and iron, particularly in the deeper parts of the oceans. The 9,000 kilometre long M81/1 voyage, under the leadership of Prof. Martin Frank (RD1), started in Las Palmas (Canary Islands), followed the West African coast and then crossed the Atlantic to the Brazilian coast before finally tracking northwards and finishing up in Port of Spain (Trinidad and Tobago). About 12,000 litres were collected with specialised sampling devices.



Mobile winch and cable owned by the U.S. GEOTRACES-programme. Photo: Gregory Cutter, Old Dominion University, Norfolk (USA).

5.5 METEOR 81/2 A+B expedition

The METEOR's M81/2A+B "CLIP" expedition, under the leadership of Prof. Kaj Hoernle (RD4) (Section 2A) and Dr. Reinhard Werner (RD4) (Section 2B), took place from March 10th to April 22nd, 2010. The objective of this expedition was to achieve a better understanding of the "Caribbean large igneous province". To this end the participating scientists recorded magnetic measurements, collected rock samples using dredges and the remotely controlled ROV Kiel 6000 vehicle, and undertook bathymetric mapping.

5.6 JAGO submersible expeditions

In 2010 the manned JAGO submersible undertook three missions under charter to other scientific institutions, as follows:

1. April - May 2010: Black Sea and Ukrainian Shelf; research vessel M.S.MERIAN (MSM 15/1 expedition), within the EU's HYPOX project entitled "In situ monitoring of oxygen depletion in hypoxic (low oxygen) ecosystems of coastal and open seas, and land-locked water bodies". PI: Prof. Antje

Submersible JAGO and RV MARIA S. MERIAN. Photo: JAGO Team.

Boetius, Max Planck Institute for Marine Microbiology, Bremen.

2. June 2010: Cap de Creus, north-western Mediterranean (Spanish sector); research vessel GARCIA DEL CID (Spain), within the EU's LIFE+ Project entitled "Marine Protected Areas (MPAs) in the western Mediterranean: inventory and designation of marine Nature 2000 areas in the Spanish sea". PI: Prof. Josep-Maria Gili, ICM Institut de Ciencies del Mar (CMIMA-CSIC), Barcelona, Spain.
3. September 2010: Canal de Menorca, Balearic Islands Mediterranean Sea; research vessel GARCIA DEL CID (Spain), within the EU's LIFE+ Project entitled "Marine Protected Areas (MPAs) in the western Mediterranean: inventory and designation of marine Nature 2000 areas in the Spanish sea". PIs: Prof. Josep-Maria Gili & Dr. Cova Orejas, ICM Institut de Ciencies del Mar (CMIMA-CSIC), Barcelona, Spain.

A total of 40 dives were performed during these missions. During the rest of the year the JAGO submersible underwent intensive maintenance in preparation for the renewal of the Germanischer Lloyd certificate, due early in 2011.

5.7 POLARSTERN ANT-XXVI/4 and ANT XXVII/1 expeditions

The ANT XXVI/4 (April - May 2010) and ANT XXVII/1 (October - November 2010) expeditions, under the leadership of Prof. Arne Körtzinger (RD2) and Dr. Karl Bumke (RD1), respectively, were performed under the auspices of the OCEANET project, funded by the Leibniz Association. The objective of this project is the development, testing, application, and assessment of autonomous observational platforms for the determination of energy and mass exchanges between ocean and atmosphere. OCEANET makes use of the biannual transit legs of RV POLARSTERN between Antarctica and Germany. Other partners in OCEANET (apart from IFM-GEOMAR) are the Leibniz Institute for Tropospheric Research in Leipzig, the Alfred Wegener Institute in Bremerhaven, and the Helmholtz Centre Geesthacht.
For further information see: http://www.ifm-geomar.de/index.php?id=oceanet

5.8 EPOCA ARCTIC CAMPAIGN 2010

From May 14th to July 22nd 2010 the impact of ocean acidification on marine organisms in the Arctic was investigated by 35 scientists from 11 European institutes. IFM-GEOMAR, the coordinating institute for this expedition, received logistical support from the Greenpeace environmental organisation for the transport and implementation of nine mesocosms, each 17 metres long, in the Kongsfjord on the north-western coast of Spitzbergen (Svalbard archipelago). These mesocosms serve as test devices for simulating future environmental conditions. Molecular and cell biologists, biogeochemists, ocean chemists and atmospheric chemists participated in this experiment. They are hoping to discover how the sensitive plankton communities in the Arctic react to ocean acidification, and how their reactions affect the food chain, the element cycle, the production of climate-active gases, and the exchange of these gases with the atmosphere. The experiment took place within the framework of the EU-funded EPOCA project (European Project on OCean Acidification - see http://www.epoca-project.eu/). A short video has been produced about this experiment (see Section 9.5).

Mesocosms in the Kongsfjord, Svalbard. Photo: M. Nicolai.

5.9 SONNE 206 expedition

The objective of the German research vessel SONNE's 206 expedition (May 30th – June 19th, 2010) was to obtain basic seismic and geochemical data from selected dewatering structures on the continental margin, off the coast of Costa Rica. The investigations during this voyage covered structures similar to mud volcanoes and a large steep slide on the continental margin known as the Jaco Scarp, caused by the subduction of seamounts. These areas are potential targets for the Integrated Ocean Drilling Programme. Seismic investigations to provide high-resolution information on the geological structures were performed during the SONNE 206 expedition. Biogeochemical investigations were also carried out to obtain information on the origin of ascending fluids, for which noble gas compositions in the pore water were determined and microbiological experiments performed.

5.10 WND-5 expedition

The fifth and final voyage in the West Nile Delta (WND) project took place from June 15th - 26th, 2010 with the Greek research vessel AEGAEO (Hellenic Centre for Marine Research). During the expedition a large number of samples were collected and the long-term observing platforms that had been installed for the project were recovered. A short video on the mud volcanoes in the WND project will soon be available through the IFM-GEOMAR website (see Section 9.5).

ROV Max-Rover on the RV AEGAEO during WND-5 expedition.

5.11 SONNE 208 expedition

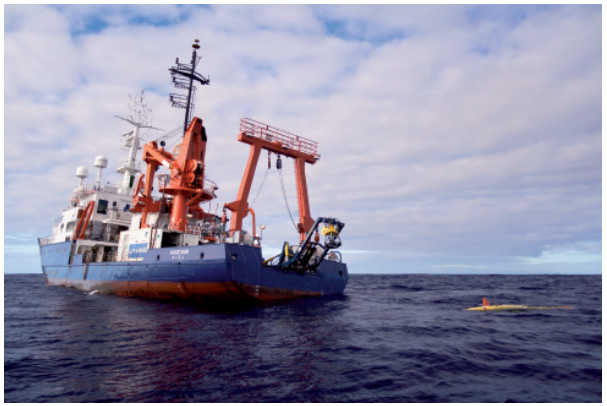
The 208th expedition of the German research vessel SONNE (July 15th - August 29th, 2010 - divided in two legs) was part of the PLUMEFLUX project investigating volcanic activity in the eastern equatorial Pacific. During the first leg the formation of underwater volcanoes on the Cocos Plate was investigated in water depths of up to 3,500 metres. The area investigated during the second leg was to the north and north-east of the Galapagos Islands, where two active volcanic systems are located close together on the Galápagos hotspot and on the mid-ocean ridge between the Cocos and Nazca plates (the Cocos-Nazca spreading centre). The objective was to achieve a better understanding of the interactions between these two volcanic areas, which have had very different histories over the past 100,000 years. As a result of technical problems the British Geological Survey's Rockdrill 2 sub-sea drilling system could not be used as had been originally planned.

5.12 MARIA S. MERIAN 15/5 expedition

The major objective of the German research vessel MARIA S. MERIAN's MSM 15/5 expedition (July 17th - 30th, 2010) was the recovery of long-term seismic acoustic systems from the western Mediterranean. These systems were deployed to enable a better understanding of the risk of earthquakes in the western Mediterranean and eastern Atlantic, where the African and European plates are in collision. In contrast to other regions the seismic activity in the Alboran Sea and the Gulf of Cadiz, on either side of the Strait of Gibraltar, is not restricted to the plate boundaries. Long-term observations will therefore provide a better understanding of the local and regional seismicity in this region.

5.13 POSEIDON 403 expedition

The research vessel POSEIDON's expedition No. 403 (August 14th - 30th, 2010) focused on the area around the archipelago of the Azores. The key scientific questions addressed related to the mixing of water masses of different densities and the energy transfer induced by this process, together



RV POSEIDON and AUV ABYSS. Photo: ABYSS Team.

with further impacts on deep-sea circulation and oxygen distribution. Recent results show that the highest mixing rates occur in the central trenches and transform zones of mid-oceanic ridges, suggesting a close link between plate tectonics and thermohaline circulation. Current metres and ship-based multibeam sonar systems onboard IFM-GEOMAR's ABYSS autonomous underwater vehicle (AUV) were used in addition to the collection of standard data such as conductivity, temperature, and depth (CTD) measurements.

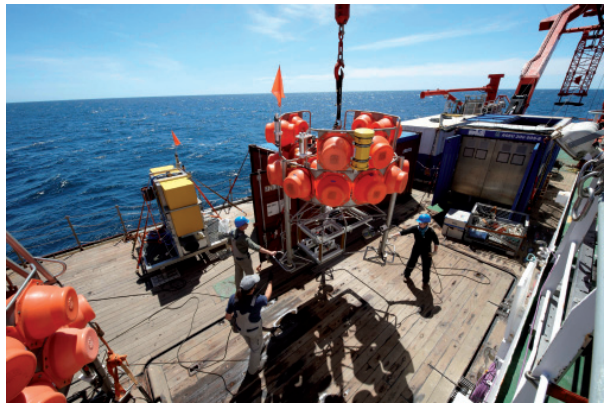
5.14 TRANSDRIFT XVII expedition

The TRANSDRIFT XVII expedition to the Russian Laptev Sea took place from September 1st to October 5th, 2010 as part of the joint German-Russian Laptev Sea Polynya project. Four long-term observing systems launched in September 2009 were recovered and two new systems implemented using the Russian research vessel "NIKOLAY EVGENOV". Water samples were also collected from about 50 hydrological stations for biological and chemical investigations. The 18 participants

in the expedition were scientists from the Russian Federation's Arctic and Antarctic Research Institute (AARI) in St. Petersburg, the State University in St. Petersburg, and the Lena Delta Reserve in Tiksi, together with students from the POMOR programme and IFM-GEOMAR. The Chief Scientists for the expedition were Dr. Torben Klagge (RD1) and Dr. Andrej Novikhin (AARI)

5.15 SONNE 210 expedition

The Chilean continental slope in the eastern Pacific was investigated by 27 scientists between September 23rd and November 1st, 2010, using the German research vessel SONNE. The expedition's objective was to achieve a better understanding of the pathways and fluxes of fluids and volatile components in the subduction zone, and an improved assessment of the risk of earthquakes, slides and tsunamis. On the SO-210 expedition, which formed part of the SFB 574 Collaborative Research Programme ("Volatiles and fluids in subduction zones"), the researchers used various types of equipment such as the ROV KIEL 6000, lander systems, etc. The Chief Scientist on the expedition was Dr. Peter Linke (RD2).



Launch of lander systems from ROV SONNE. Photo: B. Grundmann.

5.16 METEOR 83/1

The Oxygen Minimum Zone (OMZ) in the north-eastern tropical Atlantic was investigated by 26 scientists from the Leibniz Institute of Marine Sciences, together with colleagues from the Instituto Nacional de Desenvolvimento das Pescas (INDP, Mindelo, Republic of Cape Verde), between October 14th and November 13th, 2010, aboard the German research vessel METEOR. The voyage, which was carried out within the framework of the SFB 754 Collaborative Research Programme ("Climate – biogeochemical interactions in the tropical oceans"), aimed to achieve a better understanding of the variability in tropical oxygen minimum zones. The primary objective of the M83/1 voyage was to resurvey a tracer release patch about 2.5 years after the tracer injection in April 2008. Secondary objectives included determination of water mass variability and of oxygen and nutrient distributions within the survey region. The voyage also helped to delineate water mass transport pathways within the shallow subtropical cell, with a particular focus on the exchanges between the upwelling region in the Gulf of Guinea and the tropical ocean's interior. The Chief Scientist was Prof. Martin Visbeck (RD1).

5.17 MARIA S. MERIAN 17/1 expedition

Processes of continental rupture were investigated by 14 scientists from the Leibniz Institute of Marine Sciences and the Alfred-Wegener-Institute for Polar and Marine Research between November 24th and December 29th, 2010. They used the example of a classical flood basalt province (Paraná-Etendeka), to elucidate the temporal and spatial relationships between deformation and magmatic input in the course of continental breakup and the later development of an aseismic ridge on oceanic crust (the Walvis Ridge). The methodologies used included marine seismology and magnetotellurics. The main objective of the expedition was to image the crust and uppermost mantle at the continent-ocean boundary sufficiently well to be able to infer magmatic budgets and the relative timing of magmatism and deformation. The research area was located off the coast of northern Namibia and vertically above the Walvis Ridge, which is a submarine ridge that stretches from the Tristan da Cunha hotspot in the southern Atlantic to Namibia. The Chief Scientist for the MSM17/1 expedition was Prof. Jan Behrmann (RD4). This voyage formed part of the DFG Priority Programme (SPP) "South Atlantic Margin Processes and Links with onshore Evolution" (SAMPLE) programme.

5.18 POSEIDON 405 expedition

From December 9th - 23rd, 2010 the research vessel POSEIDON was involved in an expedition to the Black Sea as part of the Submarine Gas Hydrate Reservoirs (SUGAR) project. During the voyage scientists from IFM-GEOMAR tested sensor-technologies for detecting gas-bubbles and free gas in deep-sea sediments, which can indicate the presence of gas hydrates in the sediments. The Chief Scientist was Dr. Jörg Bialas (RD4).

6. Large-scale Equipment and Infrastructure

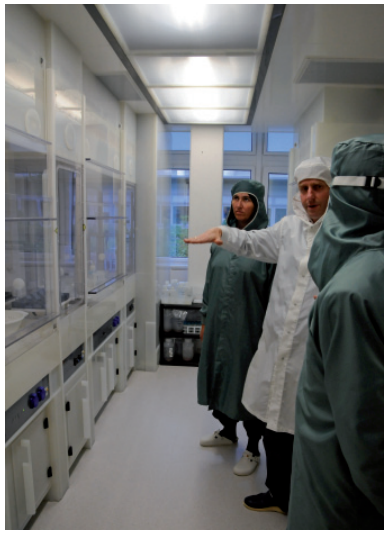
6.1 Benthic Mesocosm System

A new mesocosm system has been purchased to be used for investigating of the impact of climate change on benthic organisms. With the system located on floating elements anchored close to the shoreline, near the west shore campus, the benthos ecology group will be able to investigate how the Baltic ecosystem reacts to climate change. Various long-term experiments involving organisms that live on the sea floor are planned to start in the summer of 2011. The total investment was about 300,000 Euros.

