



future ocean
KIEL MARINE SCIENCES

Cluster of Excellence The Future Ocean

2nd Annual Report - 2007

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Cluster of Excellence
The Future Ocean

2nd Annual Report
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Content

| | |
|--|----|
| 0. Preface | 1 |
| 1. Introduction to the Cluster of Excellence | 2 |
| a. Overview and Goals | 2 |
| b. Structural Concept and Strategies | 2 |
| c. Scientific Concept and Strategy | 4 |
| d. Organization | 5 |
| e. Junior Research Groups | 7 |
| f. Funding Pathways | 8 |
| 2. Speaker's Report | 10 |
| 3. Impact on University Activities | 12 |
| a. Introduction | 12 |
| b. Defining a Profile | 12 |
| c. Management Improvements | 13 |
| d. Innovation in Education | 13 |
| 4. Central Services | 15 |
| a. Introduction | 15 |
| b. Office | 15 |
| c. Budget Report | 16 |
| d. Recruiting Junior Professors | 17 |
| e. Public Outreach | 18 |
| f. Integrated School of Ocean Sciences (ISOS) | 22 |
| g. Transfer to Application | 25 |
| 5. Research Themes and Platforms | 27 |
| a. Research Theme A: The Ocean in the Greenhouse World | 27 |
| b. Research Theme B: Marine Resources and Risks | 31 |
| c. Research Platforms | 36 |
| 6. Working Panels | 39 |
| a. Family and Employment | 39 |
| b. Quality Management | 40 |
| c. Data Management | 41 |
| Appendix | 42 |
| A. Research Theme A: Greenhouse Oceans | 42 |
| Research Topic A1: Ocean Acidification | 42 |
| Research Topic A2: Seafloor Warming | 47 |
| Research Topic A3: Oceanic CO ₂ Uptake | 49 |

| | |
|--|-----|
| Research Topic A4: Ocean Circulation and the Hydrological Cycle | 52 |
| Research Topic A5: CO ₂ Sequestration | 54 |
| Research Topic A6: Sea Surface Chemistry | 55 |
| Research Topic A7: Valuing the Ocean | 58 |
| B. Research Themes B: Resources and Risks | 60 |
| Research Topic B1: Living Resources and Overfishing | 60 |
| Research Topic B2: Marine Medicine: Interactions between Complex Barriers and Microbiota in the Ocean | 62 |
| Research Topic B3: Seafloor Resources | 66 |
| Research Topic B4: Submarine Hazards | 69 |
| Research Topic B5: Sea-Level Rise and Coasts at Risk | 73 |
| Research Topic B6: Law of the Sea and Marine Resources | 75 |
| C. Research Platforms | 79 |
| Research Platform P1: Numerical Simulation and Data Management | 79 |
| Research Platform P2: Isotope and Tracer Analysis | 81 |
| Research Platform P3: Molecular Technology | 89 |
| Research Platform P4: Ocean Observatories | 92 |
| D. Cluster Proposals in 2006 | 96 |
| E. Cluster Proposals in 2007 | 109 |
| F. References | 129 |
| G. Other Activities | 146 |

0. Preface

2007 was the first complete year for the Cluster of Excellence "The Future Ocean" after the successful launch in November 2006. In 2007 the activities focused on the achievement of the scientific and structural goals. New structures were established, and most of the fourteen scientific working groups and the cluster office started their work.

To improve research of the Cluster of Excellence, the research platforms were initially supported through a competitive proposal process for interdisciplinary projects. Twenty-nine projects were selected and funded for a maximum of two years. The first results of these projects are documented in the appendix of this report. To support marine science in Kiel the Cluster of Excellence encourages researchers to apply for initial "seed money" as a nucleus to start research projects subsequently funded by third parties. This funding pathway paved ground to submit a proposal for the Collaborative Research Centre (SFB) 754 "Climate- Biogeochemistry Interactions in the Tropical Ocean" to the German Science Foundation (DFG). The proposal was successful and a new SFB will start working in in Kiel in Summer 2008.

The administrative infrastructure of the Cluster of Excellence was established as well, and groups responsible for public outreach, financial administration, and Transfer to Application have been set up. Also in early 2007 the positions for the leaders of the Junior Research Groups were advertised. Most of the positions could be filled by Fall 2007. The first draft reports of these groups presenting their exciting new research topics are documented in this report. The Integrated School of Ocean Sciences (ISOS) began to offer structured training courses for graduates as a "virtual" graduate school.

The successful launch and the establishment of the main structures of the Cluster of Excellence within this short time frame was only possible through the remarkable joint initiative of the university and the participating institutions. Most of the truly innovative ideas could be brought to life by the extremely motivated proponents and members of the Cluster of Excellence, promoting marine sciences and related aspects not only to strictly marine disciplines, but also to economics, law or medicine. On top of that, our comrades from the Muthesius Academy of Fine Arts and Design visualized our ambitious project in an uniquely attractive way to the public through an extraordinary exhibition. We are hence looking forward to the next years of productive joint work with the Cluster of Excellence.

We hope you will enjoy reading our Annual Report 2007.



Klaus Wallmann
(Speaker 2006-Nov 2007)



Martin Visbeck
(Speaker since Nov 2007)

1. Introduction to the Cluster of Excellence

a. Overview and Goals

The ocean hosts our planet's largest ecosystem, helps regulate the composition of the atmosphere and global climate, and provides mankind with essential living and non-living resources. Coastal regions are home to the majority of the world's population and the open seas are key to global trade and security and a source of major natural hazards. In short, the global ocean is vital for human welfare now and in the future. But mankind is altering the oceans in both direct and indirect ways and on a global scale. The alteration started with fishing which has already drastically changed the global marine ecosystem. Human impact now extends from regional changes, such as alteration of coastal and deep sea habitats, to global scale impact on marine life, ocean circulation and carbon cycling through emission of CO₂ and other pollutants. The motivation for the Cluster of Excellence "Future Ocean" is the recognition of mankind's increasing dependency on the ocean in the context of our increasing power to alter it. These two factors imply a need to understand our environment in order to be able to predict and manage. They also imply a need to educate, in order to make the next generation aware of the need for responsible and sustainable use of the ocean and ensure it is prepared to adapt to the changes that we have already set in motion.

The Cluster of Excellence "Future Ocean" at the Christian-Albrechts-University in Kiel (CAU) has four major goals:

- 1) Improve our understanding of ocean changes in response to human activities;
- 2) Provide the scientific basis to develop, implement and assess sound global and regional ocean management options;
- 3) Build our capacity to reliably predict the risks associated with ocean change and natural hazards;
- 4) Explore new marine resources and develop strategies for their sustainable use.

This is achieved by a multidisciplinary research strategy on the pathways, impacts and feedbacks of ocean change and their interaction with society in terms of ocean resources, services and risks.

b. Structural Concept and Strategies

Rather than forming a separate research unit, the Cluster of Excellence is fully integrated into the university and functions as a virtual institute to strengthen multidisciplinary cooperation between several university faculties and research institutes of CAU and the participating institutions, the Leibniz Institute of Marine Sciences IFM-GEOMAR, the Institute for the World Economy (IfW), and the Muthesius School of Fine Arts. It augments, focuses and enhances marine-oriented research and education in Schleswig-Holstein and provides additional interfaces to the general public, stakeholders, non-governmental and scientific organizations as well as marine-oriented industry. A strategic instrument of the Cluster of Excellence is the establishment of dedicated Junior Research Groups (JRGs) in key interdisciplinary research areas (A1 - B6 in Fig. 1-1).

The JRGs augment the expertise provided by the well established research groups of the proponents. The group leaders are endowed with tenure-track positions which will be transferred to permanent positions (W2/W3) based on a review of merit. The Cluster of Excellence

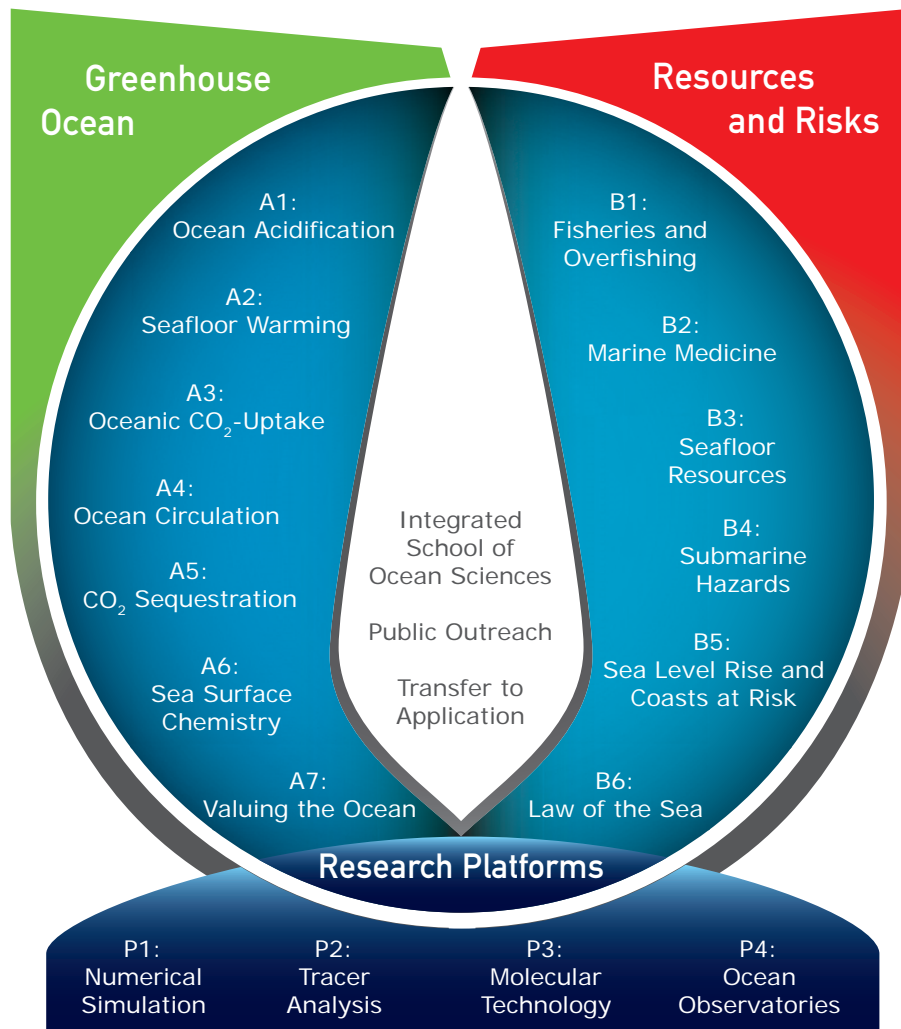


Figure 1-1. Structure of the Cluster of Excellence "Future Ocean" consisting of the research themes Greenhouse Ocean (A, green) and Resources and Risks (B, red), central services (white) and the infrastructure platforms (P, dark blue).

provides the JRGs with resources and personnel as well as scientific support through the established research groups of the proponents. The commitment of CAU and the IFM-GEOMAR to offer permanent faculty positions to up to nine of the new junior professors ensures a long term strategic impact on the fabric of the university.

Four general strategies are followed at CAU for its structural development:

- 1) concentration of the university's infrastructure resources into strategic centers;
- 2) development of a concept to establish new JRGs at the interface between and at the forefront of existing research fields;
- 3) development of a graduate program for PhD

candidates from all disciplines represented in the Cluster and of curricula with a wide disciplinary scope;

- 4) identification and support of multidisciplinary research themes through university funds to overcome the traditional boundaries between the faculties and to sharpen the University's scientific profile.

The Cluster of Excellence acts as a pilot project to implement these new structures and is, hence, fully consistent with strategic planning at CAU.

The multidisciplinary approach of the Cluster of Excellence "Future Ocean" is complemented by an integrated educational program that is run by the Integrated School of Ocean Sciences (ISOS).

Core Elements of the programme are

- 1) development and implementation of a multi-disciplinary PhD programme,
- 2) establishing a web-based e-learning platform for ocean sciences at the CAU
- 3) initiating and coordinating cooperation at the graduate level with national and international partners

The integration of six faculties of the CAU within the Cluster presents a challenging opportunity and the marine focus sharpens the educational profile of the University nationally and internationally. The ISOS provides an intellectually stimulating forum for exchange of ideas, information and educational services between the Cluster of Excellence, CAU faculties, partners in the maritime industry, and policy-making bodies.

The Cluster of Excellence "Future Ocean" communicates with the broader scientific community, the general public and the political and economic audience through exhibitions designed by the Muthesius Academy of Fine Arts, Future Ocean conferences, workshops and other public outreach activities. It is planned to present the exhibitions and additional scientific contents to the general public through the marine-oriented Kiel Science Center, projected to open in 2011. The Cluster of Excellence "Future Ocean" cooperates closely with the "Maritime Cluster Schleswig-Holstein", a network of over 1700 companies representing all branches of the maritime industry (www.maritimes-cluster.de), and additional partners to promote on-going, and develop new technology transfer activities related to marine genetic resources, gas hydrates, CO₂ sequestration, and the use of other marine resources.

c. Scientific Concept and Strategy

The mission of the Cluster of Excellence is, to address the future ocean in its entirety with respect to climate, ecosystems, resources and hazards. To achieve this, the scientific structure has been designed as two major research themes, subdivided into research topics (Fig. 1-1). These themes are supported by several platforms, installations of infrastructure which is in principle open for use by any scientific member of the Cluster of Excellence.

The research themes are titled Theme A "The Ocean in the Greenhouse World" and Theme B "Marine Resources and Risks". Both themes document the forward oriented view of the research, aiming to predict and advise rather than to document and explain what has happened. This notion is also intended to be the glue between the projects as predictions require a completely different view of the earth, than documenting the current or historic state.

To improve interdisciplinary research the Cluster of Excellence has established four overarching research platforms to provide infrastructure and resources for all scientists within the Cluster (Fig. 1-1). They offer a wide range of high-end instrumentation which was mostly acquired over the past few years. Many aspects of Cluster research require access to high performance computing facilities, and modern numerical techniques. Hence, numerical expertise and support are offered by a network connecting the recently established Interdisciplinary Center for Numerical Simulation, the Seismic Processing Center and the ocean and climate modeling groups with the Computing Centers at Kiel (P1). Research into the ocean conditions of the past and its important role in guiding our understanding of the future

ocean requires highly specialized and accurate isotope and trace metal analysis, both currently performed at Kiel. High-end instruments and advanced techniques are integrated to establish the new virtual Tracer Analysis Center (Platform P2) which offers a comprehensive analytical support for the Cluster of Excellence. Improved understanding of human diseases by the study of marine organisms and mechanistic studies of pH-sensitive processes in plankton at the molecular level will benefit from the recently established Center for Molecular Bioscience (ZMB). ZMB provides unique expertise in molecular bioscience and access to high throughput molecular techniques (Platform P3). *In-situ* observations of current conditions and on-going trends in the ocean require an array of specialized oceanographic sampling and observing platforms. The Technology and Logistics Center for Ocean Observations at Kiel serves as the ideal nucleus for a new platform offering cutting edge technology to explore the ocean over space and time and in remote regions from the oceanic crust to the

air-sea interface (Platform P4). The novel platforms set up in the Cluster of Excellence allow for a more efficient use of resources and will be developed further and strengthened according to the needs of the project.

d. Organization

A number of organizational bodies have been established in the Cluster of Excellence (Fig. 1-2) to ensure

- 1) effective cooperation between CAU, IFM-GEOMAR, IfW and the Muthesius Academy of Fine Arts in all Cluster-related activities;
- 2) influence on University policy-making towards strengthening ocean-related research;
- 3) the efficient exchange of information between the Cluster members;
- 4) the coordination of internal and external reporting, and planning activities;
- 5) an efficient monitoring system for research output;

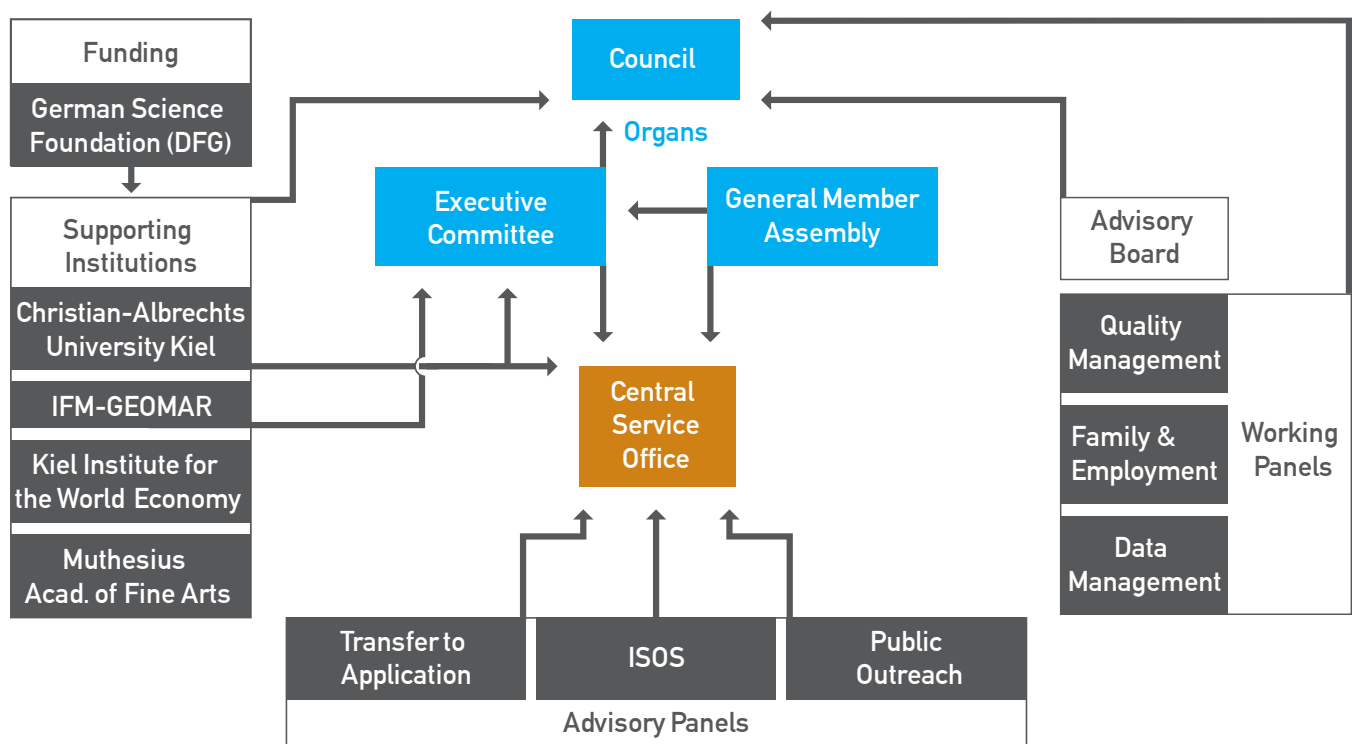


Figure 1-2. Organization schema of the Cluster of Excellence.

- 6) an appropriate budget allocation system based on research success;
- 7) effective communication with external organizations;
- 8) the transfer of newly acquired knowledge for its application outside the Cluster of Excellence;
- 9) public awareness for the "Future Ocean" themes;
- 10) multidisciplinary educational offers for graduate students.

The Cluster's Executive Committee is responsible for the overall management of the Cluster of Excellence and is accountable to the Cluster Council and the General Assembly. It consists of the Chair, the Vice Chair, the two speakers of the research platforms and two representatives from the research themes A and B. The chair and the other representatives are elected by the members of the Cluster of Excellence during the annual General Assembly. Additional members of the Executive Committee are the speaker of the JRGs, the speaker of the Integrated School of Ocean Sciences' advisory board, the President of the CAU, the Director of IFM-GEOMAR, the President of the Muthesius Academy of Fine Arts and one representative from regional maritime business. The Chair acts as intermediary to the DFG, CAU, IFM-GEOMAR and IfW and is authorized to execute project management. He is supported by a Vice-Chair. The central service office provides necessary support for project management and monitoring activities. It also supports the public outreach and technology transfer activities and the Integrated School of Ocean Sciences (ISOS). The Chair, together with the central service office, will be responsible to assure that each party undertakes all reasonable endeavors to perform and fulfill, promptly, actively and on time, all of its obligations to the Cluster of Excellence. The

central service office is particularly responsible for linking the activities and communicating the needs of the Cluster of Excellence to the University and the participating institutions. It is based at the Division of Research and Technology Transfer at CAU to assure proper interrelations with the university. The central service office provides project management in relation to the activities of the Cluster of Excellence's bodies on scientific, financial and dissemination issues, as applicable. It reviews and proposes budget transfers and the annual implementation plan to the Executive Committee. The Council of the Cluster of Excellence gives advice to the Executive Committee on all strategic decisions, such as scientific priorities, yearly budget planning and monitoring criteria. The Council comprises the two leading proponents of each research topic and research platform, the leader of each JRG, the Presidents of CAU and Muthesius Academy of Fine Arts, the Directors of IFM-GEOMAR and IfW, as well as the Chair and Vice-Chair of the Executive Committee. The General Assembly of all members decides on the admission of new members to the Cluster of Excellence and the exclusion of members. It also elects the Chair, the Vice-Chair and other members of the Executive Committee. An external Advisory Board acts as an independent quality-control and advice body to evaluate the progress of the Project. It consists of ten leading scientists, both national and international, reflecting expertise of all Cluster-relevant research fields. Additional members are appointed to evaluate the Cluster's outreach to the general public, stake-holders and industries.