New benthic mesocosm facility at the west shore building of IFM-GEOMAR. Photo: J. Steffen.

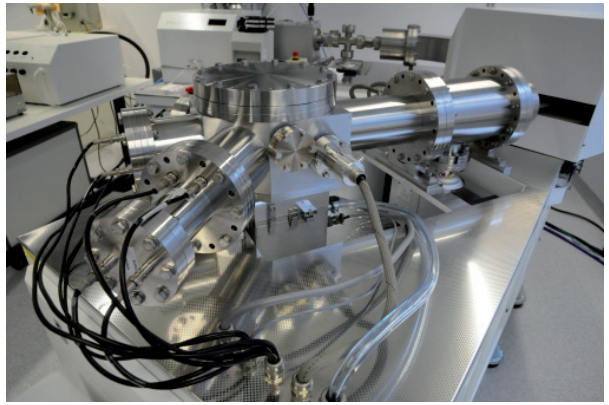
6.2 New clean-air laboratories in operation

Many of IFM-GEOMAR's research projects in oceanography, paleo-oceanography, geology, geochemistry, biology, and petrology, are based on precise and accurate stable, radiogenic, and radioactive isotope data, or on trace element data. These are extracted from a whole range of different materials including rocks, carbonates, silicates, organic materials, marine sediments, and water. Reliable data can, however, only be produced if contamination-free sample preparation can be guaranteed, and if a stable environment is provided for the instruments.



New clean laboratory facilities at the east shore facilities. Photo: J. Steffen.

In January of this year IFM-GEOMAR's new, state-of-the-art, clean-air laboratory facilities were completed and went into operation on the ground floor of the east-shore building 8E. The laboratory comprises a total area of 220 m^2, of which 72 m^2 are fully dedicated to contamination-free chemical preparation of samples for mass spectrometry. The clean-air room status of the laboratory (better than "class 100" where samples are handled) is achieved by over-pressurisation which keeps particles out. At the same time the incoming air passes through a series of filters of different sizes that remove all particles contained in the air.



A multi-collector (MC)-ICPMS in the new clean laboratory. Photo: J. Steffen.

The metal-free laboratories host 16 laminar flow benches, several of which are equipped with washers to remove particular toxic acids and fumes. The mass spectrometers on which the isotopic and elemental analyses of samples are performed have been installed in separate, but adjacent, rooms of the clean-air laboratory (2 multi-collector (MC)-ICPMS instruments and a high resolution single collector ICPMS equipped with laser ablation, as well as infrastructure and space for two further instruments). These rooms are also over-pressurised but do not require such high standards of cleanliness as the chemical laboratories. Their most important requirement for high precision measurements is a constant, stable, temperature (± 0.5°C) for the mass spectrometers. The laboratory is also equipped with a separate weighing cabinet, as well as devices for ultra clean water production and for the distillation of trace metal free acids.

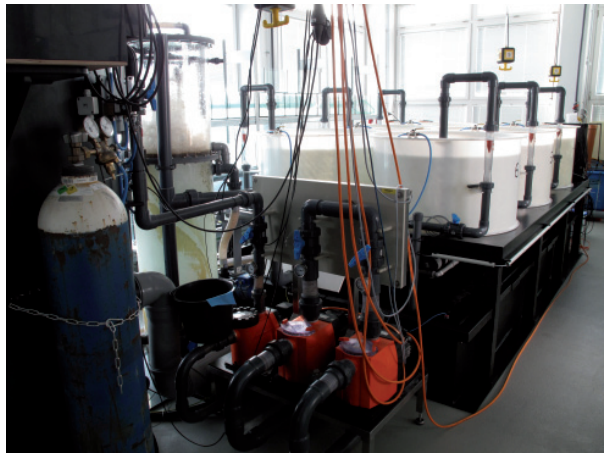
The data acquired in this laboratory and on other mass spectrometers at the institute

are the basis for many of the investigations carried out within Research Divisions 1, 2, and 4 of IFM-GEOMAR.

6.3 Aquaculture facilities

The NEMO aquaculture research project ("Nachhaltige Ernährung mit Marinen Organismen ") is part of the GMA (Association for Marine Aquaculture) in Schleswig-Holstein. NEMO has received funding of 2 million Euros from the state of Schleswig Holstein. The objective of the project is to increase the level of scientific expertise in mariculture systems, with a special focus on feeding, fish biology, and animal welfare.

The redevelopment of a former workshop in the west shore building to provide the required experimental research facilities was completed early in 2010, and the first experiments started thereafter. Preliminary results were presented at the 2nd DOKMA Symposium (Ph.D. and Master Student Symposium of the "Evolutionary Ecology of Marine Fishes" Working Group) at IFM-GEOMAR in October 2010.



The aquaculture facilities in the west shore building. Photo: H. Thetmeyer.

From a technical point of view the NEMO experimental facilities have been shown to allow the proper accomplishment of all planned experiments; moreover the NEMO facilities also provide valuable space in for experiments of the working group on Evolutionary Biology.

6.4 General overhaul of ALKOR and POSEIDON completed

With the last shipyard phase in autumn 2010 tThe final shipyard phase in the general overhaul of the two research vessels ALKOR and POSEIDON was completed in the autumn of 2010. The major items included in this modernization process were the installation of new main and auxiliary diesel engines for POSEIDON, the modernization and repair of communication, navigation, and sounding systems, the renewal of air condition systems in both vessels, as well as the replacement of a wooden deck on ALKOR and the painting of its exterior. The general overhaul of both ships, which started in 2009, was financed by six million Euros from the federal government's "Economic Stimulus Programme II".

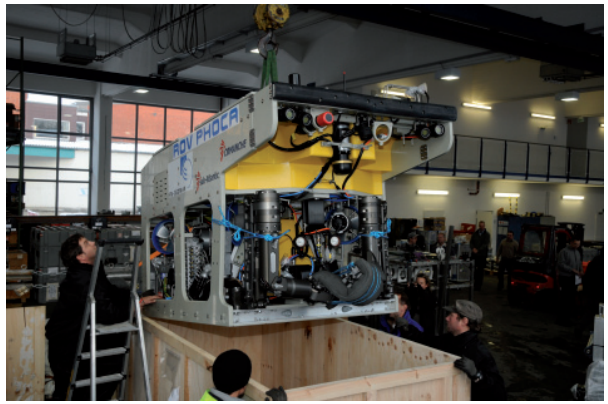
RV POSEIDON and ALKOR at Lindenau shipyard in Kiel. Photo: F. Behling.

6.5 First use of glider swarm

IFM-GEOMAR has nine underwater gliders, which is the largest fleet of gliders in Europe. These deep-sea gliders can operate to 1,000 metres depth. In spring 2010 five of these instruments were used in parallel around the Cape Verde Islands, in a first swarm experiment. Over a period of seven weeks the instruments investigated an area of 2,500 km².

The glider swarm at the Technology and Logistics centre of IFM-GEOMAR. Photo: J. Steffen.

6.6 ROV PHOCA completes IFM-GEOMAR's underwater fleet



ROV Phoca arriving at IFM-GEOMAR. Photo: A. Villwock.

The fleet of underwater vehicles at IFM-GEOMAR is growing: a new remotely operated vehicle (ROV), the PHOCA (seal), was delivered towards the end of 2010. Its primary use will be to install the modular underwater "MoLab" observatory. PHOCA is a mid-sized ROV with a total weight of 1.5 tons (in air) and a maximum diving depth of 3,000 metres. The vehicle, which is a ROV of the "Comanche"-series manufactured by the British "Sub-Atlantic" company, has important synergies with the ROV Kiel 6000 because of identical parts being used in both vehicles. Another important advantage of PHOCA is that it can be deployed from medium sized vessels such as POSEIDON and ALKOR, thus filling a gap in IFM-GEOMAR's portfolio. The total cost of the ROV PHOCA (including the control unit, winch, and cable) was of the order of 1.2 million Euros.

7. Personnel

7.1 Obituaries

Prof. Sebastian A. Gerlach

The Leibniz Institute of Marine Sciences (IFM-GEOMAR) mourns the loss of Prof. Sebastian Gerlach, who passed away on 17th June, 2010 at the age of 81. Prof. Gerlach's scientific career as a marine biologist was closely involved with the marine sciences in Kiel. He studied for his Ph.D. under Adolf Remane in Kiel and in 1977 he was appointed Director of the former Institute for Marine Research in Bremerhaven. Following the foundation of the Alfred Wegener Institute for Polar and Marine Research he returned to Kiel and in 1981 became Professor for Benthos Ecology and head of Marine Botany at the Institute for Marine Research (IfM). It was there that he started a second career, in pollution research, and became the coordinator of a large eutrophication project that initiated many other scientific research programmes, both in the North Sea and in the Baltic region. He was also coordinator for the Second Periodic Assessment (GESPA) of the Helsinki Commission (HELCOM) in 1989. He vacated his chair in 1991 but continued to lead an active life, both as an emeritus professor and sailing his yacht, the "GAMLA". With the passing of Prof. Gerlach IFM-GEOMAR and the marine research community have lost not only a scientist, but also a friend and colleague with a high national and international reputation. He is survived by his wife Christine and three children, to whom we offer our deepest sympathy.

Margit Beneke

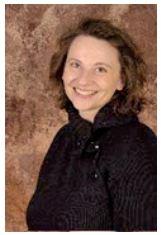
Our highly valued colleague Margit Beneke died suddenly and unexpectedly on May 18, 2010. Mrs. Beneke joined the GEOMAR Research Centre as the secretary of the director in 2002 and continued in that function with IFM-GEOMAR from 2004. We very much appreciated her outstanding competence and loyalty. Her extremely kind and helpful manner, in particular, will be remembered by her colleagues. In Mrs. Beneke IFM-GEOMAR has lost a colleague who was highly regarded, both professionally and privately, as well as a respected personality and a gentle colleague. With high appreciation she will remain in our thoughts, and our special sympathy goes to her family.

Regine Wicher

Suddenly and unexpected Our long-standing colleague Regine Wicher passed away suddenly and unexpectedly on May 19, 2010. Following her training as a agriculture laboratory technician with a major in biology, Mrs. Wicher was employed by Kiel University. In 1987 she moved to the Institute for Marine Research (today IFM-GEOMAR) where she worked initially as a technician for Prof. Gerhard Rheinheimer and since 1993 for Prof. Johannes F. Imhoff. With Mrs. Wicher's passing we have lost a highly valued, competent and conscientious colleague who will greatly be missed. Our sympathy goes to her family.

Overview

7.2 Changes in management personnel



- The vacant W3 professorship in Biological Oceanography will be filled by PD Dr. Anja Engel, the head of the Helmholtz Young Investigators Group at the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven. She will join IFM-GEOMAR in September 2011.

- PD Dr. Dirk Nürnberg (RD1, Paleo-oceanography) has been appointed to an "un-scheduled" professorship at the Faculty for Natural Sciences and Mathematics of Kiel University.

- PD Dr. Douglas Maraun (University of Gießen) has accepted an offer for a junior professorship in Maritime Meteorology (RD1). Dr. Maraun will join IFM-GEOMAR in January 2011)

- Prof. Andreas Macke (RD1, Maritime Meteorology) has accepted an offer of a W3 professorship and a directors' position at the Leibniz Institute for Tropospheric Research in Leipzig.

- Prof. Douglas Wallace (RD2, Chemical Oceanography) has accepted an offer of a Canada Excellence Research Chair in Ocean Science and Technology at Dalhousie University in Halifax, Canada. Prof. Wallace will leave IFM-GEOMAR in the summer of 2011.

- Prof. Julie LaRoche (RD2, Biological Oceanography) has accepted an offer of a faculty position at Dalhousie University in Halifax, Canada. She will leave IFM-GEOMAR in 2012.

7.3 Honours and awards

Order of Merit of the State of Schleswig-Holstein for Prof. Peter Herzig

Prof. Peter M. Herzig, Director of the Leibniz Institute of Marine Sciences (IFM-GEOMAR) in Kiel (Germany) and Maritime Coordinator for the State of Schleswig-Holstein, has been awarded the Order of Merit of the State of Schleswig-Holstein by Prime Minister Peter Harry Carstensen. Prof. Herzig received this high award for his outstanding contributions to Marine Sciences, and in particular for developing the Leibniz Institute of Marine Sciences into one of the leading international institutions in the field of marine research.

Prof. Dr. Peter Herzig with Prime Minister of the State of Schleswig-Holstein Peter Harry Carstensen.

"Golden Spike" honours for modelling of the Agulhas current

PD. Dr. Arne Biastoch (RD1, Theory and Modelling) earned the "Golden Spike Award" during the "High Performance Computing in Science & Engineering 2010 Workshop" in Stuttgart. Dr. Biastoch received the award for his work on high-resolution modelling of the Agulhas current, which was published in Nature in 2009.

Georg-Wüst Award for Andreas Oschlies

Prof. Andreas Oschlies (RD2, Biogeochemical Modelling) is to be honoured with the Georg-Wüst Award 2011 by the German Society for Marine Research (Deutsche Gesellschaft für Meeresforschung - DGM) in recognition of his outstanding scientific accomplishments. The official ceremony will take place in April 2011, at the General Assembly of the European Geosciences Union (EGU) in Vienna.

In addition to the above awards a number of young scientists have also earned awards for the exceptional quality of their posters and presentations at various scientific meetings (see Appendix 7.7).

8. International Cooperation

During 2010 IFM-GEOMAR continued to foster its established international cooperation with various institutions in the field of marine research. In this context the highlights were:

8.1 Partnership for Observation of the Global Oceans (POGO)

The 11th annual meeting of the Partnership for Observation of the Global Oceans (POGO), an international organization of marine research institutes, took place in Moscow (Russian Federation) from January 26th-28th, 2010. About 60 participants from 35 marine research institutions and organizations teamed up for the largest meeting of this group so far. Under the chairmanship of Dr. Kiyoshi Suyehiro, Director of the Integrated Ocean Drilling Programme, the meeting focused on questions relating to global and regional observing systems. In 2011 IFM-GEOMAR's Director Prof. Peter Herzig will commence a two year period as chairman of this organization's international planning committee for marine research.

Participants of the 11th POGO Meeting. Photo: POGO.

8.2 G3-Consultations

Representatives of the three leading European marine research institutes (G3) - Ifremer in France, the National Oceanography Centre (NOC)in the UK, and IFM-GEOMAR - met in Kiel on December 7th, 2010 within the framework of the trilateral cooperation between these institutes. (The three partners signed a cooperation agreement in December 2008, with the overall objective of fostering the marine sciences on an international and, in particular, a European level.) The topics discussed focussed on the EU-funded Eurofleets project, the use of large-scale equipment, and recent developments in the partner institutions.

8.3 Cooperation with China

A high-ranking delegation with representatives from the State Oceanographic Administration in Beijing, China, visited IFM-GEOMAR in October 2010. The major purpose of the visit by these delegates from this key institution for marine research in China was to explore possible options for further cooperation in the marine sciences. As well as IFM-GEOMAR the group also visited the universities of Kiel and Bremen, both of which established successful liaisons with the Ocean University in Qingdao some years ago.

9. Notable events, visitors and public relations

9.1 Deutsche Bank – IFM-GEOMAR Marine Research Award

Prof. Peter Herzig, Prof. Annette Schavan, Prof. Karin Lochte and Till Keulen. Photo: J. Steffen.

For her outstanding contributions in the field of biological oceanography the Director of the Alfred Wegener Institute for Polar and Marine Research, Professor Dr. Karin Lochte, received the "Deutsche Bank – IFM-GEOMAR Marine Research Award 2010" endowed with 10,000 Euros. The laudatory speech was held by Professor Dr. Annette Schavan, Ministry for Education and Research.

9.2 Petersen Excellence Professorships

In 2010 five top-class scientists received a research award of 20,000 Euros each from the Dr. Werner Petersen foundation. In return the scientists spent four weeks at IFM-GEOMAR and offered a scientific short-course for young scientists. Each of the award winners also gave a public presenta-

Prof. Jonathan Erez (m) with Prof. Anton Eisenhauer (r) and Prof. Peter Herzig (l). Photo: J. Steffen.

tion in their specialised field of research, in the form of an evening lecture. The 2010 awards were presented to Prof. Steven Scott (University of Toronto, Canada), Prof. Jonathan Erez (Hebrew University of Jerusalem, Israel), Prof. Boris Worm (Dalhousie University, Canada), Prof. Chris German, (Woods Hole Oceanographic Institution, USA), and Prof. Sallie Chisholm (Massachusetts Institute of Technology, USA). An additional three awards are planned for 2011.

9.3 Important visitors

US-Ambassador Philip D. Murphy

Philip D. Murphy, the Ambassador of the United States of America in Germany, visited IFM-GEOMAR on November 3rd , together with Inmi Kim Patterson, the American Consul General in Hamburg. The visitors were informed about the activities and projects of IFM-GEOMAR, as well as about deep-sea technologies available in Kiel. Prof. Peter Herzig, Director of IFM-GEOMAR, pointed out that the institute cooperates closely with

Ambassador Philip D. Murphy (r) with Consul General Inmi Kim Patterson (m) and Prof. Peter Herzig. Photo: J. Steffen.

many American research institutions such as the Woods Hole Oceanographic Institution in Massachusetts and the Scripps Institution of Oceanography in California. Ambassador Murphy showed a lively interest in the marine sciences and in the German research funding system.

Maritime Coordinator of the Federal Government

The new Maritime Coordinator of the Federal Government, Permanent Secretary Hans-Joachim Otto, visited IFM-GEOMAR on January 15th. As well as general aspects of marine research there was a major focus on applied research projects and on recent developments in marine technology. Other topics discussed were the initiative "Zukunft Meer" of the provincial government and the "German Association for Marine Technology" (GMT).

Hans-Joachim Otto (r), Prof. Herzig (m) and Dr. Olaf Pfannkuche (l). Photo: A. Villwock.

In addition, delegates from Jeddah in Saudi-Arabia (20th January), the Australian Institute of Marine Science (7th March), India (30th-31st August), and South Korea (22nd October) were welcomed at IFM-GEOMAR.

9.4 Pupils and schools

IFM-GEOMAR supports interactions with pupils on several levels. The main foci are:

Practical training

In 2010 IFM-GEOMAR received about 200 applications for practical training, most of which were from school students but 60 of which were from university students, technical trainees, etc. More than 50 training courses for school students, mostly of two weeks' duration, were carried out with a main focus on marine biology and the aquarium. A week-long summer school in marine geosciences was again advertised (the fourth such summer school): 23 school students and two university students took part out of a total of 40 applicants.

Projects with schools

The cooperation with selected partner schools and specially talented and motivated pupils that had been established under the "NaT-Working Marine Research" project funded by the Robert Bosch Foundation (the "Robert Bosch Stiftung") has continued through collaboration with the Cluster

Dr. Joachim Dengg receives the certificate from Dr. Johann Wadephul, member of parliament and deputy chair of the Hermann Ehlers Stiftung. Photo: J. Steffen.

of Excellence "The Future Ocean". A number of "NaT-Working" pupils won awards in the programmes "Schüler experimentieren" and "Jugend Forscht". In November 2010 the "NaT-Working Marine Research" project received the Kai-Uwe von Hassel Award from the Hermann Ehlers Foundation.

This programme is supplemented by the public outreach project of the Collaborative Research Centres "SFB 574" and "SFB 754". The central element of this project, which is funded for a period of three years by the German Research Foundation, is the mediation of scientific content from the SFBs through a video project especially designed for school students (see Section 9.5). The first products were generated during a week-long summer school with selected partners.

In cooperation with the shipping company "Forschungsschifffahrt", two specially qualified pupils were selected to participate on

Britta Jordan and Bennet Jess with Michael Ippich (l) and Olaf Thiede (behind) from the shipping company "Forschungsschifffahrt" and Dr. Reinhard Werner (r) from IFM-GEOMAR. Photo: J. Steffen.

the SONNE expedition SO 208. They reported their experiences regularly through the local newspaper, the "Kieler Nachrichten".

Finally, the IFM-GEOMAR school programmes have been presented at several meetings and symposia, for example at the international Euroscience Open Forum (ESOF2010) in Turin, Italy, at the "Lernwelten" conference in Hamburg, and at the SINUS[2] annual meeting.

Guided tours for schools and the general public

About 60 guided tours were conducted during 2010, of which 30 were for school groups. The total number of visitors on these tours was 1500, of which about 900 were school students. The tours have a typical duration of two hours and particular interests are catered for as far as possible.

2. Increasing the Efficiency of Teaching in Mathematics and Science Education (SINUS) in Primary Schools

In a special cooperation with the Fielmann company, two separate day visits were organized with a special intensive introduction to the field of marine research.

9.5. Public relations

"World Ocean Review" presented by the Cluster of Excellence and Mare publishers

Nikolaus Gelpke (Mare Publisher) and Prof. Martin Visbeck (IFM-GEOMAR). Photo: A. Villwock.

In cooperation with the Mare publishers, the non-profit organization maribus Maribus non-profit organization, and the International Ocean Iinstitute, the Cluster of Excellence "The Future Ocean" presented the first "World Ocean Review". This 236 page book describes on a scientific level the current state of the oceans, with the overall objective of raising public awareness on the importance of the oceans. The publication of this book, which is freely available and is published in both German and English. The first edition comprised 50,000 copies. More information is available under http://www.worldoceanreview.com.

Overview

Diving into "The Future Ocean" – a special exhibition in the Deutsches Museum

The future ocean explorer, a multi-touch device was one of the most popular parts of the exhibition in Munich. Photo: Future Ocean.

From late March to late August 2010 a special exhibition was presented by the Cluster of Excellence "The Future Ocean" in the Deutsches Museum in Munich. In an exhibition covering approximately 300 square metres within the Centre for New Technologies, Kiel marine sciences showed how the world's oceans might change in the future and what dangers these changes might present for the human race. Thousands of visitors including many school groups were welcomed and guided through the exhibition.

"The oceans under climate change" - Kiel marine sciences in the German Bundestag

At the invitation of the German Bundestag, Kiel marine sciences presented a four-week special exhibition entitled "The role of the ocean in climate change" in the Paul-Löbe Haus building in Berlin. The exhibition opened on September 12th, 2010, the Open Day at the Bundestag. It was jointly developed by IFM-GEOMAR, the Cluster of Excellence "The Future Ocean" , and the Muthesius School of Fine Arts, and illustrated various aspects of the marine sciences, with a special emphasis on the interactions between oceans and climate, and was mainly directed towards members of parliament and employees of the German Bundestag.

The exhibition "The Ocean under climate change" in the Paul-Löbe-Haus of the German Bundestag in Berlin. Photos: A. Villwock.

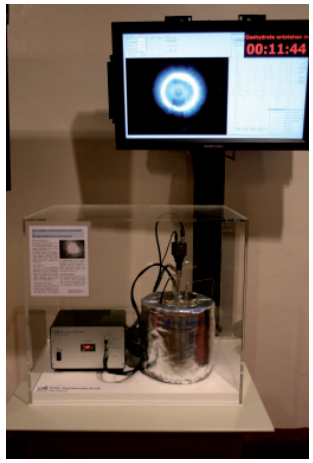
IFM-GEOMAR at the Open Day of the German Bundestag

For the Open Day at the German Bundestag (September 12th, 2010) IFM-GEOMAR was invited to organize a special programme for children. "'Hands-on' marine organisms", special talks from the "Childrens' University", and other attractions from the marine sciences were offered for younger visitors, in the Paul-Löbe Haus building in Berlin. The event was organized in conjunction with the special exhibition on "The role of the ocean in climate change" that opened on the same day (see above).

"Hands-on" marine organisms during the Open Day at the German Bundestag. Photo: A. Villwock.

Exhibition on gas hydrates on the MS WISSENSCHAFT

Since 2002 the exhibition ship MS WISSENSCHAFT has been going on tour every year as a floating science centre with an interactive exhibition. The exhibition theme is always based on the subject of the "Science Year" of the BMBF, and about 30 cities are visited each year with the target group be-



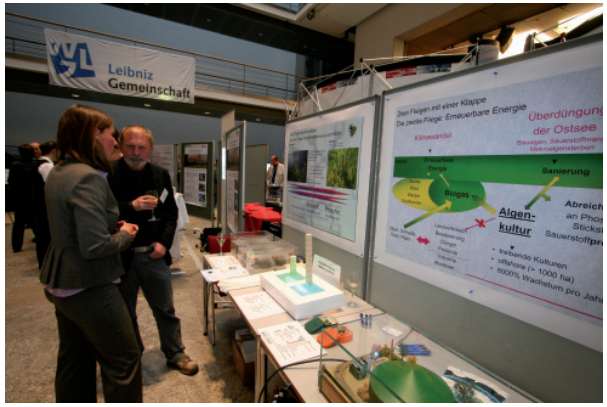
Pressure lab for gas hydrate formation on the MS Wissenschaft. Photo: A. Villwock.

ing primarily school groups. In 2010, the "Year of Energy", IFM-GEOMAR participated with a module on gas hydrate research. As well as providing general information about gas hydrates, the module also comprised a pressure laboratory in which the formation and dissolution of hydrate could be observed. The laboratory was provided by PSL Systemtechnik GmbH. During the course of the year the exhibition was seen by 105,000 visitors at 34 different locations.

Film projects: short scientific videos and SFB "YouTube" video project

Apart from still images the Public Relations department at IFM-GEOMAR also collects video material for public outreach purposes. This footage material is available to the media on request. As an addition to the existing IFM-GEOMAR image film, a four-minute trailer was produced in 2010. The video is available in both German and English.

In a second project, short scientific videos about actual research topics or state-of-the-art marine technologies will be produced. The first series will consist of up to six videos. The storyboard, the filming, and a preliminary rough cut will be produced in house while the final cut, sounds, and post-production will be completed by external professional support. By the end of 2010 three products had been finalised on mesocosm experiments and ocean acidification, marine substances research, and the West Nile Delta project and mud volcanoes. The videos are available in both German and English through the IFM-GEOMAR website at www.ifm-geomar.de/index.php?id=filme



As part of a public outreach project by the two Collaborative Research Centres (SFBs) a video project with pupils (age 15-16 years) has produced a number of short videos in YouTube format targeting children of the same age. The collection will be made available via the SFB website.

Other public events:

- "See History" exhibition project at the Kiel Art Gallery (Kunsthalle zu Kiel), January-December. Historic paintings (landscape painting) were presented together with pictures of actual research expeditions, with a regional relationship between the two.
- "Voices from the Sea" photo exhibition at IFM-GEOMAR east shore facilities (from 12th September) & Aquarium (from 2nd October)
- Public lecture: "Why a polar bear needs a refrigerator" by Prof. Latif (Kunsthalle, 16th March)
- Kids Festival Kiel – "Hands-on Marine Organisms" (8th-9th May)

Top: Exhibition project „See History", middle: parliamentary evening of the Leibniz Association on Biodiversity, lower: open ship during Kieler Woche. Photos: A. Villwock.

Overview

- Participation at the Leibniz Association's parliamentary evening on Biodiversity, in Berlin. (18th May), where the topic presented was "Bio-energy from algae".
- Participation in Kiel Week (19th-27th June): Kiel Week presentation series (21st-25th June) and Open Ship (25th June)
- "Lütt-Ing" – Event for pupils (with approximately 200 participants) (22nd June)
- Participation in the "long night of the museums" 2010 (Aquarium) (27th August)
- Panel discussion on occasion of the 50th anniversary of the Intergovernmental Oceanographic Commission (IOC), Paul-Löbe-Haus, Berlin (6th October)

Scientific Highlights

A selection of short scientific reports in this section provides an overview on IFM-GEOMAR research activities and results throughout 2010. This encompasses summaries from major expeditions, interdisciplinary activities, technology development and scientific results. These are just a few highlights from the broad scope of marine research at IFM-GEOMAR.

- Spatial variability of sea level change
- Arctic waters on the verge of changing?
- Arctic Ocean turning corrosive
- When chemical oceanographers go robotic – first high-quality CO_2 measurements from profiling float –
- Less biomass, smaller algae and a bit earlier: the plankton spring bloom in warming waters
- Save the fish: attempts to change European fisheries management
- Submarine landslides off NW-Africa: how dangerous are they?
- Birth and evolution of seamounts in the Cape Verde archipelago
- SFB 574: Volatiles and fluids in subduction zones – highlights from the last cruise

Spatial variability of sea level change

Claus Böning, Ocean Circulation and Climate Dynamics – Theory and Modelling
Mojib Latif, Ocean Circulation and Climate Dynamics – Maritime Meteorology

Globally averaged sea level has risen by just under 10 cm during the last 50 years as a consequence of global warming. The rise, however, is not uniform, neither in time nor in space. Natural climate fluctuations and associated changes in the ocean currents have contributed to the inhomogeneity and is an important factor which will determine the pattern of future sea level rise. While research in the past years has focused on the global-mean trend and its attribution to the melting of glaciers and the thermal expansion of sea water under global warming, attention is shifting to the geographical pattern of sea level change. This is essential for coastal impact assessments, but has not been practical yet because ocean projections from current climate models widely diverge. The improvement of regional sea level prediction requires a better understanding of the underlying dynamical causes.