It is anticipated that the Cluster will evolve in four phases. Accordingly, the main focus of Cluster activities will shift from (A) an initial networking phase to (B) a scientific output phase, to (C) an increase in external funding phase, and to (D) a

final structural consolidation phase. This implies, that during the initial phase greater emphasis is placed on indicators related to success in achieving structural goals (implementation of new research groups, networking, interdisciplinary approaches), whereas pertinent scientific measures (publications, impact factors, Master's and doctoral theses, fund acquisition, transfer to application) will grow in importance with time. Annual reports are provided by the central service office and the Executive Committee and are presented to the Council, the General Assembly, the Advisory Board and the DFG.

e. Junior Research Groups

A strategic instrument of the Cluster of Excellence is the establishment of JRGs in key interdisciplinary research areas. These JRGs augment the expertise provided by the well-established research groups of the proponents. The positions of the group leaders are endowed with tenure-track positions and thus have the option of being converted to permanent positions (W2/W3) based on a review of merit. The Cluster of Excellence provides the JRGs with resources and personnel as well as scientific support through the established research groups of the proponents. The JRG leaders are members of the Cluster of Excellence and the Council. The JRG speaker and an alternate are elected by the JRG leaders for a yearly term and are members of the Executive Committee. All JRG leaders are eligible to apply for resources and address the emerging new research topics of the "Future Ocean" as identified in the proposal or added by the Council. About 50 % of the total funding of the Cluster of Excellence is used to set up the new JRGs. The scientific progress of the JRGs is presented during an annual symposium organized by the Cluster of Excellence, as well as during a visit of the advisory committee.

Thirteen JRGs are currently established at ten different institutes at CAU and at the Leibniz Institute of Marine Sciences (Table 4-1, page 17). Positions were openly announced as W1 or W2 professorships and endowed with a true tenure track option, both novelties in the university recruitment scheme. The positions were moreover endowed with exceptional funding for additional personnel and research equipment to allow the new professors to quickly set up functional research groups.

The CAU will provide seven faculty positions augmented by two additional professor positions at IFM-GEOMAR that will be offered to successful JRG leaders by the end of the first Cluster funding period. The commitment of CAU to establish additional permanent faculty positions in key research areas implies that the Cluster of Excellence will have a long-term strategic impact on the fabric of the university.

In 2010, each JRG leader will be evaluated by an appointments committee set-up by the corresponding faculty at CAU. Scientific members of the committees are the dean of the faculty, the proponents of the respective JRG, a representative of the Cluster's Executive Committee and additional faculty members. The JRG leaders will be evaluated by external reviewers appointed by the committee and by members of the Cluster's Advisory Board. Based on these external reviews, the committee will either approve or not recommend the appointment of the JRG leader as a permanent faculty member. The decision of the appointments committee will be presented to the Faculty Convention. Based on the advice given by the committee and the Faculty Convention, the CAU Senate will appoint the new faculty members.

f. Funding Pathways

About 50% of the total Cluster funding is distributed among Cluster members through an internal proposal system. The whole institutional working group of each member of the Cluster of Excellence is eligible to apply for funding. The individual funding schemes implemented fall into six categories:

- research projects
- scientific infrastructure
- seed money
- conferences and workshops
- visiting scientists
- travel support

Research Projects

The Cluster of Excellence provides grants for projects with clearly defined topics related to the project's research themes. Assessment criteria for the review process are: (1) Scientific significance with regard to the major themes; (2) Contribution to networking within the Cluster; (3) Multi-disciplinary approach; (4) Clear working hypotheses and reasonable limitation of the topic; (5) Originality; (6) Quality of previous work. Proposals submitted to the central service office are subject to internal and external review before they are either approved or rejected.

Development of Scientific Infrastructure

The Cluster provides grants to strengthen the scientific infrastructure through investments and technical personnel. Proposals are compiled by the central service office and sent to the corresponding Platforms P1-P4 (see Fig. 1-1). Based on the recommendation of the platform, and the Council the final allocation of resources is decided.

Seed Money

The Cluster provides seed money to attract further third-party funding to Kiel. Requests for seed money can be submitted to the Cluster Office at any time. Cluster scientists planning to submit a large scale proposal related to the research themes of the Cluster are allowed to request funds to cover printing costs, technical support, and other costs arising during the development of a new proposal. The new projects should be coordinated at Kiel and should have a minimum financial volume of 500.000 EUR.

Conferences, Workshops and Symposia

Conferences and other scientific meetings organized by members and furthering the aims of the Cluster of Excellence can be co-financed through application for funding at the Integrated School of Ocean Sciences (ISOS). Calls for proposals requesting funding for scientific meetings are published four times a year by the Integrated School of Ocean Sciences (ISOS).

Visiting Scientists

The Cluster of Excellence provides funding to cluster members to invite scientific experts working in cluster-related fields. Visiting scientists stay for periods of several days to months. Proposals for visiting scientists are handled by the ISOS. It is expected that each guest will hold a lecture /seminar etc. which is advertised to ISOS PhD candidates. In 2007, xxx visiting scientists were funded through the Cluster.

Travel Support

The Cluster provides funding for PhD students and Postdocs to present their scientific results at national and international workshops,

symposia and conferences. PhD students who are members of the ISOS and Postdocs who are part of a member's working group or work for projects funded by the Cluster of Excellence are eligible to apply for travel support. Requests for travel support can be submitted to the ISOS at any time and are evaluated and approved by the ISOS steering committee.

Information about the allocation of funds during 2007 are given in chapter 4.c, Budget Report.

2. Speaker's Report

2007 was the first complete year for the Cluster of Excellence "The Future Ocean". To implement and establish the declared scientific and structural goals of the Cluster of Excellence was among the main challenges. First of all, many new structures had to be developed and scientific working groups and the cluster office had to be set up.

Terms of reference were prepared to structure the work and responsibility among bodies of the project, in which scientists from the University of Kiel, Leibniz Institute of Marine Sciences, Kiel Institute of the World Economy, and Muthesius Academy of Fine Arts and Design cooperate. The established bodies of the Cluster of Excellence are: Steering Committee, Council, General Assembly and Advisory Board (see Fig. 1-2, page 5). Draft contracts were compiled to regulate cooperation between the university and the partner institutions. In these contracts positions essential for the cluster were already identified. These core professorships secure the long-term scientific expertise in the cluster. For sustainability of the topics, the cluster of excellence will be involved in search committees for vacant professorships in these fields.

In September 2007 the first meeting of the Advisory Board took place. Members of the Advisory Board are fourteen scientists with expertise in various scientific fields of the cluster. In their first meeting the Advisory Board reviewed the scientific goals of the cluster and provided advice for an effective implementation. Some board members attended the following annual retreat. In November 2007 the General Assembly elected a new Steering Committee and honored the work of the first Steering Committee.

One of the main strategic tasks of the cluster in 2007 was the filling of the Junior Research Group leader positions. They were broadly advertised in national and international journals. The positions attracted several strong candidates, which were invited to give presentations on their intentions and visions for the Cluster of Excellence. Many promising ideas were presented, and hence most positions could be filled in 2007. A major constraint for the staffing of some positions was, that the general condition of the Federal Excellence Initiative didn't offer clear regulations for true tenure track positions. The appointed tenure track professors therefore demanded clear criteria and an open decision process on which temporary positions will be promoted to permanent positions. These criteria will be finalized in 2008 together with the JRG leaders.

For support of the research groups and scientists in the Cluster of Excellence a central service office was established (see chapter 4 of this report). All office positions were filled in 2007. The office coordinates all activities in public outreach, transfer to application and the Integrated School of Ocean Sciences (ISOS). ISOS started the program for graduate students in October 2007, drawing mainly on lectures by the JRG leaders as well as invited scientists. ISOS faced several challenges during its initial phase. During the startup phase lecture rooms could not be provided exclusively for ISOS. The question whether ISOS classes count against teaching obligations for professors was discussed as well.

The Executive Committee of the Cluster of Excellence pays special attention to the central office's Publication and Outreach activities, as it feels that public visibility and identification with the themes of the Cluster of Excellence are key to the strategic success of the project. To promote this

the Muthesius Academy of Fine Arts developed a new corporate design coordinated by the public outreach section of the central service office. In addition a number of promotion items like flyers, pencils, t-shirts and others were produced. An exhibition developed by the Muthesius Academy of Fine Arts and the Cluster of Excellence was an overwhelming success in 2007. The exhibition, as a whole or in modules, was presented at various occasions throughout the year. At the end of the year a concept for a permanent exhibition in the International Maritime Museum Hamburg was prepared.

To enhance research in the Cluster of Excellence the four research platforms were supported and a competition for interdisciplinary projects in the cluster was initiated in 2007. A total of twenty-nine interdisciplinary projects were selected for funding. Their documentation fills up most of the pages of this report. In 2008 all Junior Research Group leaders will establish their group and start their research work. The 2008 report will thus be enriched by the results of the Junior Research Groups.

3. Impact on University Activities

a. Introduction

The Cluster of Excellence "Future Ocean" is a major pilot project aiming to develop the currently very broadly organized university Kiel into a foci driven research university covering a broad range of scientific disciplines. During the development of the Cluster of Excellence four major venues to contribute to the establishment of a modern university in Schleswig-Holstein were outlined:

- **Interdisciplinary research:** the development process of the Cluster of Excellence boosted discussions between different disciplines and generated many fruitful initiatives. New fields for the university were opened, which were based mainly on the excellent opportunities for interdisciplinary research. The idea to fill gaps in a scientific field through Junior Research Groups (JRGs) establishing a tenure-track system was another idea that was tasked onto the cluster during its initial phase.
- **University - Institutional relationships:** the cluster generation process led to intense discussions between the university and its partner institutions in the region. These resulted in a much more focused definition of interests and understanding among the university and its partners.
- **Management tools:** the idea to set up new management tools, was governed by the requirement to be attractive as a university for the most innovative high-profiled scientists and the and the urgent need to speed up decision processes while keeping the basic democratic concepts established at the university.
- **Doctoral education:** The cluster is a major

player in the university process of developing an overall concept in doctoral education.