Coastal sea level records together with modern satellite measurements reveal a mean increase of about 1.6 mm/year during the last 50 years, with some indication of acceleration during the recent years featuring a rate of about 3 mm/year. Local rates of change, however, significantly differ from the global average in many places and also experienced a strong temporal variability. During El Niño, an inter-annually occurring warming of the tropical Central and East Pacific, for instance, sea level typically rises by about 20 cm in the eastern Equatorial Pacific for several months, while it drops more or less simultaneously by a similar amount in the west. Strong swings in local sea level due to such natural climate oscillations are also seen over time spans of many years: in the western tropical Pacific sea level rose by about 10 cm since the second half of the 1990s (Fig. 1), much more than the global average, thereby amplifying concerns about the future fate of low-lying tropical islands. The eastern Pacific, however, featured a drop of sea level during this time.

Although much of this variability averages out when considering longer periods, recent studies found indications of considerable geographical deviations from a globally-uniform trend to persist even over several decades. A prominent example is the eastern tropical Indian Ocean, with multi-decadal changes of ±2-3 mm/year on top of the global-mean rise (Fig. 2).

Regional sea level swings on the short inter-annual time scales are largely wind-driven: changing ocean currents lead to a redistribution of the upper-ocean (thermocline) layer of warm water. Forced ocean model simulations suggest that in the tropical oceans wind-driven changes appear also important on the longer, multi-decadal time scales

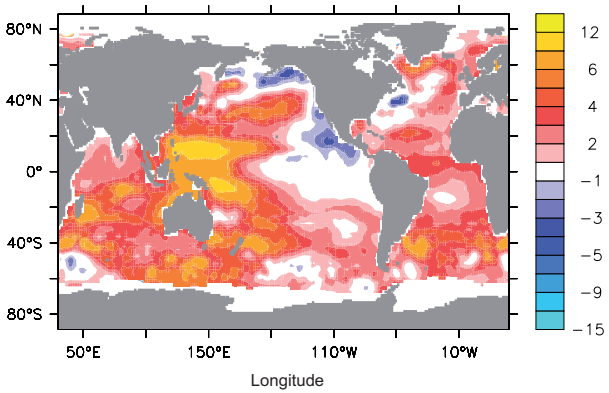


Figure 1: Rate of sea level change (mm/year) during 1993-2010 as derived from satellite altimetry. Source H. Ding, IFM-GEOMAR.

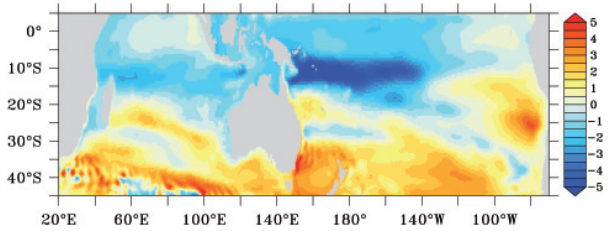


Figure 2: Sea level trend over the last five decades in the Indo-Pacific (relative to the global-mean rise) as simulated by an ocean model forced by the fluctuating atmospheric conditions at the sea surface: while sea level in the eastern and south Pacific rose at a higher rate than the global mean trend, the model reconstruction suggests a falling trend in the western tropical Pacific and parts of the Indian Ocean. (From Schwarzkopf and Böning, 2011).

(Schwarzkopf and Böning, 2011). The sea level drop off Western Australia (Fig. 3) during the 1960s-1990s, for instance, appears to be related to a decrease in upper-ocean heat content related to changes in tropical ocean currents due to a weakening of the Trade Winds over the Pacific. Heat content

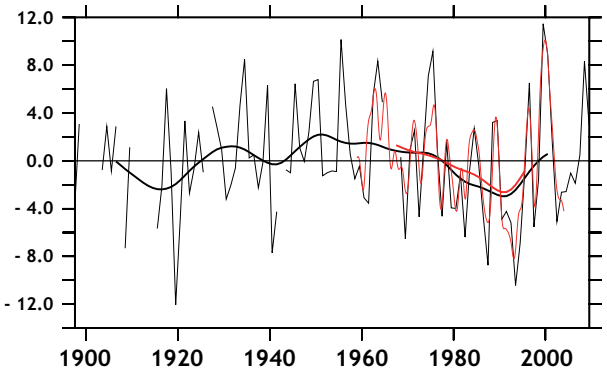


Figure 3: Interannual variability and multi-decadal changes of sea level (in cm) off the west coast of Australia as given by a tide gauge record at Fremantle (black) and the corresponding model simulation (red). The global-mean trend was removed from both time series. (From Schwarzkopf and Böning, 2011).

anomalies in the West Pacific then propagate through the Indonesian Passages to the west coast of Australia. The subsequent radiation of the signal by planetary waves to the west eventually produces an elongated band of falling sea level along most of the South Tropical Indian Ocean. Whether or not the changes in the Pacific trade winds contain an anthropogenic signal is being controversially discussed (e.g. Meng et al., 2011).

Another area of interest regarding regional sea level change is the North Atlantic. In addition to strong inter-annual sea level variability associated with wind-driven changes in ocean circulation, significant longer-term trends may be expected here, if the Gulf Stream/North Atlantic Current system would slow down in a warming 21st century as projected by the majority of climate models.

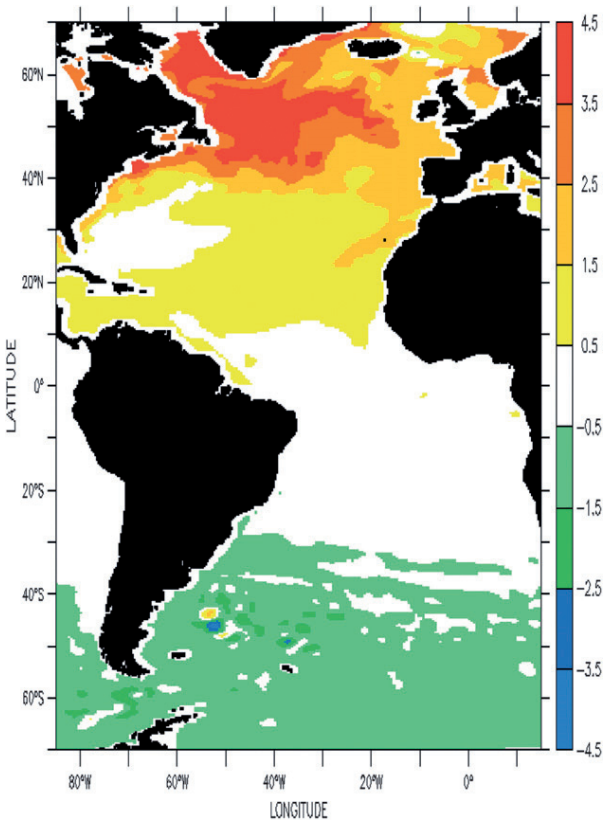


Figure 4: Future sea level change (in mm/year) in the Atlantic Ocean (relative to the global mean rise): model projection for the case of a gradual weakening of the Gulf Stream/North Atlantic current system. (From Lorbacher et al., 2010).

Ocean circulation models suggest that even a gradual decline by only about 30% over 50 years of this current system would lead to a significant geographical redistribution of sea level (Fig. 4). While it would fall in the South Atlantic relative to the global mean, the North Atlantic would see an additional rise, of 2-4 mm/year along the North American, and about 2 mm/year along the European coasts (Lorbacher et al., 2010).

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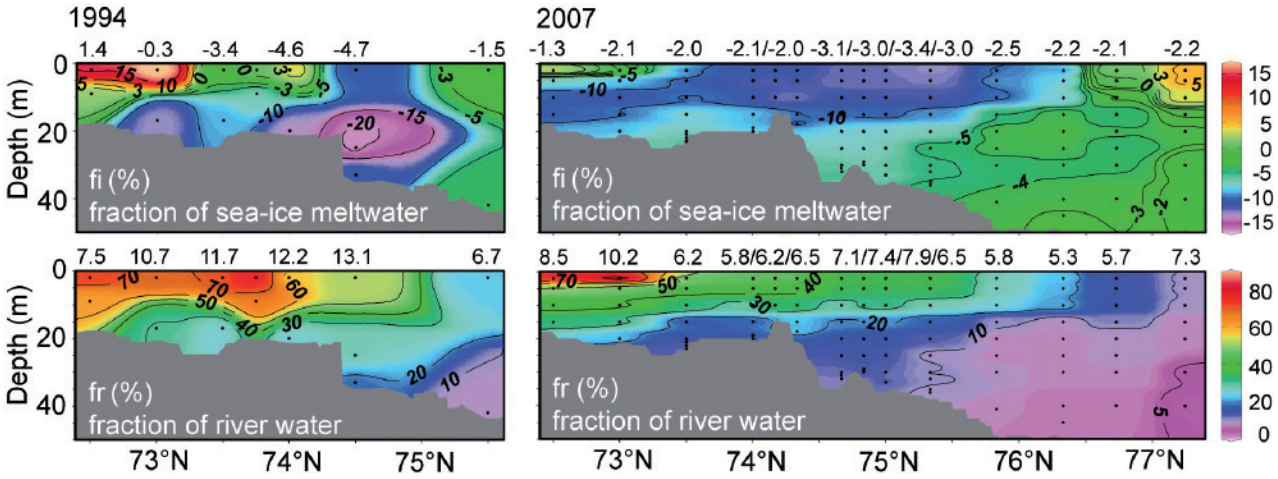
Arctic waters on the verge of changing?

Dorothea Bauch, Ocean Circulation and Climate Dynamics – Paleoceanography
Heidemarie Kassens, Ocean Circulation and Climate Dynamics – Paleoceanography

Satellite images document a decrease in Arctic ice cover in summer by 40% during the past 30 years. However, responsible processes and possible consequences of this decrease are little understood. The joint Russian-German project „Laptev Sea Polynya" is coordinated by IFM-GEOMAR and aims to ascertain the causes and consequences of climate change and its essential mechanisms in the Arctic. Now the project scientists revealed a changed water mass distribution in the Siberian Laptev Sea which might be of consequence for ice formation in the whole Arctic.

The project focuses on polynyas, open water areas between solid coastal ice and drift sea-ice of the open ocean. During winter large amounts of sea-ice form in these polynyas and consequently influence the water column. However, it is extremely difficult to observe this process in situ due to the severe winter conditions in this region. The use of stable oxygen isotopes of the water bypasses this problem because when the water freezes, the isotope ratio changes and these changes can be traced even a year later since the residence time of the water is larger than one year. In summer, when the Siberian coastal waters are ice-free, water samples can be taken relatively easily. Thus, it is possible to reveal how much sea-ice was formed in previous winters (Bauch et al., 1995).



The Laptev Sea Polynya during the field campaign in April 2008. Photo: H. Kassens, IFM-GEOMAR.

Although ice forms at the ocean surface, its isotopic traces are usually found at the bottom of the relatively shallow Laptev Sea because salt is released from the sea-ice and the resulting water is subsequently denser than the surrounding water mass, and sinks. However, measurements carried out in 2007 show a completely different picture: maxi-

Figure 1 (left): While the calculated fractions of river water (fr) show similar distributions in both years the fractions of sea-ice meltwater (fi) show a qualitatively inverse distribution in summer 2007 relative to 1994. The south to north oriented section along about 125 to 130°E shows maximal influence of sea-ice formation (negative fi) in the bottom layer in 1994 (left hand panels), while in 2007 (right hand panels) maximal influence is found in the surface layer. During 1994 at most stations only single samples were taken within the surface layer and bottom layer and the contour lines are mere interpolations between surface and bottom layer values, but due to the qualitative difference between the years, the lack of vertical resolution is not a problem. Inventory values in meters of river water and sea-ice meltwater are shown on top of sections. Figure taken from Bauch et al. (2010)

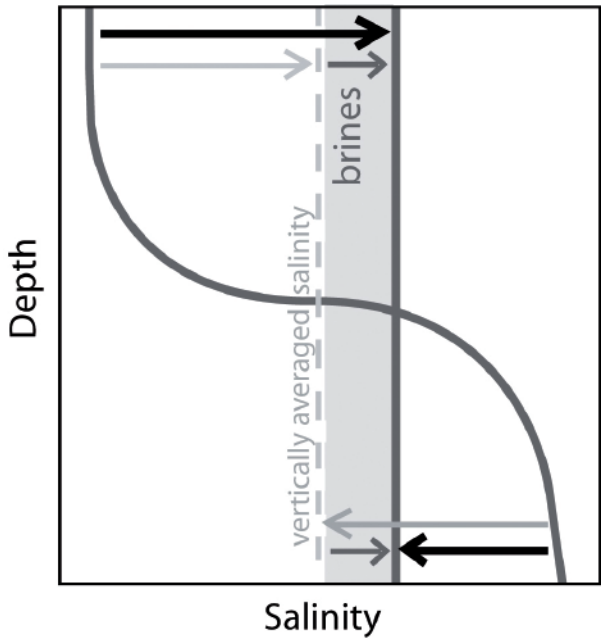


Figure 2: Primarily wind driven polynya events may decrease bottom salinities. The schematic drawing shows the typical low-salinity surface layer and the high-salinity bottom layer (gray curve) on the shelf transformed by mixing into a uniform profile at the average salinity of the initial water column (stippled gray line and light gray arrows) increased by the amount of brines released to the water column by sea-ice formation (dark gray arrows and gray line).

mal isotopic traces of sea-ice formation were found in the surface layer (see Fig. 1 upper panel). These findings contradict our conception of the stratification and distribution of water masses in this region.

A change in the mechanisms of ice formation in the coastal polynya might explain the unusual observations. In summer 2007 the Arctic Ocean experienced the lowest ice coverage on record and the observed polynyas in the Laptev Sea were unusually wide and persistent at the end of winter 2006/2007. This suggests a larger impact of sea-ice formation. But a polynya opening does not only trigger sea-ice formation and the unusually wide polynya opening also causes enhanced advection in the water column. Enhanced advection in 2007 can explain why the signal from sea-ice formation did not predominantly reach the bottom layer and also explains the salinity difference with less saline bottom water in summer 1994 compared to 2007 (not shown). Primarily wind driven polynya events may actually decrease salinities within the bottom layer, even though sea-ice formation adds overall brines to the water column (Fig. 2). If the inverted distribution in 2007 was not a singular event, but a long-term trend, the surface layer of the Arctic Ocean would receive saltier waters from the shelf (Bauch et al., 2010). This would result in the ice cover being less effectively isolated by the lower density gradient in the surface layer against the relatively warm and salty Atlantic layer present at about 200-300 m water depth in the whole Arctic Ocean. This could accelerate the decrease in the Arctic ice cover.

Further research is of particular importance as the Arctic is a key area for investigating climate change. Because the data coverage will always remain patchy due to the severe climate conditions in the Arctic, important focus of the project at IFM-GEOMAR are therefore process studies. Here we are also only at the beginning of understanding Arctic environmental mechanisms. Direct investigations near the ice edge of the polynyas are planned for an upcoming winter expedition in April 2011.

Background information:

The joint Russian-German project "Laptev Sea Polynya" focuses on Arctic front and polynya systems in the Laptev Sea, Siberia, the response of these systems to climate changes, and feedback mechanisms affecting global climate. The project involves multidisciplinary investigations, namely remote sensing, meteorology, oceanography, physics, hydrochemistry, biology, paleoceanography, and climate modelling. It is funded by the German Federal Ministry of Education and Research and the Russian Ministry of Education and Science.

Links:

www.ifm-geomar.de/go/polynja : Laptev Sea Polynya project

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Arctic Ocean turning corrosive

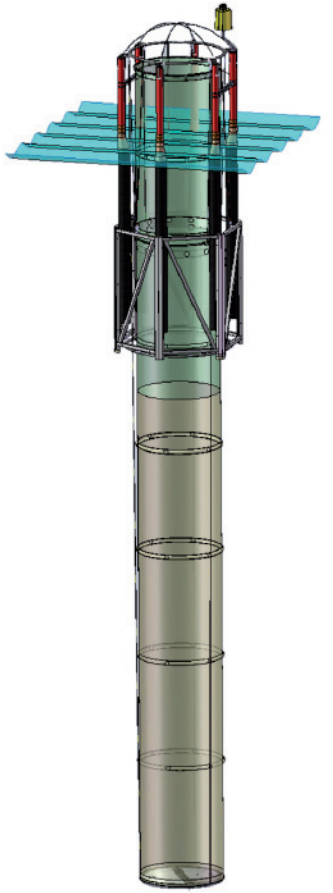
Ulf Riebesell, Marine Biogeochemistry – Biological Oceanography

The cold waters of the polar seas are naturally low in carbonate saturation. As uptake of anthropogenic CO_2 continues to acidify the oceans worldwide, the Arctic Ocean will be the first to pass the chemical threshold where surface seawater becomes undersaturated, i.e. corrosive for unprotected shells and skeletons of calcifying organisms. While the overall impacts of ocean acidification on the Arctic ecosystems are still unknown, the predicted changes in seawater chemistry are expected to make it increasingly difficult for calcareous organisms to inhabit these regions.

If atmospheric CO_2 levels continue to rise at current rates, in less than 10 years from now about 10% of the Arctic Ocean is projected to have crossed the saturation threshold for aragonite, one of the major forms of calcium carbonate. By the time atmospheric CO_2 exceeds 490 parts per million (2040 to 2050, depending on the scenario considered), more than half of the Arctic Ocean is projected to be corrosive to this mineral. In case of unabated CO_2 emissions, the entire Arctic Ocean will turn corrosive before the end of this century. The projected changes in ocean acidity go beyond anything organisms have experienced in the last 20 million years of their evolutionary history. Arctic waters are home to a wide range of calcifying organisms, both in benthic and pelagic habitats, including shell fish, seas urchins, coralline algae, and calcareous plankton. Many of these are key species providing crucial links in the Arctic food web, such as the sea butterflies (pteropods), which serve as food for fishes, seabirds and whales.

To study the impacts of ocean acidification on plankton communities, a group of 35 researchers of the EU-funded European Project on OCean Acidification (EPOCA) conducted the first major CO_2 perturbation experiment in the Arctic Ocean. Led by the Leibniz Institute of Marine Sciences (IFM-GEOMAR) nine mesocosms were set out in the Kongsfjord off the north-western coast of Svalbard. Each of the giant, 17 m long 'test tubes' held about 50 cubic metres of seawater. The enclosed plankton community was exposed to a range of different CO_2 and pH levels, representative for glacial to projected mid-next-century levels (Fig. 1) and was closely monitored over a 5-week period. The EPOCA scientists, who stayed at the Ny Ålesund research station, sampled the mesocosms daily from zodiacs with plankton nets, water samplers and pumps, and conducted measurements with profiling sensors and in situ probes.

EPOCA's 2010 mesocosm campaign, which involved molecular and cell biologists, marine ecologists and biogeochemists, ocean and atmospheric chemists, addressed a range of urgent questions concerning the impacts of ocean acidification on Arctic ecosystems. How will ocean acidification affect the production of food at the base of the Arctic food web and its transfer to consumers at higher levels? How will ocean acidification influence competition and trophic interactions at various levels of the pelagic ecosystem? Will there be winners and losers of ocean acidification? Another set of questions concerns the possible consequences for the cycling of key elements. Will ocean acidification affect the sequestration of carbon in the



Above: Esperanza with mesocosms on deck. Photo: U. Riebesell. Right: Schematic diagram of a mesocosm system.

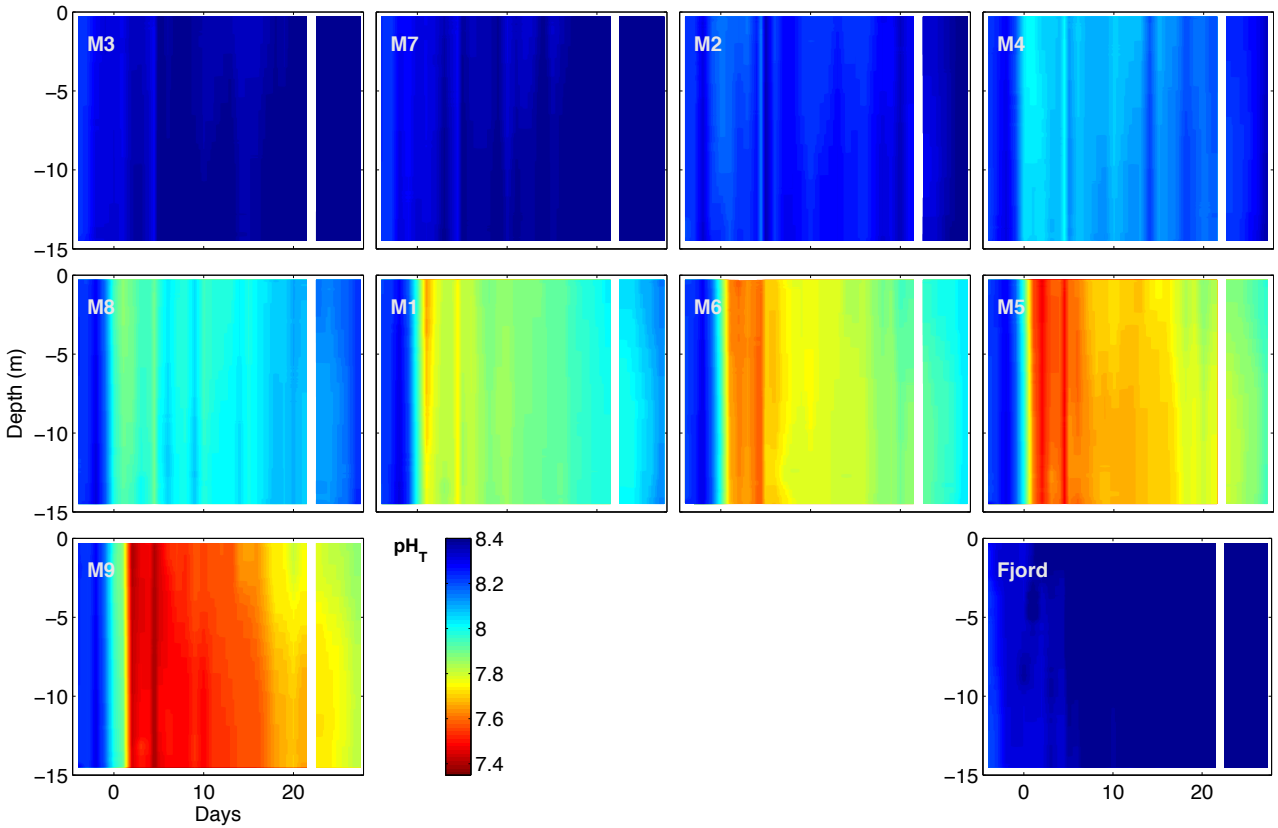
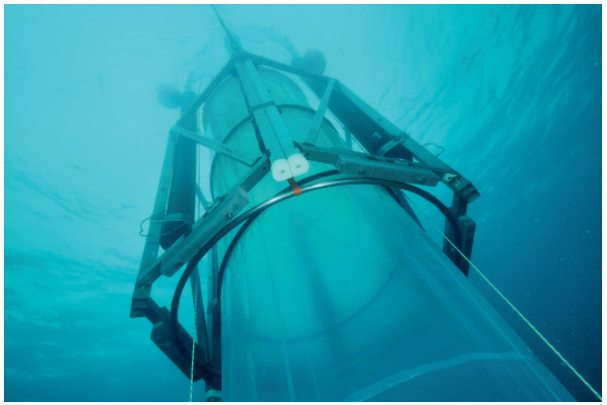


Figure 1: Temporal development of seawater pH in the nine mesocosms and the adjacent fjord. From days 0 to 4, CO_2 enriched seawater was added to the mescosms in different amounts to achieve a gradient representative for glacial to projected mid-next-century pCO_2 levels of 180 to about 1050 µatm, respectively.

Arctic ocean? Will it change the turn-over and balance between the primary building blocks of life such as carbon, nitrogen and phosphorus? A third set of questions concerns the exchange of climate relevant gases between ocean and atmosphere. Will ocean acidification affect the production of these gases and if so, will it amplify or dampen global climate change?

The scientists participating in this unusual campaign, the first of its kind in polar waters, were prepared to face a range of technical and logistical challenges. In addition to the nine mesocosms, each weighing nearly two tonnes, they had to transport over 150 boxes of scientific equipment to the high Arctic. IFM-GEOMAR, as the coordinating institute, received support from the Greenpeace vessel ESPERANZA, which transported the mesocosms and other heavy equipment from Kiel to Ny Ålesund and back as part of its 2010 Arctic Campaign. Another challenge, the risk of damage to the mesocosms by drifting sea ice and icebergs calving off the three glaciers extending into the Kongsfjord, could be avoided by 24-hour ice watches and pushing icebergs off their track with small boats before they could hit the moored mesocosms. Considering the many unknowns involved in this endeavour, the experiment went surprisingly smooth and according to plan. The scientists collected nearly 15,000 samples and acquired data for over 45 parameters characterizing the responses of the Arctic ecosystem to ocean acidification. The results of this study, which will be presented at various international conferences this year, are expected to provide the first comprehensive insight into the sensitivities of an Arctic ecosystem to a rapidly acidifying ocean.



Underwater photo of extended mesocosm enclosure. Photo: Y. Gladu.

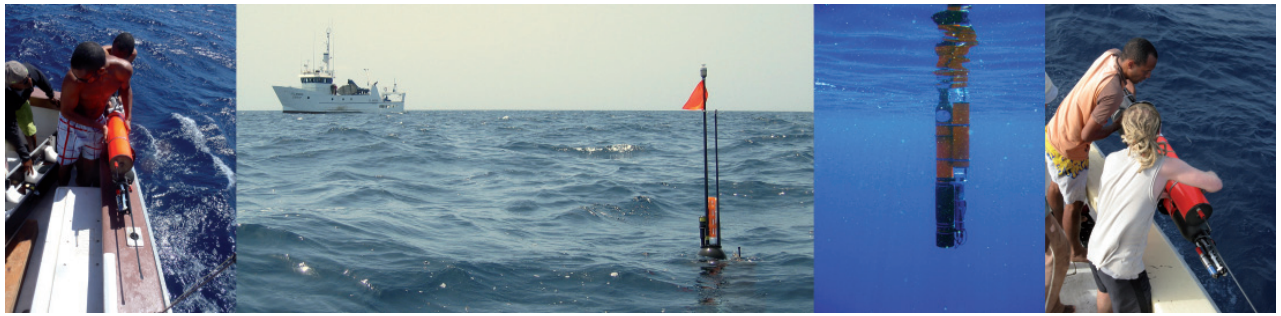
When Chemical Oceanographers go robotic – first high-quality CO_2 measurements from profiling float

Björn Fiedler, Peer Fietzek, and Arne Körtzinger,
Marine Biogeochemistry - Chemical Oceanography

An autonomous prototype profiler developed by IFM-GEOMAR is currently operating successfully at the recently established Cape Verde Ocean Observatory (CVOO) thereby complementing time-series activities at the site. Simultaneous CO_2 and O_2 in situ observations performed on the same platform are highly demanded by the scientific community (Keeling et al., 2010). A major step towards this aim has now been realized by the Chemical Oceanography department in RD2.

In the past, different approaches for autonomous observation of the world ocean's physical state have been followed, e.g. long-term moorings, buoys, and surface drifters. A more recent story of great success is the international ARGO programme which is maintaining a worldwide fleet of over 3000 autonomously operating, freely drifting robotic instruments. This network provides real-time data for temperature and salinity from the ocean's upper 2000 meters. Recently several efforts have been made to extend this platform to chemical sensors which would provide a research quality in marine biogeochemistry (Gruber et al., 2010). One successful example of this is the use of ARGO float for high-quality oxygen measurements (Körtzinger et al., 2004). Since then major improvements have been achieved in the sensor-based measurement of the CO_2 partial pressure (pCO_2) such that these instruments now start to become suitable for deployment on autonomous platforms such as profiling floats.

A successful collaboration of and initiated by IFM-GEOMAR with two German companies (Optimare, Bremerhaven & CONTROS, Kiel) has been established within the framework of the BMBF-funded project SOPRAN with the aim to realize autonomous pCO_2 measurements on a profiling float. The resulting prototype builds on a modified ARGO float (NEMO), equipped with an oxygen sensor (4330 Optode, Aanderaa, Norway, Bergen) and an externally mounted pCO_2 sensor (membrane-based nondispersive infrared sensor, CONTROS) with an additional battery pack. Redundant satellite telemetry (ARGOS & Iridium) provides a fast data link to shore and also permits bi-directional communication between operator and device which allows to change mission parameters en route. The float is designed to conduct missions for several months (depending on configuration and battery payload) and recovery can easily be done via remote control and GPS geolocation. The ambitious development of this device went through several steps and generations of prototypes which varied in different sensor payloads, instrument designs and software modifications. Former prototypes underwent thorough sea trials during field campaigns at CVOO and have led to the final instrument design (see figure panel below) which was deployed in the most recent mission described below.



Conducted field work with the new O_2/CO_2 float at the Cape Verde Ocean Observatory: An intensive partnership with colleagues from INDP Mindelo has been established.