All these processes started during the planning phase of the Cluster of Excellence and were hardly challenged during the implementation phase.

b. Defining a Profile

From the beginning, the process of thematic consolidation at the university benefited from the successful example of the cluster of excellence. But - it also produced a lot of concern, whether this could negatively influence other fields. The success of two other proposals which are funded through the the German Excellence Initiative and two collaborative research centres funded by the German Science Foundation (DFG), Christian-Albrechts University Kiel (CAU) showed that other topics are also suited for this concept. The search within the scientific community in Schleswig-Holstein for scientists with matching interests fostered open discussions to identify common goals and apply for central support to achieve these goals (financially as well as management wise). This led to a process, opening new opportunities for development within the university through the inclusion of criteria of scientific excellence. Furthermore it could be shown that the university benefits from cooperations with partners in order to create critical masses, which might lead to problems in the longer run. As an example the idea to set up an Institute of Coastal Research at CAU in cooperation with Alfred Wegener Institute (AWI), Bremerhaven and GKSS Research Centre, Geesthacht was born during the re-evaluation of key competences among IFM-GEOMAR and CAU in marine sciences. As a strategic measure of the Cluster of Excellence, the placement of the marine science orientated JRGs within various institutes and faculties of the

university opened up exciting new opportunities to strengthen ocean-related research at CAU and tighten the profile of the university as a whole. We are sure that new ideas will emerge from this setup, but this is too early to judge now. This planning and discussion process may have been even more fruitful for the university itself, than the establishment of the Cluster of Excellence itself. The current integration of the JRG leaders into the faculty and institutional system is an ongoing but very successful process. The university recognizes the big success of the recruitment procedure, which was streamlined for rapid hire of group leaders. As another piece of the puzzle the recruitment workshop for all candidates improved the ties between the CAU and interviewers. Several Candidates took advantage of this workshop to brainstorm initial cooperations among each other, which can be taken as a measure for the open trustful spirit which was communicated throughout this process.

c. Improved Management

By setting up a Management Board involving officials from the university and IFM-GEOMAR, the Cluster of Excellence developed a periodical meeting schedule, allowing to discuss project related topics and to inform each other about strategic plans within each organization. By setting up a Science Commission within the university the CAU adopted this process to its overall research planning. Even more an annual meeting of this commission is planned, involving the heads of Research Institutions of the region for a strategic planning. The nomination process of the JRGs resulted in a deep problem driven cooperation of science and administration. It hence led to a better understanding of processes and interests of each partner. CAU uses the positive experience from these processes to

develop and establish similar procedures with other non-university research institutions.

The funds received by the Cluster of Excellence were not strictly bound to detailed cost tables, as it had been the case in the past, but could be managed in a very flexible way by the project itself. Hence, in order to make best use of the funding and to plan targets to reach the cluster goals, new decision and administration processes were required. These processes were developed at the central service office in cooperation with the management board and the university administration. Many of the decision making procedures assuring a fair level of funding of Cluster of Excellence projects worked quite well and will be incorporated in the regular processes of the university in the future. One very important process was the recruitment of JRG Leaders, which went significantly faster than usual. In addition the Cluster of Excellence proved very effective in targeting gender goals. As a consequence the university has decided to reorganize its recruitment process for professors. Many of the lessons learned through the recruitment process for the Cluster of Excellence are now under discussion to be implemented in the university as well. We have seen that the establishment of a Management Board for this Cluster of Excellence was a major factor to speed up the recruitment process. It is still important to implement ways to increase the influence of research demands and overall goals on the hiring process.

d. Innovations in Education

The Integrated School of Ocean Sciences (ISOS) has been an effective test-bed for development of a graduate platform extending over five faculties of the University. ISOS has thus been uniquely and ideally placed to develop and

improve structural concepts that are needed in the ongoing incentive to establish a center for graduate education at the University. Through close cooperation with other University Institutions such as the Center for Academic Further Education and the International Center, ISOS is exploiting synergies and contributing expertise to develop the field of graduate education for the CAU as a whole.

A further structural contribution of the ISOS to the University educational structure has been in the development of a CAU-wide e-learning strategy. This has used concepts developed in ISOS for faculty and students from multiple disciplines and integrating these with other e-learning initiatives already existent. Drawing on this experience, ISOS has played the lead role in a successful proposal that will lead to a CAU-wide e-learning project to be funded by the state government starting at the end of 2008.

4. Central Services

a. Introduction

In order to achieve the administrative goals of the Cluster, a central service office has been established at the Christian-Albrechts University (CAU). Main tasks are the general management of the funds of the Cluster of Excellence, to offer the services of the Integrated School of Ocean Sciences (ISOS), as well as to coordinate the Public Outreach and Transfer-to-Application programmes.

The Department is fully embedded in the existing structures of research management at CAU to ensure the use of pertinent expertise and to interlink the structural planning of the project and the university. It makes use of the existing administrative structures at CAU with regard to fund administration and personnel management. New paths are implemented for quality management, administration of structured graduate education,

as well as for the coordination of public outreach and Transfer-to-Application programmes. The department holds a staff of eleven new positions as organized in three functional subunits (Fig. 4-1).

b. Office

The central service office supports the Executive Committee and the Council of the Cluster of Excellence in the realization of their scientific goals and will bring into agreement the goals of structural development of the project and those of the CAU. Moreover, coordination with the various funding bodies of the Cluster (DFG, University, other third parties) takes place through the Office. To ensure the successful realization of the scientific goals, a scientific controlling system is established to monitor the scientific, educational, and exploitation/dissemination output. A financial controlling has been implemented to ensure the efficient use of the resources in accordance with the goals and annual implementation plans as

Cluster of Excellence Central Services

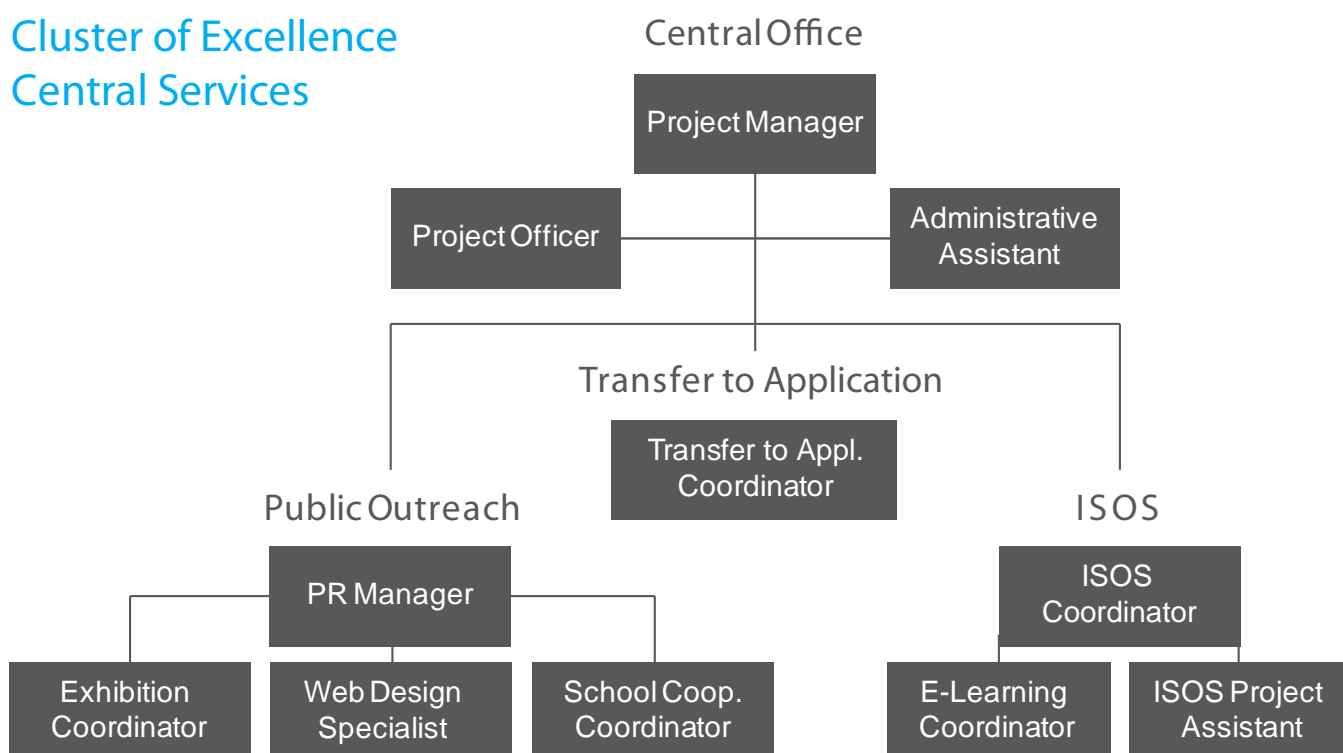


Figure 4-1. Organization of the central service office of the Cluster of Excellence.

well as with funding party regulations. Moreover, the office is coordinating procedures and policies for the dissemination of knowledge from the project.

During the first year the Cluster's funding allocation and financial controlling systems have been

developed to support

the appointment procedures and the installation of the new JRGs, to organize and carry out calls for research and platform proposals, to develop pertinent review procedures for the internal proposal system, and to set-up the Cluster Department itself.

c. Budget Report

In fiscal year 2007 the Cluster of Excellence Future Ocean had a total budget of 7.4 Mio €. Due to the ongoing recruitment process of the JRGs considerable savings were made, which were allocated to the further development of a robust research infrastructure. Investments originally planned for the following fiscal year 2008 were therefore pulled up one year earlier in 2007. This resulted in an actual fraction of 58% (4.6 Mio €) of the budget spent for research platforms instead of the originally planned 30%. At year's end the total budget was well-balanced in the areas of the research projects and central offices projects with all funds invested.

In accordance with the annual implementation plan funds were used for research projects,

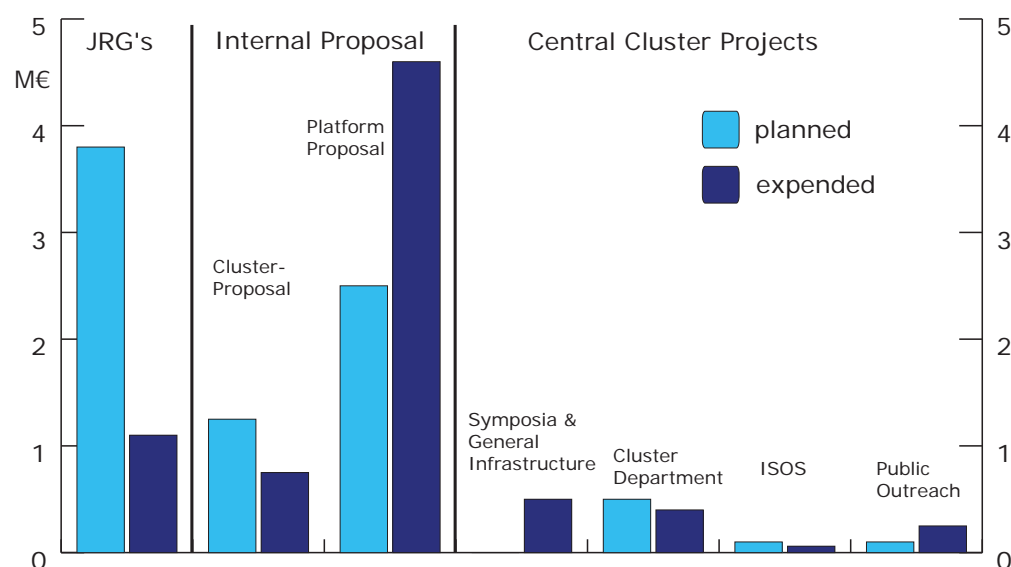


Figure 4-2. Fund allocation of 2007 within the Cluster of Excellence: planned vs. actually expended money.

platform development, the set-up of the new JRGs and the central service office. Additional funds were used to strengthen the general research infrastructure for the Cluster of Excellence (i.e. online access to Nature, Elsevier through the University Library). Symposia were organized to further networking within the project as well as in the frame of the transfer-to-application forum. A summary of fund allocation in 2007 is reported in Fig. 4-2.