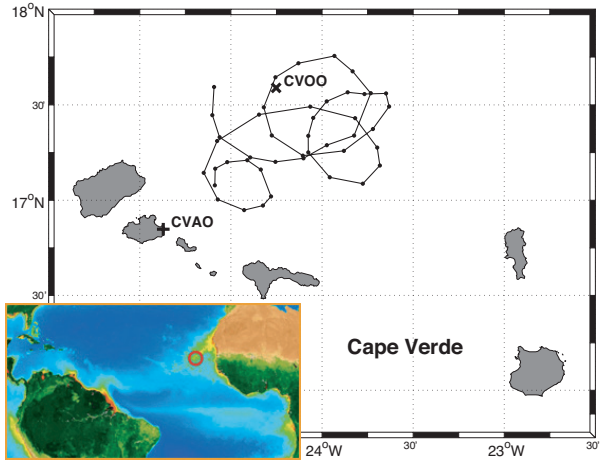


Figure 1: Trajectories of the profiling float during its 8-week lasting mission between CVOO and CVAO.

In cooperation with our partner in Cape Verde (Instituto Nacional de Desenvolvimento das Pescas, INDP) an 8-week campaign was conducted at CVOO from Nov. 2010 to Jan. 2011 during which the instrument recorded 44 profiles in the upper 200 meters of the water column (Fig. 1). Every 31 hours the instrument reached the surface in order to transmit data to Kiel. Each profile contains high resolution data for CO_2 partial pressure, oxygen, salinity, temperature, and pressure. The quality of pCO_2 data was assured by automated zero-point calibrations before and after each profile. Accuracy of oxygen data is given through a precise lab-based sensor calibration prior to deployment and through measurements of atmospheric oxygen concentrations after each profile at the surface.

The data obtained during this mission (Fig. 2), which to our knowledge represent the

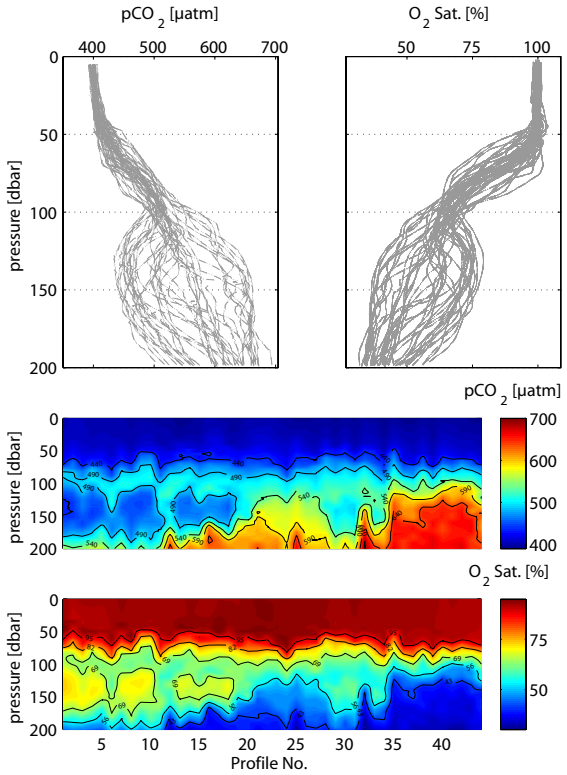


Figure 2: Obtained (raw) data for pCO_2 and O_2 resolves small scale features at CVOO. Data quality underlines the feasibility of this in situ approach.

first combined vertical profiles of CO_2 and O_2 performed ever by an autonomous profiling device, demonstrate a remarkable precision and robustness and will allow for a detailed view into the carbon and oxygen dynamics in the Eastern Tropical North Atlantic. In conjunction with the Cape Verde Atmospheric Observatory (CVAO), which is located downwind of the region of our float observations, both CVAO as well as CVOO can be linked with each other in a direct approach.

The next float mission is already underway at this moment and further missions will be carried out subsequently as an innovative part of the time series observations at Cape Verde.

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Less biomass, smaller algae and a bit earlier: the plankton spring bloom in warming waters

Ulrich Sommer, Aleksandra Lewandowska, Marine Ecology – Experimental Ecology
Ulf Riebesell, Marine Biogeochemistry – Biological Oceanography

Climate warming will affect the phytoplankton spring bloom. Experiments conducted at IFM-GEOMAR indicate, that bloom biomass of phytoplankton will become less, average cell size will become smaller, the biological carbon pump will be weakened and the timing of the bloom will be advanced a bit in a warming climate.

Warming of our climate is now beyond doubt while the extent of warming and mankind's ability to reduce emissions of green-house gasses is still a matter of debate. Global warming also affects our planet's water bodies, as shown for example by a 1.1°C increase over 40 years in sea surface temperatures in the Helgoland Roads time series. The more pessimistic scenarios of the IPCC predict a warming of up to 6°C for the end of the century. Geographic distributions of species and seasonal activity patterns have already begun to shift, with potential consequences for the structure and function of ecosystems and ecosystem goods and services for mankind. Those consequences of regional species shifts and seasonal activity shifts were the focus of the DFG-funded priority program AQUASHIFT ("The impact of climate variability on aquatic ecosystems: Match and mismatch resulting from shifts in seasonality and distribution") which started in 2005 and was coordinated by Ulrich Sommer from the IFM-GEOMAR. Funding of AQUASHIFT is now approaching its termination and the last AQUASHIFT-experiments at IFM-GEOMAR have been terminated in early 2010.

At IFM-GEOMAR, the focus of AQUASHIFT activities was put on the spring bloom of plankton, an annually repeated burst of phytoplankton productivity at the beginning of the growth season which is of utmost importance for the nutrition of the pelagic food web reaching from phytoplankton over protozoa and crustacean zooplankton to fish. From 2005 on, 8 to 12 mesocosms were installed in four temperature controlled rooms (Fig. 1). Seawater with its natural plankton content of plankton was maintained under 4 different temperature patterns: the present long-term average of late winter/early spring sea surface temperature pattern ("business as usual") and 2, 4 and 6°C above that (mild to strong warming scenarios). During the first years, the four temperature scenarios were tested under different light regimes mimicking cloudy to sunny winter-spring transitions. During the last two years the coldest and the warmest temperature scenarios were combined with the experimental factors light and density of overwintering zooplankton.

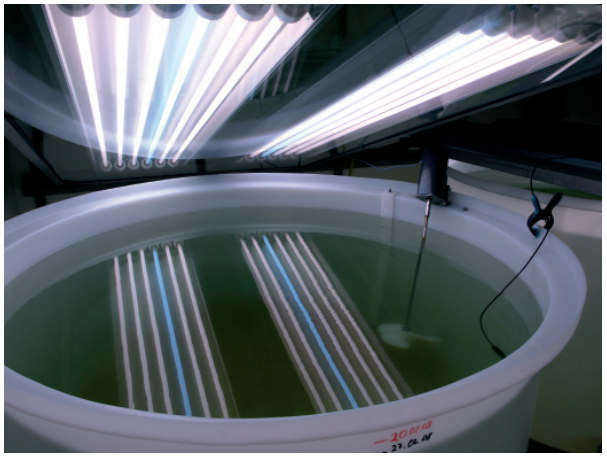

Figure 1: Mesocosm with opened light unit.

Despite considerable interannual variability, a number of patterns were consistent across all experiments and compare well to field observations:

1. The magnitude of the phytoplankton spring bloom (phytoplankton biomass) decreases with warming (Sommer and Lengfellner, 2008), while phytoplankton production rates did not show this trend in all experiments. The decreasing biomass could be explained by stronger grazing activities of the overwintering copepods, which was also supported by the observation that experimentally increasing the density of overwintering copepods has the same effect on phytoplankton as warming (Sommer and Lewandowska, 2011)
2. The mean body size of phytoplankton and to a lesser extent also of zooplankton decreased under warming conditions (Daufresne et al., 2009). The phytoplank-

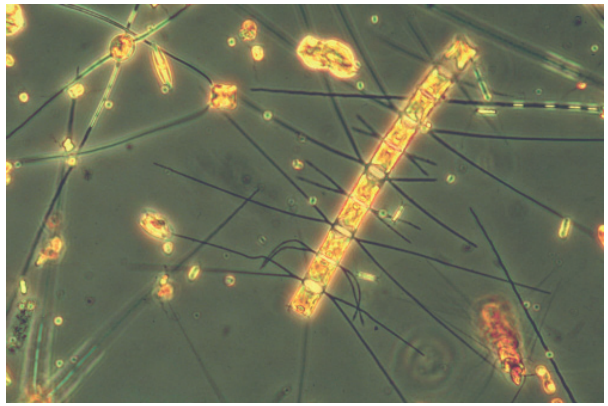

Figure 2a: Microscopic photograph of a spring bloom under business-as-usual temperature: high biomass dominated by medium sized diatoms, which are a good food for copepods.

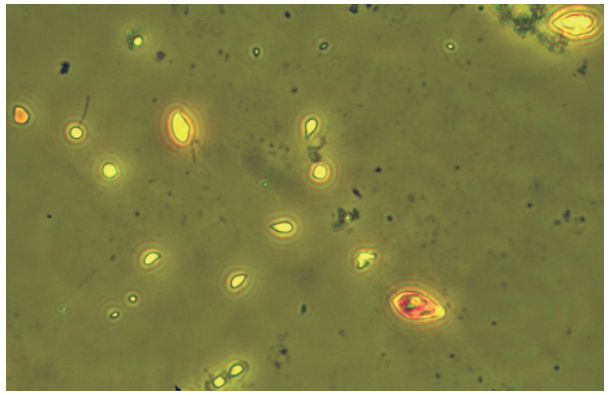

Figure 2b: Microscopic photograph of a spring bloom under 6°C warmed (+6°C) conditions: low biomass dominated by small flagellates, a poor food for copepods. dominance by medium sized diatoms, which are a good food for zooplankton.

ton size effect can be explained by preferential feeding of copepods on larger phytoplankton species and leaving the smaller ones (Fig. 2).

3. The higher respiration under warmer conditions led to a reduced amount of remaining POC available for downward export by sedimentation and thus to a potential weakening of the biological carbon pump (Wohler et al., 2009). This is a matter of serious concern, because it implies a positive feed back loop ("vicious cycle") in the CO_2 effect on temperature: warmer oceans would be weakened in their ability to take up CO_2 from the atmosphere.
4. The onset of the spring bloom was almost independent of temperature but depended on passing a threshold daily light dose of ca. 1.3 E m^{-2} d^{-1} calculated for the mixed water layer (Sommer and Lengfellner, 2008). The peak of the phytoplankton spring bloom was slightly accelerated by warming (ca. 1 day earlier per °C), while release of nauplii from the eggs of overwintering copepods was strongly accelerated (ca. 9 d $°C^{-1}$). But only under the extreme combination of strong warming (+6°C) and low light (84% loss of sunlight by clouds and underwater shading) this led to a temporal mismatch between food supply and demand in the phytoplankton-copepod food chain: Nauplii starved before there was a sufficient supply of algal food (Sommer et al., 2007).

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Save the fish: attempts to change European fisheries management

Rainer Froese, Evolutionary Ecology of Marine Fishes - Marine Ecology

With three scientific studies and a number of high-level presentations, IFM-GEOMAR contributed to the efforts of rebuilding Europe's fish stocks and putting European fisheries management on a sustainable and profitable path.

The Common Fisheries Policy (CFP) is the European Union's instrument for the management of fisheries, aimed at enhancing the sustainability of fish stocks and the economic competitiveness of the fishing industry. However, neither the living aquatic resources, nor the profits of the fishing industry have benefited from it, with 88% of the stocks being overfished and profit margins of fishermen continuously in decline (EC, 2009) (Figure 1). An ideal fisheries policy should foster the sustainable use of fish stocks, provide for coherent laws and regulations that yield adequate economic incentives, and guarantee consistent enforcement of the legal framework. Furthermore, the regulation scheme ought to be based on transparent rules rather than a discretionary political decision-making process, which may be blurred by short-term interests. In the context of the Kiel Future Ocean Cluster of Excellence, researchers from IFM-GEOMAR, the Kiel Institute for the World Economy, the Walther-Schücking-Institute for International Law, and the Economics Department of the Christian-Albrecht University in Kiel joined forces to explore the biological, economical, legal and political shortcomings that have led to the failure of the CFP. The study was published in *Marine Policy* (Kahlilian et al., 2010) and concluded that excessive quotas set by the Council of Ministers and payment of direct and indirect subsidies by both the EU and Member States has resulted in too much fishing effort and excessive exploitation rates, resulting in low stock sizes, low catches and severely disturbed ecosystems. From a legal perspective, compatibility of the CFP with the EU Treaty in general and the precautionary principle in particular was at least questionable. The lack of transparency of its regulations as well as insufficient control and enforcement of its provisions have added to the failure of the CFP. Short-term political considerations have regularly overruled scientific advice in the decision-making of the Council. Overregulation and contradictory rules have resulted in a low level of acceptance of the CFP.

In a second study (Froese and Proelß, 2010), the researchers evaluated whether Europe would be able to meet the political commitment given at the Development Summit in Johannesburg in 2002, to rebuild its fish stocks latest by 2015. The analysis showed that, if current fishing pressure continues, 91% of the European stocks will remain below target. If European ministers in charge of fisheries were serious about meeting their obligations, they would have to reduce drastically fishing pressure and halt fishing completely on some stocks. But even if all fishing were halted in 2010, 22% of the stocks were so depleted that they cannot be rebuilt by 2015. The study showed that under a business-as-usual scenario, Europe will miss the 2015 deadline by more than 30 years.

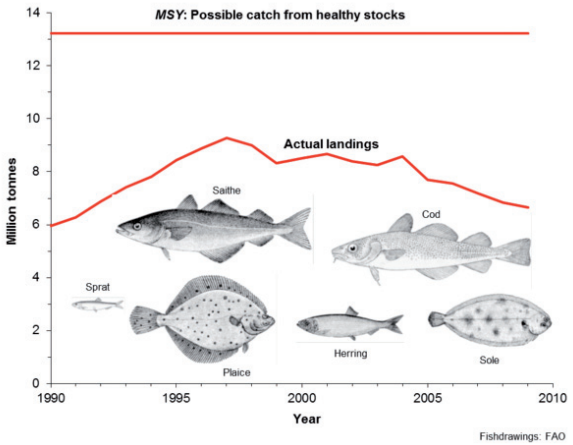

Figure 1: Potential long-term catch and actual landings for 56 major European fish stocks.

In a third study (Froese et al., 2010), the Kiel researchers teamed up with colleagues from Australia and the USA to design harvest control rules for European fisheries that are economically sound, compliant with international fishery agreements, based on relevant international experiences, supportive of ecosystem-based fisheries management and compatible with the biology of the European fish stocks. They showed that the proposed rules would have prevented the collapse of

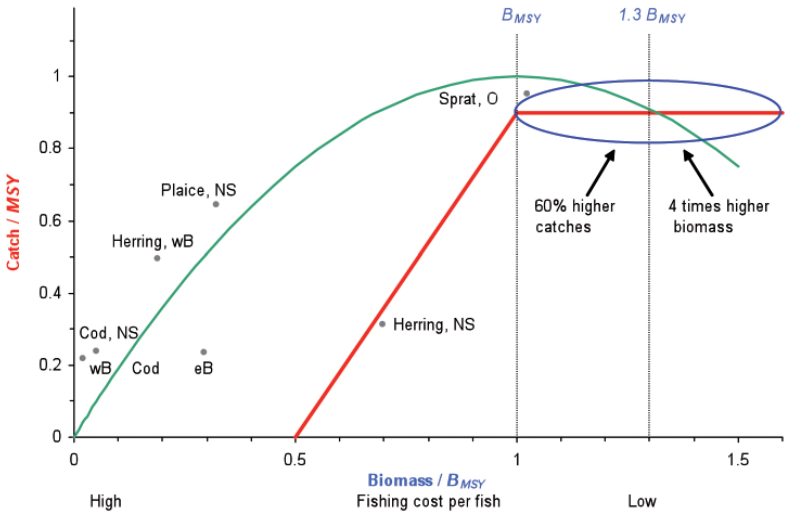

Figure 2: Proposed harvest control rules for European fisheries (red line), stabilizing stock sizes and catches in an area (blue ellipse) where stock biomass will be four times larger and catches 60% higher than currently. The green parabola indicates the generalized relationship between catches and biomass. Stocks above that line will shrink, stocks below that line will grow. NS = North Sea, wB = western Baltic, eB = eastern Baltic.

the North Sea herring in the 1970s and that they could deal with strong cyclic variations in recruitment such as known for blue whiting. Compared to the current CFP system, these rules would lead to higher long-term catches from larger stocks at lower cost and with less adverse environmental impact.

The proposed harvest control rules are shown in Figure 2. They would stabilize stocks at large sizes, 30% above the internationally agreed reference point Bmsy. This is meant to account for uncertainty in stock assessments and for natural fluctuations in stock size. Also, at this stock size, fishing cost per fish are minimized and profits of the fisheries are maximized, i.e., this is the area of maximum economic yield. Stocks would be on average four-fold larger than now and catches could be increased by about 60%.

The proposed harvest control rules are in stark contrast to an alternative plan considered by the European Commission (ICES, 2010). That plan allows continued fishing on depleted stocks and catches beyond the maximum sustainable yield (MSY). Uncertainty, natural fluctuations or economic optimisation have not been considered. If that plan is adopted, the continuing failure of the Common Fisheries Policy is likely.

The outcomes of these studies were presented to decision makers and stakeholders, including an informal dinner presentation to members of the European Commission, a breakfast meeting with WWF Brussels, a cocktail briefing at the European Parliament, a 'Kamin Abend' in Berlin with members of the German Ministry of Agriculture, a meeting with Fisheries Permanent Representatives in Brussels, an invited presentation at the World Trade Organization in Geneva, a keynote at the BSH Meeresumwelt-Symposium, and a presentation at the Forum Bestandserhaltende Fischerei in Hamburg.

The public was informed through numerous interviews, including dedicated articles in leading news papers and also in Nature News. A Deutsche Welle TV interview was translated into many languages and even made it into YouTube. There were several podium discussions, e.g. at the ATLANTIS Film Festival in Wiesbaden, the OCEAN 2012 event in Hamburg, the End of the Line launch in Frankfurt, and the Global Economic Symposium in Plön, Germany. We hope that these efforts will succeed in shaping the future Common Fisheries Policy and contribute to the rebuilding of European fish stocks and the ecosystems that support them.

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Submarine landslides off NW-Africa: How dangerous are they?

Sebastian Krastel, Dynamics of the Ocean Floor - Marine Geodynamics

The passive NW-African continental margin is characterized by several very large but infrequent landslides. Most of these landslides occurred during periods of low or rising sea level. Hence, the probability of future large-scale slope failures during the current sea level high stand is generally considered to be low. This interpretation is challenged by new observations during a recent research cruise to the Sahara Slide.

Submarine landslides are the dominant process for sediment transport from the continental shelf to the deep ocean. Sand-rich gravity flow deposits form many of the World's largest oil and gas reservoirs, while mud-rich deposits may sequester globally significant volumes of organic carbon. Landslides and sediment gravity flows are also a significant geohazard to seafloor infrastructure. In some cases, submarine landslides have generated tsunamis that have caused widespread damage to coastal communities.
The passive continental margin off Northwest Africa is characterized by low sediment supply by rivers, even during glacial times, but high primary productivity caused by oceanic upwelling results in relatively high sedimentation rates. The margin shows several large-scale but infrequent landslides and numerous canyon/channel systems (Fig. 1, Krastel et al., 2011). The four major slides (excluding landslides around the Canary Islands) are Dakar Slide, Mauritania Slide, Cap Blanc Slide, and Sahara Slide from south to north. These slides show run-out distances up to 900 km and volumes of up to 600 km^3; they belong to the largest submarine landslides on continental margins worldwide.

It is important to assess the geohazard potential related to submarine mass wasting off Northwest Africa, especially as the area offshore Mauritania is a current focus for hydrocarbon exploration and production. Age data are available for most of the major slide events suggesting that all major slides occurred during periods of low or rising sea level. The uppermost slide unit of the Mauritania Slide, e.g., is dated at 10.5-10.9 ka (Henrich et al., 2008) at the end of Late Glacial sea-level rise. Direct linkage between sea level and slide occurrence is not well understood, but indirect effects include spatial variations in primary productivity and hence the maximum sedimentation rate (Georgiopoulou et al., 2010). As a consequence, the probability of future large-scale slope failures during the current high stand is generally considered to be low. This view is challenged by new observations made during Poseidon-Cruise P395 in spring 2010. Detailed maps of the upper headwall of the Sahara Slide (Fig. 2) reveal a complex morphology typical for a retrogressive slab-type failure, with multiple headwall incisions and several glide planes. Some areas are characterized by elongated blocks, which have not moved far, while other areas are characterized by quickly disintegrating sediment masses. Seismic data show older mass transport deposits and giant downslope striking mound-like features, which are aligned with the sidewalls. We suggest that migrating fluids along and on top of the mound-like features control the location of the failure.

The well-studied distal deposits of the Sahara Slide yield an age of 60 ka

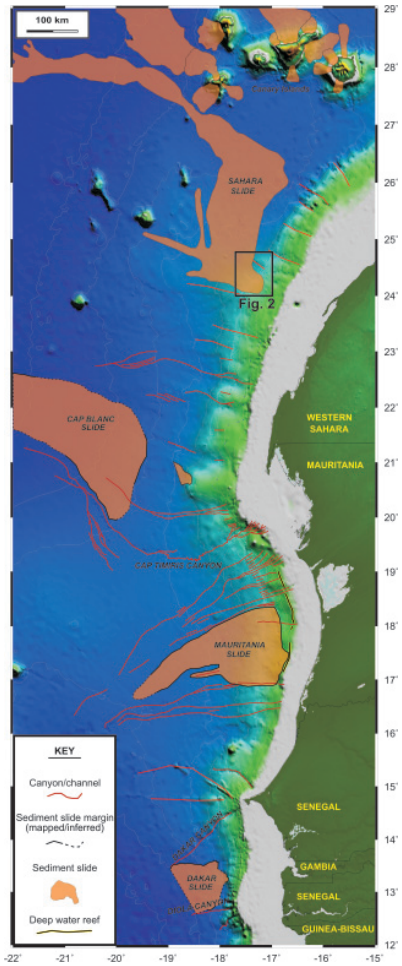

Figure 1: Map showing the distribution of seafloor features on the Northwest African continental margin.

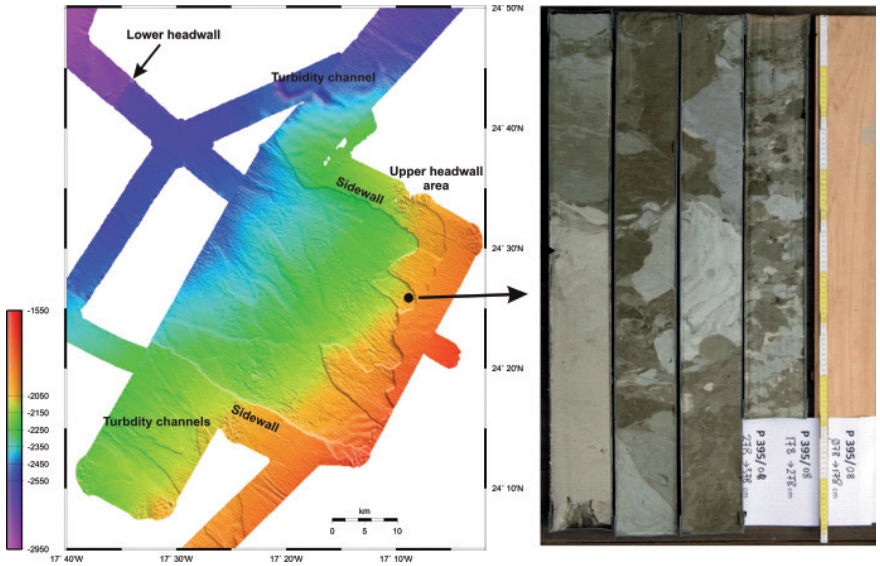

Figure 2: Left: Bathymetric map of the Sahara Slide headwall showing a complex morphology typical for a retrogressive slab-type failure. Right: Core taken immediately beneath the headwall showing a typical debrite. A hemipelagic drape of less than 5 cm indicates a late Holocene age of the debrite.

for the main slide event, which is a period of global sea level rise (Georgiopoulou et al, 2010). Several cores taken immediately beneath the headwall of the Sahara Slide, however, show pronounced slide deposits with a thin (< 5 cm) Holocene drape (Fig. 2). Using average sedimentation rates of 2 – 4 cm/ka in this area, we infer an age of 1 - 2 ka for the deposition of the mass transport deposits (Krastel et al., 2011). This event is most likely the largest submarine failure in historic times. Therefore, it questions a stable NW-African continental margin during the current sea level high stand. We are currently investigating whether this young age represents a major re-activation of an existing headwall or a major failure of undisturbed slope sediments.

The young age and large size of the Sahara slide immediately brings up the question of the tsunami potential of submarine landslides off NW-Africa. The principal tsunamigenic potential of submarine landslide is a matter of ongoing debate. Volume and initial acceleration are the most important parameters but other factors (e.g., flow dynamics, water depth, velocity, length, thickness) might be important as well. Especially initial acceleration and flow dynamics are very difficult to reconstruct based on geological and geophysical measurements alone. At least one slide off NW-Africa (Mauritania Slide) shows indications for a landslide-triggered tsunami. A turbidite containing shelf sands, deposited immediately above the slide deposits, might indicate mobilization of shelf sands by a tsunami.

Due to this uncertainty for landslide-generated tsunamis, one focus of our future work will be a more realistic assessment of the tsunami potential of submarine landslides. We started to employ an integrated model that combines the simulation of landslides and related tsunamis, and compare model results to measured slide geometries. If a specific model run produces a terminal slide geometry that is similar to the observed slide geometry, we assume that we selected realistic parameters for the slide, which then in turn allows assessing the height of the associated tsunami. In addition, the young age of the Sahara Slide calls for a re-assessment of the risk potential of NW-African and other passive margin.

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Birth and evolution of seamounts in the Cape Verde archipelago

Thor H. Hansteen and M80/3 shipboard scientific party, Magmatic and Hydrothermal Systems - Dynamics of the Ocean Floor

Tens of thousands of submarine volcanoes, so-called seamounts, with heights of more than a few hundred meters, exist in the world ocean. The Cape Verde archipelago is of volcanic origin and includes several prominent seamounts, which can give important information on the origin of submarine intraplate volcanism.

The Cape Verde island group is centered on the largest bathymetric swell in the Atlantic Ocean, thought to result from the interaction between the near-stationary Cape Verde Mantle Plume and the African tectonic plate (Courtney and White, 1986). There is a clear age progression of both subaerial and submarine volcanism, with volcano ages of several million years in the east and active (ongoing) volcanism in the southwest and northwest (Holm et al., 2008) (Fig. 1). Thus the oldest islands in the east include Sal, Boa Vista and Maio, and the active island volcanoes in the west are Fogo and Santo Antao.

During the the RV Meteor M80/3 cruise in 2010, we investigated the birth and evolution of seamounts at Cape Verde using bathymetric mapping and detailed sampling with the "ROV Kiel 6000". Prominent extinct and eroded submarine volcanoes in the east include Senghor Seamount, Boa Vista Seamount, Cabo Verde Seamount and Maio Seamount (Fig. 1). Active submarine volcanoes in the west include Cadamosto Seamount (Grevemeyer et al., 2010), Charles Darwin Seamounts, and the newly discovered Sodade Seamount. Young volcanism at Cape Verde occurs at water depths down to about 4000m, and comprises explosive volcanism and emplacement of massive lava flows. The volcanic areas show a very high biodiversity at all depths.

Charles Darwin Seamounts and Sodade Seamount have considerable morphological similarities, as they comprise several volcanic cones covering a roughly circular area on the sea floor (Figs. 2, 3). Both are geologically young, seen morphologically from the several eruption centers that have not yet merged to form a single, large seamount. There is, however, a major difference between the two areas. The most prominent peak at Sodade Seamount is a ca. 1300 m high ridge structure consisting of pillow lavas, suggesting outflow of submarine lavas along a dominant rift zone as the main growth mechanism. Charles Darwin Seamounts, on the other hand, comprises two large craters with a diameter of about 1 km each, formed by explosive volcanic activity at about 3500 m depth (Fig. 3).

Cadamosto Seamount (Fig. 1) is a large mountain, rising from about 4000 m to

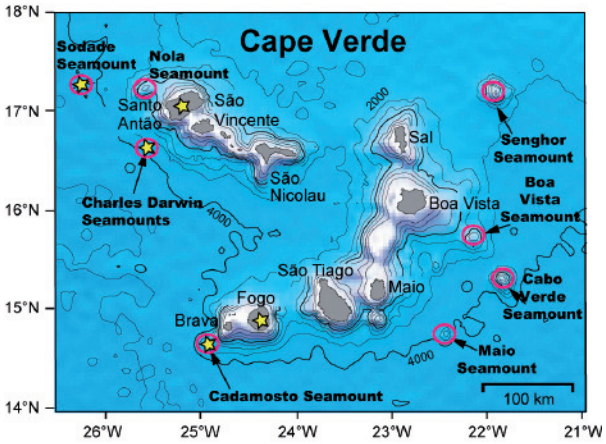

Figure 1: Location of islands and prominent seamounts at Cape Verde. Active volcanoes are marked with a yellow star.

1400 m below sea level. It has a rather unusual phonolitic compostion, suggesting that the magmas responsible for its formation evolved in large magma chambers in the crust. Volcanics from the large explosive Cao Grande eruption on Santo Antao have a very similar chemical composition (Mortensen et al., 2009), indicating that Cadamosto also has a potential for violent eruptions. It is the seismically most active seamount at Cape Verde, and may grow to become the next Cape Verde island (which can take roughly 100.000 years).