The financial controlling as realized through an existing data bank system for fund administration at CAU has been fully established in the central service office and guarantees the efficient use of the financial resources of the project at all operation levels. Reports are presented to the Executive Committee and Council regularly as a basis for further fund allocation decisions. In the future a data bank will be implemented as an efficient scientific controlling system for monitoring the structural evolution and performance of the Cluster. It will be based on the existing UNIVIS data bank system at CAU. The data bank will contain measurable quantities of scientific, educational, and transfer-to-application outputs of the Cluster. Annual reports will

Table 4-1. Allocation of new JRGs, appointed JRG leaders, and date of appointment.

| JRG | Host Institute | Appointee | From | Appointed |
|--|--|---------------------|--------------------------------------|------------|
| A1 Ocean Acidification | IFM-GEOMAR, Marine Biogeochemistry | Frank Melzner | Alfred Wegener Institut, Bremerhaven | 01.10.2007 |
| A2 Seafloor Warming | IFM-GEOMAR, Marine Biogeochemistry | Tina Treude | University of Southern Calif., USA | 01.12.2007 |
| A3 CO ₂ -Take-Up in the Ocean | CAU, Interdisciplinary Center for Numerical Simulation | Thomas Slawig | TU Berlin | 01.09.2007 |
| A4 Ocean Circulation | CAU, Institute of Geosciences | Birgit Schneider | CNRS Gif sur Yvette, France | 01.01.2008 |
| A5 CO ₂ -Sequestration | CAU, Institute of Physical Chemistry | - | - | - |
| A6 Chemistry of the Ocean Surface | CAU, Institute of Physical Chemistry | Gernot Friedrichs | University of Kiel | 01.08.2007 |
| A7 Environmental And Ressource Economics | CAU, The Kiel Institute for the World Economy (IFW) | Kathrin Rehdanz | University of Hamburg | 15.12.2007 |
| B1 Living Resources and Overfishing | CAU, Institute of Economics | Martin Quaas | University of Leipzig | 01.11.2007 |
| B2 Molecular Marine Medicine | CAU, Center for Molecular Biosciences | Philip Rosenstiel | MPI for Molecular Genetics, Berlin | 15.10.2007 |
| B3 Seafloor Resources | IFM-GEOMAR, Dynamics of the Ocean Floor | Lars Rüpke | University of Oslo, Norway | 01.10.2007 |
| B4 Natural Hazards | IFM-GEOMAR, Dynamics of the Ocean Floor | Sebastian Krastel | University of Bremen | 01.03.2008 |
| B5 (1) Sea Level Rise and Coastal Erosion | CAU, Institute of Geosciences | Kerstin Schrottke | RCOM, Bremen | 01.01.2008 |
| B5 (2) Risk Management in the Coastal Zone | CAU, Institute of Geography | Athanasios Vafeidis | University of Southampton, England | 01.02.2008 |
| B6 Law of the Sea | Walther Schücking Institute of International Law | Alexander Proelß | University of Tübingen | 01.09.2007 |

be provided to the Executive Committee and the Advisory Board through this databank.

d. Recruiting Junior Professors

Thirteen JRGs are currently established at ten different institutes at CAU and at the Leibniz Institute for Marine Sciences (Table 4-1).

Positions were openly advertized as W1 or W2 professorships and endowed with a true tenure

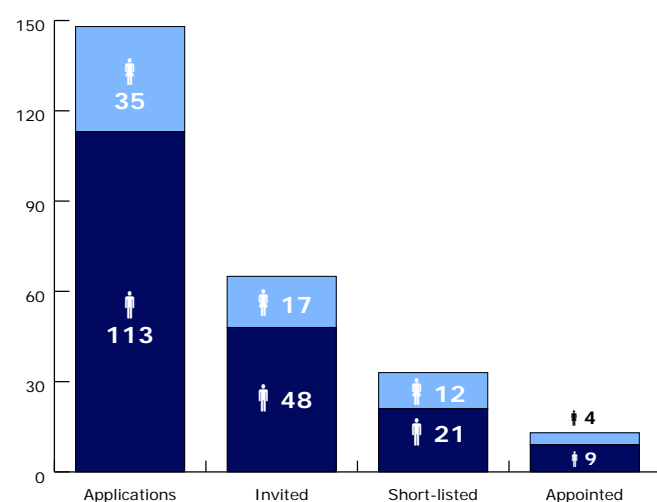


Figure 4-3. Junior Professor appointment statistics: female vs. male applicants.

track option, both novelties in the university recruitment scheme. The positions were moreover endowed with exceptional funding for additional personnel and research equipment so that the new professors should quickly be able to set up excellent research groups.

A total of 148 applications was received (Fig. 4-3), 60% from Germany, 22% from other European countries, 14% from the US, and 4% from others. The position A7 for Ocean Economics was re-announced more broadly as Environmental and Resource Economics to draw a larger number of applications. In January 2007 a total of 65 young researchers were invited to present their research plans with respect to Future Ocean related topics at a joint symposium held at Kiel. Based on the faculty evaluation procedures finally thirty-three candidates were short-listed by twelve appointment committees of the corresponding faculties. To ensure an appointment policy in accordance with the Cluster of Excellence's scientific and structural aims principal

investigators of the Cluster as well as representatives of the Cluster's Executive Committee participated in the individual committees. In compliance with personal and legal qualification requirements finally eight candidates were appointed at the W1 and five at the W2 level. To date (Spring 2008) appointment negotiations have been finished and except the position in Research Topic A5 (see report on Research Topic A5 in Appendix A) all the positions have been filled.

The CAU will provide seven faculty positions augmented by two additional professor positions at IFM-GEOMAR that will be offered to successful JRG leaders by the end of the first Cluster funding period. The commitment of CAU to establish additional permanent faculty positions in key Cluster research areas implies that the Cluster will have a long-term strategic impact on the fabric of the University.

In 2010, the JRGs will be evaluated by an appointments committee to decide on a promotion of the tenure track professors to full professorship.

e. Public Outreach

Introduction

The public outreach (PO) project aims to raise public awareness for the overall themes of the Cluster of Excellence "Future Ocean", but also provides vehicles for internal communication within the project and among the members. To meet this target several venues are taken

Internal communication:

- Internal website
- Monthly newsletter
- Internal cluster events

External communication:

- Website (new design in 2008)
- Press releases
- Public events and exhibitions
- School cooperation

All activities are carried out by the central service office of the Cluster of Excellence in cooperation with the related departments of the University and the IFM-GEOMAR.

Staffing

In 2007 four positions within the PO group have been filled. These comprise a web design specialist M. Lüning, an exhibition coordinator A. Wallaschek and a coordinator for school cooperation K. Knickmeier. In addition a PR manager F. Balzereit has been hired in October 2007, after this position had been filled with temporary staff over the course of the year.

Muthesius Academy of Fine Arts

Although not obvious in the beginning, the Muthesius Academy of Fine Arts and Design is a very important member of the Cluster of Excellence. Its main role is, to develop novel ways to enhance public visibility through improved corporate design and organization of innovative exhibitions and installations. The Muthesius Academy is also involved in the production of an image movie as well as virtually any outreach activities performed by the Cluster of Excellence. All these activities resulted in a tremendous boost of recognition of the project on many levels of public and political awareness. This success would not have been possible without the involvement of the Muthesius Academy of Fine Arts.

Exhibition Activities

The exhibition "Ozean der Zukunft" introduces the visitor to the main topics of the Cluster of Excellence, new challenges in marine research, methods and equipment as well as to the latest scientific results. The exhibition was developed by a joint approach of science (CAU, IFM-GEOMAR) and art (Muthesius Academy of Fine Arts): Interactive and reactive simulations, genuine instruments and models suggest at present "a dive to the deep sea" and enable the visitor to experience different scenarios. The audience is guided by qualified staff and the exhibition is accompanied by lectures, thematic movies and discussions forums. The modular system of the exhibition allows for a successive integration of new modules to keep track with the development of project themes. This concept permits moreover to adjust the presentation of the exhibition (as a whole as well as of individual parts) to the particular need and focus of the event. The exhibition has been presented two times (October 2006 and June 2007) before it travelled to Berlin in October 2007. Further presentations were carried out in 2008.

For the further development of the modular concept a series of workshops will be required to ensure the exchange between all relevant scientists and the exhibition designing crew. For the future the focus lies on interactive modules, for example sensitive projection screens which allow the presentation and linkage of different topics as well as the interaction with the visitors. The concept aims at compact modules to enable an easy and low cost transport for short-term events. Additionally, an individual use of exhibition parts will be required for special events like conferences, fairs or un-staffed locations. In view of determining factors of finance, space, or time, a

concept allowing a multifunctional presentation of the exhibition at any time and any location will be created.

A co-operation has been initiated between the Cluster of Excellence and the marine-oriented Kiel Science Centre (opening planned for 2011). Presently the exhibition team of the Cluster of Excellence is contributing to the conceptual development. The Science Centre offers the opportunity for the public to keep track with the current topics of the Cluster of Excellence "Future Ocean" in the long run.

Internal communication

Since its establishment the PO group pays special attention to internal communication. The purpose is, to improve the internal flow of information, and strengthen the identification of the over 140 scientists who are members of the Cluster of Excellence. Another goal is to intensify the networking within the cluster, and to share information, results and activities to nurture interdisciplinary projects in order to overcome the borders and limitations of individual institutions and faculties towards a local marine science community. In 2007 the internal communication activities by the PO group focused on the following.

The intranet part of the Cluster of Excellence "Future Ocean" web site (<http://www.ozean-der-zukunft.de/allgemein/intern.shtml>) is used to share internal documents. These are i.e. minutes from panel meetings, information related to internal Cluster proposals, seed money and project information. It can be accessed through a special log-in procedure and is frequently used by the members of the project.

To improve the internal flow of information a concept for an internal newsletter was developed. The newsletter is published on a monthly schedule since January 2008, and reports on staff matters, publications in scientific journals, and general activities within the Cluster of Excellence. In addition internal events are held to introduce the research themes to members and personnel at cooperating institutions.