The observed age progression at Cape Verde has important geodynamical consequences. First, there is simultaneous magmatic activity in the northern and southern island chains,

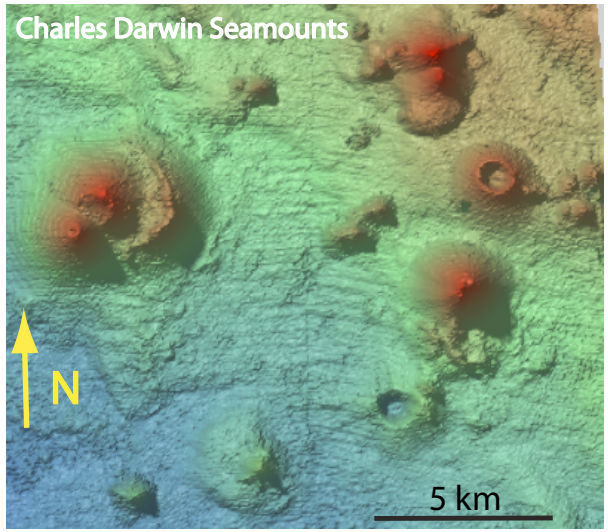

Figure 2: The Charles Darwin Seamounts at about 3500 m water depth off Cape Verde. The two large crater structures in the right half on the picture originated from explosive volcanism at such depths.

reflecting two separate regions of melt formation in the underlying mantle. Second, the general westward age progression is superimposed by a periodic rejuvenation of activity on the eastern rim of the melting region beneath each chain (Fig. 1). Within the southern chain, Fogo Island and Cadamosto Seamount are both active, while Brava Island, located between the two, is less active. In the north, Santo Antao Island, Charles Darwin Seamounts and Sodade Seamount are active, while Nola Seamount, which is located between the three, is extinct or dormant. This scenario may indicate the existence of a pulsating or heterogeneous mantle plume beneath Cape Verde.

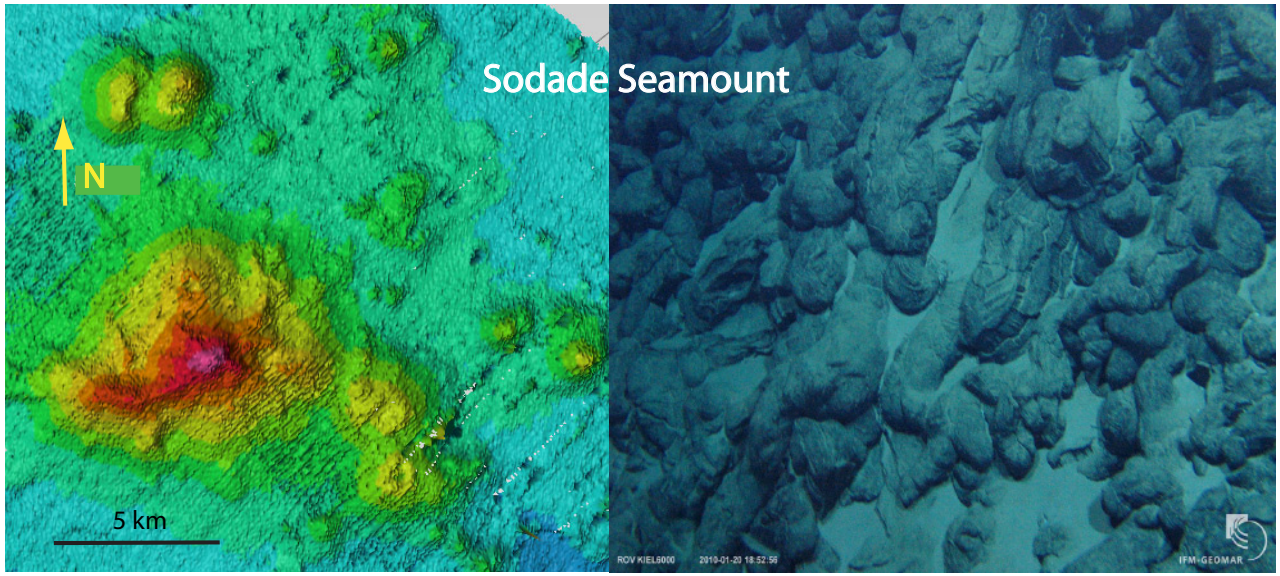

Figure 3: The newly discovered Sodade Seamount with its characteristic ridge structure. The right picture shows typical pillow lavas at Sodade (Picture taken with the "ROV KIEL 6000").

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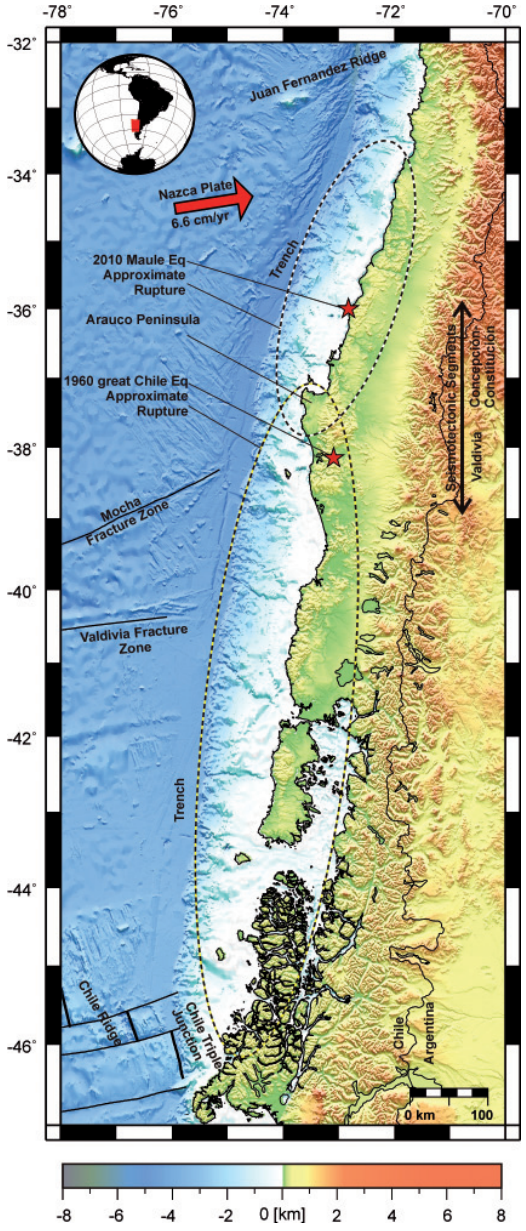
SFB 574: Volatiles and fluids in subduction zones – highlights from the last field campaign

Peter Linke, Marine Biogeochemistry – Marine Geosystems

The Collaborative Research Centre 574: Fluids and Volatiles in Subduction Zones has the overarching goal to understand the role and fate of volatiles and fluids in the entire subduction system. The SONNE cruise SO-210 was the last major expedition of the 12-year programme.

The expedition SO-210 (23.09.-1.11.2010, Valparaiso – Valparaiso) to the continental margin of Chile (ChiFlux) was the last cruise in the framework of the joint Collaborative Research Centre (SFB) 574. The overarching goal of SFB574 is to understand the role and fate of volatiles and fluids in the entire subduction system. Volatiles and fluids have a major influence on, e.g., short- and long-term climate change, the geochemical evolution of the hydrosphere and atmosphere, as well as subduction-related natural hazards, such as earthquakes, volcanic eruptions and tsunamis, because they are cycled through the entire subduction system. During the first six years of the SFB 574, our investigations concentrated on the erosive Central American subduction system (Sahling et al., 2008). One of the major results of the SFBs forearc investigations was the development of a new model for the hydrogeological system of an erosional convergent margin and the effect of forearc dewatering on earthquake activity in Central America (Ranero et al., 2008; Worzewski et al., 2010). The hydrogeological conditions at the entrance to the subduction zone determine the influx of volatile components into the system. Our on-land investigations at the volcanic arc have revealed how the output of volatiles into the atmosphere varies along the subduction zone as a function of input flux and geometry and dynamics of the subduction process (e.g., Sadofsky et al., 2008; Kutterolf et al., 2008).
To determine whether this model is also applicable to accretionary margins, and if not



Left: RV SONNE, Photo, B. Grundmann.

Right: Morphologic and tectonic features of Southern Central Chile between 33°S, where the Juan Fernandez Ridge is subducting and the Chile Triple Junction at 46°30'S. Epicentres and rupture areas of the 1960 and 2010 megathrust earthquakes are indicated. The rupture areas define the seismotectonic Valdivia and Concepción-Constitución segments that overlap at Arauco Peninsula.

Working area on RV SONNE. In the front the new "elevator lander" system, in the back the ROV Kiel 6000. Photo: B. Grundmann.

how it needs to be modified, is a major goal for the remainder of the SFB.

The Chilean margin, which switched from erosion to accretion within the last several million years, has been chosen for this study. The extensive work offshore Central America has shown that fluid venting - mainly occurring at mounds, along faults and at submarine land-slip scarps in the mid-slope area of the continental margin – is controlled by the dewatering of subducted sediments. Morphological, geochemical, biological, geophysical and volcanological investigations of the forearc of the Chilean subduction system between 33-37°S were the main focus of the SO-210 expedition to test the model of the subduction hydrogeological system.

Major goals of the expedition were: 1) to investigate the dewatering processes in the forearc of the central Chilean subduction zone, in particular the origin and output flux of vent fluids and volatiles, 2) to study biological processes fuelled by the discharge of fluids and volatiles (e.g. methane), 3) to use cold seep carbonates as a geochemical archive of cold seep activity, 4) to evaluate the role of forearc fluids in triggering mass wasting events that could generate tsunamis, 5) to characterize geochemically the subducting sediments, in order to determine the input flux of climate-relevant volatiles (CO_2, sulphur and halogens) and a variety of trace elements, necessary for determining the mass balance of chemical fluxes through the subduction system, and 6) to investigate the distribution of volcanic ashes to improve estimates on the volume of material emitted by volcanic eruptions and to date distinct events within the sedimentary sequence. An additional goal was to detect recent changes in the morphology of the sea floor and the discharge activity of fluids and gases that may have been caused by the earthquake on February 27, 2010, and the associated tsunami. Due to this multi disciplinary approach the deck and laboratories of RV SONNE were crowded with instrumentation like the ROV KIEL 6000, a gravity corer, CTDs, TV-grab, multicorer, a video sled and 4 landers, which can be deployed video-guided. This suite of instrumentation obtained the first comprehensive data set from fore-arc sediments off Chile which were presented in an international workshop in Pucón, Chile right after the cruise.

Integration of these results with parallel amphibious geophysical observations and analytical studies of the volcanic arc on land will allow us to compare the Chilean and Central American subduction systems in terms of their volatile and fluid cycling processes in order to achieve a better understanding of how subduction zones operate, what are their controlling processes and process rates, and how these pre-determine associated geohazards.

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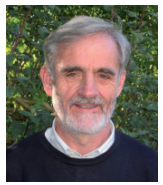

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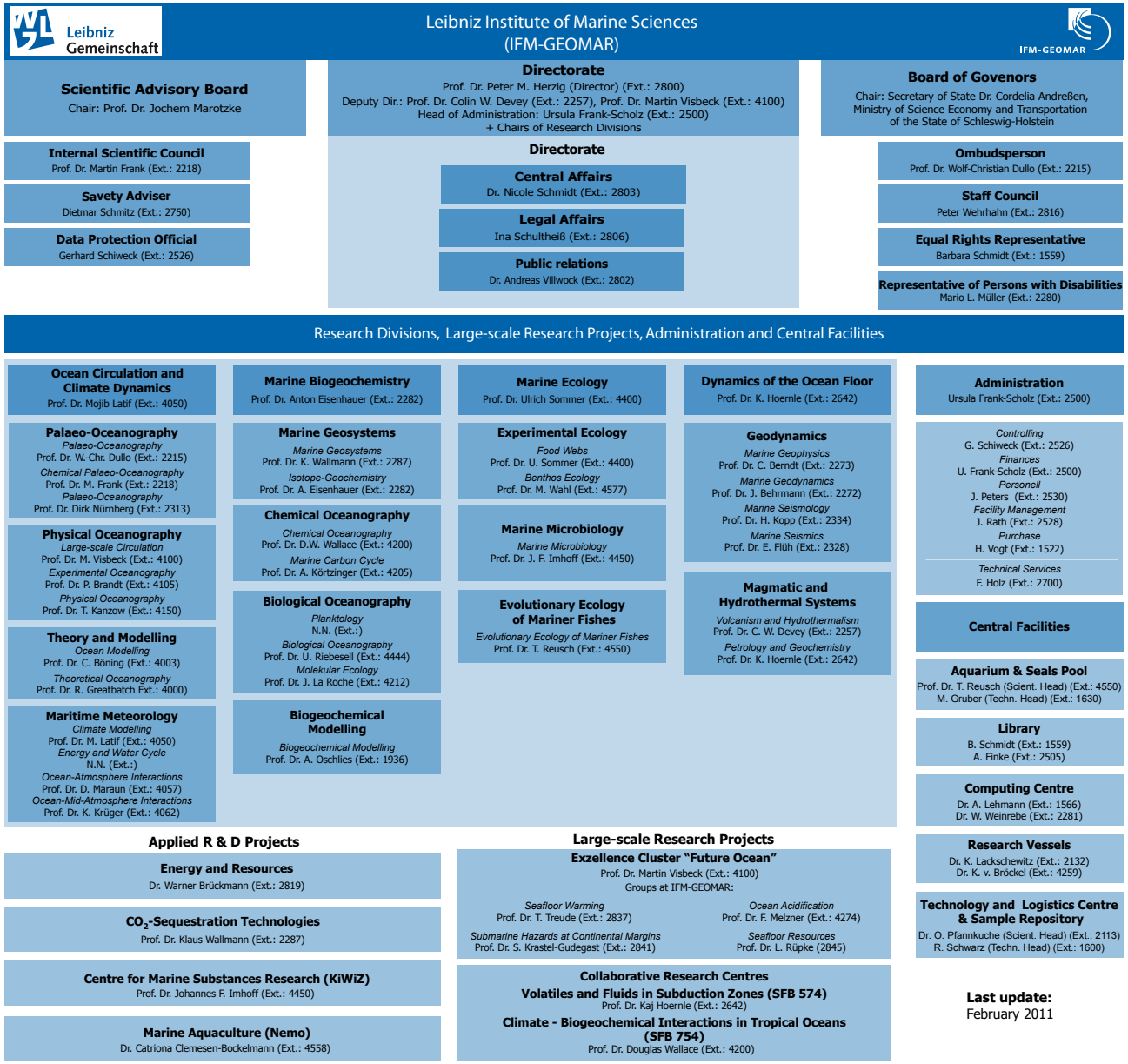
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