External Communication

Activities in 2007 have focussed on

1. the implementation of a database providing specialists on all the themes relevant to the Cluster, organized by the press and communication office of the CAU Kiel. This list is continuously updated. This database is online since April 2007 and was visited by more than 6.000 persons. Over 50.000 search requests have been registered.
2. the close collaboration with print, electronic and online media was supported by a number of press events (including a two-day media workshop in spring 2007) and twenty-seven press releases in 2006 and 2007.
3. the presence of the Cluster in the media is continuously monitored and evaluated. An increase has indeed been registered over the course of 2007. The rise in student registrations in project related disciplines (e.g. marine biology, geosciences, etc.) observed in Fall 2007 may be related to the Cluster of Excellence's media presence.
4. the web site as an internal and external communication tool of the Cluster of Excellence is continuously updated. It is permanently growing and delivers detailed information about activities, projects and news about the Cluster members.



Figure 4-4. Optimized logo of the Cluster of Excellence. Upper version: German; Lower version: English.

5. the corporate design and logo of the Cluster of Excellence was much improved (Fig. 4-4) and is applied to all publications, such as leaflets, posters, press kits, and the web presence of the Cluster. The development was embedded into the course program of the 7th and 8th semester of the Muthesius Academy. The new design was presented in March 2008, and will finally be implemented by the end of 2008.
6. a new slogan "Understanding the Ocean Sustaining our future" was developed and introduced to the corporate design.

Forthcoming activities aim to

- enhance the internal information flow within the project.
- produce a cooperate film for the Cluster in cooperation with the Muthesius Academy of Fine Arts.

School Programs

To address the next generation of science students and to transfer new scientific knowledge directly to schools, the Cluster of Excellence in cooperation with "NaT-Working Marine Research" of IFM-GEOMAR offers high school students lectures and various opportunities for joint experiments in labs on- and off-shore. This work was intensified after May 2007, when K. Knickmeier was hired as coordinator for school cooperation. As a result of the support by the project, the existing school

network was expanded from the originally eight to now ten schools in Kiel and vicinity.

Major projects of school cooperations in 2007 were:

Courses: Two six-month enrichment courses for gifted students (Fig. 4-5). The first course was taught in 2006/07 under the topic "The Science in Schätzing's 'The Swarm'" (grade 9 to 11). The second course was taught in 2007/08 "Biosphere Ocean – how is life under water?" (grade 6 to 8). Output from these courses were highlighted to the public in student presentations at "Enrichment Days" at the high school Kieler Gelehrtenschule in May 2007 and primary school Theodor Heuss Schule in April 2008.

For grade 13, a one-year course on iron fertilization and CO₂ uptake with various scientists from the Cluster of Excellence was implemented in the school year of 2007/08. Students presented their results to Cluster scientists in talks in January 2008.

Expeditions: A major project was an 8-day expedition to Gdansk (Poland) with *RV Alkor* in October 2007 with eight students, three scientists and a teacher. The students were from seven different schools in Kiel, Germany and Bergen, Norway. Ten stations were sampled in the Arcona Basin, Oderbank, Bay of Gdansk (Poland) and at the Gdansk Deep. During the stations hydrographical and biological measurements (plankton and benthos) were realized and a special plankton net (WP3) was used to investigate the abundance of the lobate ctenophore *Menemiopsis leydii*. It is one of the "alien species" invading the Baltic Sea which were introduced there via ships' ballast water. The observation data of *Mnemiopsis leydii* on this cruise was entered directly



Figure 4-5. Enrichment courses are taught in various high schools.

into the data base of a plankton working group at IFM-GEOMAR. The cruise was covered by several reports in the newspaper *Kieler Nachrichten* and in a special issue of the weekly magazine *Der Spiegel*.

In November, eleven students from Humboldt-Gymnasium Kiel took part in one-day *Alkor* cruises with scientists and students. As a result, eight students started one-year projects in different departments of IFM-GEOMAR and the Zoological Institute, CAU.

Symposium: A two-day symposium "NaT-Working Marine Research" was held in Bad Segeberg, Germany in February 2007. The symposium was attended by 120 students and eighteen teachers from seven schools and served as a venue for the students to present the results of their science projects on posters or talks. Together with fifteen scientists from the Cluster of Excellence workshops and talks were organized for the students and teachers.

Exhibition: More than 120 guided tours through the main outreach exhibition of the Cluster of Excellence "Ozean der Zukunft" were organized for school classes from Schleswig-Holstein and other parts of Germany in June and July 2007.

Contributions to new Projects: In June 2007 the school projects were presented as part of the review event of the Collaborative Research Center (SFB) 754. A proposal for joint outreach of the SFB, the NaT-Working and the Cluster of Excellence is now submitted to DFG—Experiences from the school cooperations contributed to a proposal CarboSchools submitted within the seventh European Union Framework Program. Meanwhile the funding for CarboSchools has been granted with Kiel being one of the partners in this project.

Further perspectives of school program outreach activities in 2008 are:

- cooperation with Federal Environmental Competition (Bundesumweltwettbewerb; coordinated by the Leibniz Institute for Science Education, IPN). A special award is announced for "Future Ocean – too high, too warm, too acidic".
- continuation of contributions to the project "Forscherferien" (Researcher Holidays) organized by IPN. It includes three half-day excursions to Kiel Beach "Falckensteiner Strand", carried out for third and fourth grade pupils. The kids get acquainted with the flora and fauna of the sea in their immediate vicinity.
- coordination of the publication of a school book for marine sciences by Cornelsen-Verlag, Berlin.
- the third enrichment course with the topic "Climate Change and the Role of CO₂ in the Ocean", grade 9 to 10.
- procurement of five expedition boxes on the subjects of hydrology, marine chemistry, plankton, benthos, climate change (CO₂). Teachers can borrow these boxes for use in their schools.
- implementation of a children's marine sciences university at Kiel (age 8 to 12, and 12 to 16).
- compilation of ten boxes with marine sciences books appropriate for students ("The Ocean in a Box") for long-term loans to partner schools.

For a complete list of projects see Appendix G.

f. Integrated School of Ocean Sciences (ISOS)

Introduction

The Integrated School of Ocean Sciences (ISOS) has developed into a well established platform within the Cluster of Excellence. The core activities are

- a PhD program in marine sciences and
- a web-based e-learning platform for ocean sciences at the CAU.

Furthermore, ISOS is developing structural components that both support the Cluster of Excellence and have a longer-term and broader reach within the university. These structural elements include:

- provision of a graduate educational platform in compliance with the requirement for funding of larger projects by the DFG (e.g. SFBs) and increasingly the EU (e.g. ITNs). One successful SFB and ITN each have already integrated the ISOS in part of their proposals.
- identification of PhD-specific course requirements in transferable skills, tailoring of courses to fit these and hand-over of these to the Center for Academic Further Education
- creating a nucleus to support and where

appropriate initiate multidisciplinary teaching offers across faculties

- serving as an institutional platform for cooperation and exchange in education with national and international partners

Additionally, ISOS has been actively involved in two major proposals

- the EU- Initial Training Network CalMarO (Calcification in Marine Organisms, www.calmaro.eu), funded with 2.7 Mio EUR from July 2008 – June 2012
- a proposal entitled "e-Learning Koordination und neue Medien" (e-learning and new media) submitted by the CAU to the ministry for science, economy and traffic of the state of Schleswig-Holstein (proposed volume 727.000 € from 2008 – 2011)

The ISOS PhD Programme has exceeded its target membership within the first year. A total of fifty PhD candidates are registered, of which 50% are female. From these candidates eighteen are directly financed through the Cluster of excellence, the others through various projects of Cluster Members. 50% are doctoral students of the Leibniz-Institute of Marine Sciences (IFM-GEOMAR), the rest coming from a further twelve Institutes of the CAU from the faculties of natural sciences, law, medicine and economics. This diversity enables ISOS to develop and test graduate support structures that may potentially be of longer-lasting and wider benefit to the University as a whole.

Courses and Activities

The "ground rules" for ISOS participation require a minimum of courses for in-depth scientific expertise, multidisciplinary knowledge and

acquisition of vital transferable skills. Thesis committees include two to three supervisors; a framework for supervision includes biannual meetings, the minutes of which are submitted to ISOS.

ISOS Courses (see Appendix G for a list) are developed in one of three manners:

- through direct input by scientists of the Cluster of Excellence, in particular JRG leaders (e.g. "Neue Meeresnutzung")
- on request by groups of students; ISOS liaises with Cluster Principal Investigators (PIs) and JRGs who develop these courses (e.g. "Mass Spectrometry and Optical Spectroscopy")
- transferable skills through professional trainers. ISOS closely monitors and determines the course content, since experience has shown that PhD needs differ in many instances from a mixed University audience. Close cooperation with the Centre for Academic Further Education avoids unnecessary overlap.

The first PhD retreat met with extremely positive response. Retreat themes are decided by consensus among the PhDs. ISOS is responsible for inviting high-level guests for informal and personal interactions. For the first theme "maritime consultancy" the founding Director of "Coastal Research Management" was invited, follow-up included a visit to the Consultancy offices and identification of potential collaboration. Biannual retreats will follow.

Additional support has been offered to the JRG Leaders in the areas of academic didactics, leadership training, and one-to-one career coaching. Input by the JRG leaders to ISOS has been outstandingly positive, resulting in development

of several multidisciplinary courses, PhD-specific disciplinary offers and joint seminars.

The ISOS Lecture Series provides a platform for presentation of Cluster activities to a larger audience at the University. In the Winter semester 2007 the new JRG Leaders were primary speakers; in the Summer semester 2008 the four research and infrastructure platforms of the Cluster of Excellence are to be presented.

Funding to Cluster scientists for the organization of conferences and invitation of guest researchers is administered by the ISOS. Four conferences and invitation of three guest scientists were co-financed in 2007. Each of these activities results in an accompanying offer for graduate students.

ISOS and CAU

By representing the marine focus in education at the CAU, ISOS is able to play a role in international partnerships and cooperations at an institutional level. Thus:

- ISOS officially coordinates the training activity of the Marie Curie Initial Training Networks (ITN) CalMarO, funded from July 2008 to June 2012 with 2.7 Mio €.
- ISOS represents the CAU on the MENTOR (Marine European Network for Training of Researchers) Network, a consortium for graduate training between the Universities of Bergen, Brest, Bremen, Southampton and Kiel.
- ISOS networks with the graduate schools of the other Northern German Clusters of Excellence in Kiel, Hamburg and Bremen – open exchange of course offers exists and joint symposia are planned.

- In cooperation with the Bergen Marine Board in Norway, ISOS has fostered exchange of information between scientists leading to potential longer-term cooperation between several Kiel JRG groups and their colleagues in Bergen, particularly at the "interface" marine disciplines of economics and law.

E-learning

e-Learning activities at ISOS have established a web-based information e-learning base and provide accompanying services to support production and integration of e-content in cluster education and to unify access to all courses for participating students.

The information platform is a web site for PhD candidates and cluster members and provides a public site for announcements of lecture series, current events etc. It includes a list of ISOS PhD candidates and a PhD forum to support PhD networking.

The e-learning base offers portals at the master and graduate levels, including course materials and e-learning content. By the end of 2007 nineteen courses and more than 400 active users were registered. These are expected to be doubled by the end of 2008.

Services for members of the Cluster of Excellence include individual trainings in the use of the e-learning system and in the development of e-content units. The overall strategy

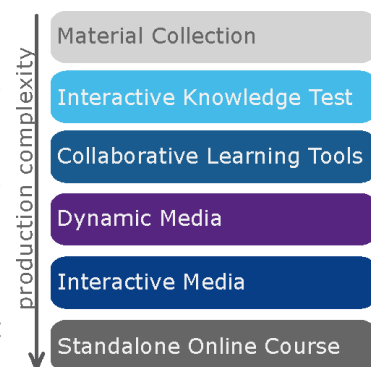


Figure 4-1. Six different categories of media types ranked in steps of increasing production complexity

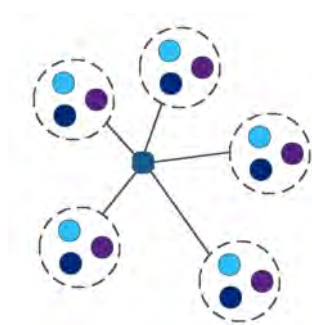


Figure 4-2. Satellite teams for e-content production.

is to extend existing learning resources with dynamic and interactive e-content of different types (Fig. 4-1) on a course-by-course basis. This extension strategy allows teachers to stepwise increase the interactive e-con-

tent parts in their courses and, hence, to add educational value.

The production will be organized in small temporary satellite teams (Fig. 4-2) consisting of teachers/authors, student assistants and members of the ISOS e-learning group. Teams are organized by the ISOS e-learning coordinator. Following this approach, four content-related projects have already been realized and several more are in development.

On a more technical level, ISOS is involved in platform development with the open source provider. Furthermore, specific learning tools (i.e. educational simulation framework and interactive maps) are in preparation. Recently, the ISOS e-learning group strongly influenced a proposal for e-learning integration at university level.

Outlook: After an initial year, ISOS has developed both functional components as well as structural foundations to fulfil a role as a central university-wide platform in marine sciences for educational and exchange activities. In the coming year, other central activities will include establishment of a mentoring program, PhD network enhancement through "career evenings" and course developments. Activities will include exchange and joint organization of workshops and symposia with national and international partners, giving PhDs

wider exposure at a European level. The structural establishment of a graduate center at the CAU is taking place at the CAU, in which ISOS will play a forerunner role and synergies are expected to develop with the Graduate School "Human Developments in Landscapes" also funded through the Excellence Initiative, supporting a wider thrust toward an integrated graduate educational concept for the University.

g. Transfer to Application

The major goal of the activities related to Transfer to Application is to initiate the application of knowledge and new technologies developed by the Cluster of Excellence by industry and organizations.

In order to reach this goal three types of contact are essential:

- connecting scientist with industry to share scientific findings and results.
- connecting industry with science to exchange knowledge about engineering developments in industry.

Vehicles to foster these contacts are to

- organize topical science/industry meetings
- represent the Cluster of Excellence at industrial exhibitions and science fairs
- offer to the scientists a Point-of-Contact for questions about intellectual property and patenting of novel ideas.

During the early phase of the Cluster of Excellence it was essential to evaluate the topics and research themes of the involved persons and institutions. For a general survey, the scientists were contacted and interviewed numerous times

in order to identify aspects of their research and work, potentially leading towards a technological development. About half of the interviews led into structured conversations to identify topics for possible cooperation between the scientists and companies. The first substantial conversations began in May 2007.

At the same time contact was established to local organizations, i.e. the Maritime Cluster, a local network of over 1200 companies from all areas of the maritime industry. Together with the Maritime Cluster the "Science meets Industry" marketplace conversations were initiated. During these themed events researchers present their work and report about its relevance to possible industrial application. Talks can be intensified during a following forum meeting, offering room for conversation between science and economy. An improved bidirectional event featuring science and industry projects reporting to each other to enhance a dialog is planned for 2008.

An important partner for the Cluster of Excellence is the Patent Exploitation Agency Schleswig-Holstein GmbH (PVA SH) an organization funded by the University and several other public service institutions. To educate the researchers on the opportunities, challenges and legal aspects of patents informational events were organized. This led to several in-depth personal conversations and discussions where particular topics required closer individual illumination.

Several conferences, exhibitions and fairs were attended in order to make contact with various companies relevant to the Cluster of Excellence. This includes participation at the Fall meeting of the American Geophysical Union (AGU) in San Francisco, the most important conference for Earth science. Some effort was put into an

appearance on the Oceanology International (OI) 2008 in London, the most important industry exhibition for exploration and technology. This, however, had to be postponed into the future.

In addition the technology transfer currently develops and maintains a catalogue with instrumentation and laboratories owned by the Cluster of Excellence. This ensures that, e.g., industry can identify experts and services within the project and can make contact if necessary. This catalogue is maintained through project funds.

5. Research Themes and Platforms

a. Research Theme A: The Ocean in the Greenhouse World

Introduction

The oceanic response to anthropogenic greenhouse gas emissions is investigated under Theme A "The Ocean in the Greenhouse World". The combined oceanic response to this forcing is complex and includes large-scale changes in ecosystem structure and ocean circulation. The internal cycling of carbon, nutrients and oxygen within the ocean and physical exchange of greenhouse gas, heat, water and momentum across the air-sea and ocean-seafloor interfaces are also affected by anthropogenic greenhouse gas emissions and global climate change. Internal oceanic feedbacks may amplify the external anthropogenic forcing with largely unknown consequences for oceans, global climate, and human society. Cluster Theme A encompasses basic and applied research into these roles and responses of the oceans in the Greenhouse World. The overarching questions of Research Theme A are:

- a) What are the biological and chemical responses of the ocean to changing atmospheric composition?
- b) How do ocean circulation and the ocean ecosystem interact with altered radiative forcing?
- c) What is the ocean's capacity for current and future mitigation of atmospheric CO₂ increase?
- d) What are the implications of these changes to the marine system for human welfare and greenhouse gas management?

Within Research Theme A seven Research Topics have been defined as projects. Project A1 is establishing new linkages between expertise in marine biology and geochemistry and related physiological and biochemical expertise at Kiel to improve the mechanistic understanding of the response of marine organisms to elevated CO₂ and decreased pH. Warming of intermediate-depth waters has the potential to drive major changes in seafloor processes, including accelerated decomposition of methane hydrates and as yet unknown effects on benthic ecosystems. Project A2 addresses this issue by combining expertise in benthic ecology and geochemistry with new observational technologies. Project A3 builds on expertise in ocean modelling, marine carbon observations and synthesis in a new partnership with advanced numerical techniques research. The goal is to improve our ability to quantify the current and future anthropogenic CO₂ uptake of the ocean. Project A4 takes advantage of the existing expertise in past ocean climate proxy research and uses ocean and climate models in order to reconcile observational records from past climates with dynamically consistent climate scenarios. Project A5 is planned to address the potential and risks associated with CO₂ disposal in marine sediments. Specifically, expertise in marine geochemistry, inorganic and theoretical chemistry will collectively be focused on improving our understanding of the behavior of CO₂ in marine sediments under the pressure and temperature conditions of the deep ocean. In Project A6 physical chemical structures and interactions at and near the air-sea interface are studied, including reactions important for understanding the ocean's response to the changing composition of the surface ocean and troposphere. Here, new linkages between physical and theoretical chemistry and marine science

are being established. The changes predicted for the future ocean by projects A1 through A6 have considerable implications for human welfare. Ocean carbon sequestration (on-going or deliberate) is important for an evaluation of carbon abatement strategies and global carbon management accounting. The economic and human welfare implications of future ocean change are the focus of project A7, which takes advantage of the existing economic expertise at IfW and the scientific insight provided by other parts of the Cluster. Project A7 is strategically placed at the interface between basic scientific insight, quantitative assessment, and socio-economic understanding to produce evaluations of the human-dimension implications of Future Ocean change.

Activities

Within the Cluster's theme A, six out of seven junior professorships could be successfully filled between September 2007 and January 2008. All six junior research groups (JRGs) are now in the process of building their research groups in a competitive job market. Particularly in the physical sciences it has been very difficult to recruit postdoctoral researchers and PhD students. However, all JRGs have by now attracted some promising PhD students and postdoctoral researchers. The groups are now fully operational, and in the following we give a brief overview with short examples of the work initiated so far within the individual Theme-A projects.

Project A1 "Ocean Acidification" investigates both auto- and heterotrophic systems under different CO₂ levels. Research is highly interdisciplinary, encompassing molecular biological, biochemical, biogeochemical, isotope-chemical approaches on

organisms exposed to elevated pCO₂s in mesocosm experiments and in laboratory settings.

Junior professor F. Melzner took up his position in October 2007. Within the JRG, personnel has been hired very successfully (3 PhD students, assistant medical technician (MTA), one 50% Postdoc). Initial research efforts focus on establishing sea urchin, mussel and cephalopod culturing systems. First experiments on mussel acid-base regulation and on sea urchin larval development have been performed. The JRG has also successfully applied for funding via the Cluster-Proposals, strengthening ties to JRG B2 (Marine Medicine) and to group A2 (Seafloor warming).

Project A2 "Seafloor Warming" investigates the impact of temperature increases in bottom-near water on benthic organisms as well as on the stability of submarine gas hydrates. We expect shifts in benthic community structures caused by temperature-dependent physiological changes of benthic organisms (e.g. via changes in predator-prey relationships). The stability of gas hydrates is expected to reach critical levels especially in high-latitude low-water-depth regions such as coastal submarine permafrost in the Arctic Ocean as well as along the deep-water stability limits at continental margins (~500 m water depth). Dissociation of gas hydrates and subsequent increase of methane emissions from the oceans would lead to a rise in radiative forcing and therewith create further global warming.

The Junior Research Group has been set up and is led by Tina Treude, who took up office in December 2007. The JRG will focus on the effect of bottom-near temperature increase on the stability of submarine gas hydrates. A combination of (1) oceanographic modeling of bottom water temperatures, (2) numeric reaction-

transport modeling, and (3) biogeochemical field and laboratory studies will be applied to gain a better understanding of gas hydrate dissociation and environmental consequences. Modeling of heat flow, gas hydrate dissociation, methane fluxes, and changes in biogeochemical reactions will be supported by field measurements and laboratory experiments. One special topic will be the understanding of AOM as methane and CO₂ sink through the precipitation of authigenic carbonates as well as the sensitivity of these microbe-mineral-interactions to changes in temperature and pH.

Project A3 "Oceanic CO₂ Uptake" investigates the future CO₂ uptake of the ocean by means of coupled biogeochemical ocean circulation models. Since the ecological and biological processes underlying biogeochemical cycles are not fully understood, a large number of empirical models exist. Within A3, the Kiel Climate Model system has been augmented by a typical nutrient-phytoplankton-zooplankton-detritus (NPZD)-type biogeochemical model of nitrogen and carbon cycles. Results of this initial work showed substantial deficiencies with respect to observations. It could be shown that these were not primarily due to errors in the physical model or in some insufficient grid resolution. Instead, deficiencies must be due to shortcomings of the biogeochemical module. A specific task of A3 is to assess and optimize such biogeochemical models to reproduce available observations.

Junior Research Group A3 is led by Professor Thomas Slawig who took up his position in September 2007. In close collaboration with modeling groups at IFM-GEOMAR his group has begun to prepare for an objective assessment and subsequent optimization of biogeochemical models. In a first study, alternatives to the widely-

used pseudo-time-stepping approach have been investigated in order to run transient models into steady state in a much more efficient manner. These methods are based on so-called inexact Newton-Krylow methods. The implementation of a scientific software framework is under way in order to provide a common interface for a wide range of biogeochemical models. In order to optimize the parameters of the spun-up models, an efficient optimization framework has to be set up. To this extent, the use of local gradient-based optimization methods has been started. Work undertaken in Project A3 has benefited substantially from the computational infrastructure provided via Platform P1.

Project A4 "Ocean Circulation and Hydrological Cycle during the Holocene and Anthropocene" concentrates on linkages between oceanic and atmospheric climate modes, their impact on the hydrological cycle, as well as on past changes in tropical ocean circulation and biogeochemical cycles. The project addresses very different time scales from sub-decadal to millennial climate variability, comparing model results with historical data series and geological climate proxy records, or testing different model approaches for ocean change predictions. For the study of causes and effects of climate variability, including feedbacks and non-linearities of the system, JRG A4 uses state of the art coupled ocean-atmosphere or climate-carbon cycle models and makes heavy use of the computer infrastructure provided via platform P1. To gain confidence in future climate predictions such models should be able to represent past climate variability. On the one hand, the application of a model to past climate conditions allows for model validation by comparison with paleoreconstructions, while on the other hand existing climate hypotheses can be tested.

The Junior Research Group in A4 started in January 2008 with the appointment of Prof. Birgit Schneider at the Geosciences Institute of the CAU. In early 2008 the theme A4 was represented by Birgit Schneider in a round table meeting organised by the JSPS (Japan Society for Promoting Sciences) and the German Science Foundation (DFG) that aimed at fostering collaborations between Japanese and German young researchers in climate sciences. With new A4 theme-related projects we are participating in the new Schwerpunktprogramm: "Integrierte Analyse zwischeneiszeitlicher Klimadynamik" (INTERDYNAMIK, SPP 1266) of the DFG and in several subprojects of the new Kiel Collaborative Research Project (SFB) 754 on: "Climate-Biogeochemistry Interactions in the tropical Ocean". In addition, several PI's of A4 are engaged as co-proponents of the new Graduate School "Human development in landscapes" that was awarded to the CAU as the third project of the excellence initiative in 2007 and is mainly related to archeology and historical sciences. This will provide strong links between both activities in the field of climate research and more structured education of joint graduate students.

Project A5 "CO₂ Sequestration" is the only project area in which the Juniorprofessorship position could not be filled. The position had been offered to two excellent candidates, but unfortunately both decided to turn down the offers in favor of a permanent position in the first instance, and in favor of a competitively paid institute position in the second one. Because the negotiation phase took an entire year and the remaining Cluster time is limited, it was decided to not re-advertise the position.

In the meantime a significant amount of research on CO₂ sequestration has been initiated at

IFM-GEOMAR via industry-funded projects in close association with the Cluster. These have been initiated by Klaus Wallmann, the previous speaker of the Future Ocean Cluster, and will ensure that research in this area will be pursued in Kiel.

Project A6 "Sea Surface Chemistry" aims to link expertise from physical chemistry and marine chemistry for the purpose of studying processes at the ocean surface. Many of these processes are far away from being well understood and progress in this field is expected from applying new experimental methods. The JRG A6 has been established in August 2007 and is headed by Gernot Friedrichs. The group (1 postdoc, 2 PhD, and 1 diploma student) focuses on identifying and studying chemical processes occurring at the water/air interface in microscopic detail by using modern laser spectroscopic methods. In the mean time, a new laser laboratory has been installed providing sensitive cavity-ringdown- and sum-frequency-generation spectrometers. While the new spectrometers are still in their start-up phase, first studies are concerned with the sensitive detection of alkyl halides and the role of the organic microlayer, which is prevalent at the ocean/atmosphere interface. Another focus of JRG A6 lies on the development of optical instrumentation for marine research applications. In close collaboration with other research theme A members, an innovative CO₂ analyzer for isotope ratio measurements is currently tested, and yet another project is concerned with the design of an optical biofilm sensor.

Project A7 "Valuing the Ocean" aims at the economic valuation of the ocean's role in the carbon cycle and possible consequences for management as well as abatement and mitigation strategies. This includes assessments of carbon

capture with respect to different leakage rates. Since December 2007 Juniorprofessor Katrin Rehdanz is heading the JRG of A7. She has begun to investigate the consequences of ocean acidification which, so far, has not usually been considered in assessments of carbon emissions. Other work includes assessments of ocean fertilization, possible or necessary economic incentives, and the legal aspects of iron fertilization (close collaboration with Project B6 "Law of the Sea and Living Resources"). Project A7 also investigates the economic aspects of carbon sequestration and emission allowance trading. It is planned to model the interaction of energy and carbon markets with carbon capture and storage in the global economy with the IfW's computable general equilibrium model DART.

b. Research Theme B: Marine Resources and Risks

Introduction

Theme B "Marine Resources and Risks" focuses on the understanding and management of marine resources and the assessment of hazards. Oceans provide resources and services to mankind, such as fish and seafood, genetic resources for medical purposes, fossil fuels and minerals. However, the sea is also a source of hazards through tsunamis, storm surges and sea-level rise. These opportunities and risks pose several general questions:

- a) Which physical, chemical, biological, and geological mechanisms lead to the evolution of certain resources?
- b) What are the mechanisms that lead to marine hazards threatening coastal population?
- c) Are ocean organisms a model system for human diseases providing a new tool in medical research?
- d) How should ocean resources be managed in a sustainable manner and which institutional and legal frameworks are necessary for such endeavors?
- e) How can risks be assessed, how can damages from hazardous events be evaluated, and which countermeasures can be taken to mitigate these?

In project B1 fishery management is studied with the special focus on multispecies interaction and the link between commercial species, non-commercial species, and the ecosystem. Marine life and fisheries are presently studied, but have not previously been linked to economic expertise at Kiel. Building on this expertise, a new JRG was established to improve the management strategies of fish stocks and fisheries, incorpo-

rating economic, legal, and scientific aspects. Kiel-based scientists from medical and natural sciences join for the first time in Project B2 to study marine organisms as a model system to gain a better understanding of the mechanisms triggering human diseases. The proponents and the new JRG will apply a genomics approach to investigate the evolution and function of orthologs to human susceptibility genes for barrier dysfunction in marine organisms from diverse phyla. This approach is possible because the genes which cause barrier disease have been conserved through evolution. As an ultimate goal, the knowledge required in the marine model organisms will be applied to develop novel therapeutic or preventive strategies for human barrier disorders. The study of the occurrence and formation of marine resources, such as gas hydrates and hydrothermal deposits, is an important focus of research in Kiel. However, further expertise is needed in the area of fluid flow and coupled reactions, which are responsible for the formation of these deposits. This aspect is addressed by a modeling-oriented new JRG in project B3 which will also serve to link existing research groups in this field. Despite growing concerns regarding submarine earthquakes, slumps and slides and their consequences, such as the triggering of tsunamis, marine seismology is not an established discipline in Germany. To close this gap, a JRG was set up as Project B4 in order to address the problems of submarine hazards at continental margins. To strengthen the existing groups investigating sea-level change, coastal evolution and coastal zone management tasks, new expertise is needed to analyze physical-morphological changes in coastal seas and to develop new tools to assess the vulnerability and resilience of coastal zone communities. The socio-economic relevance of coastal change and risk

assessment justifies the establishment of two new JRG's in project B5 covering this important field. Project B6 strengthens the expertise in maritime law and a JRG contributes to the development of new laws for the sustainable use of marine resources based on a sound understanding of the oceanic ecosystem. The link between the topics of Theme B is the focus on marine resources and risks for human society. Therefore, the economic and legal aspects bridge the six topics and create a unique scientific network which is capable of developing innovative and comprehensive approaches in the investigation and management of marine resources and risks.

Activities

All research groups within Research Theme B succeeded to fill the seven positions for Junior professors, the last researchers being hired in April 2008. All JRGs are now in the phase of forming their research teams and hiring PhD students and Post-Docs. Several groups have finished this process and have already started on working on their research projects.

The Junior Research Group B1, Living Resources and Overfishing, started working at November 1, 2007 when M. Quaas came to the University of Kiel as the new leader of the JRG. Against the background of the present massive overfishing of seas, the research of the JRG is directed at developing new concepts of fisheries management that promote a sustainable fishery. Research started in two directions. Firstly in cooperation with PIs Till Requate and Rainer Froese, and an international partner from the University of Trondheim, the management of an age-structured fish population has been investigated. First results suggest that it may be optimal to harvest a certain fraction of younger age classes of fish, although

it is generally preferable to direct fishing effort more to the older age classes. Moreover, simulations indicate that the optimal steady state is periodically oscillating, with several overlapping frequencies under some parameter settings. In a second project, the effects of consumer's preferences for food fish diversity have been studied in a multispecies fishery model. Further projects in B1 focus on estimating recruitment of cod as a function of stock of other species such as sprat and herring as well as environmental conditions, such as adverse oxygen conditions. Further projects by PIs focused on further development of basic equations underlying mortality, somatic growth, reproduction and population increase of marine populations. Moreover experiments on mesocosm are performed to study the effects of winter/spring warming on the spring development of plankton and the proliferation of food to zooplankton feeding fish. Further, a survey on long-term data on cod, sprat, zooplankton and phytoplankton has been conducted revealing that depletion of cod caused an increasing abundance of sprat because of reduced predation of cod on sprat. A final project studies invasion by the ctenophore *Mnemiopsis leidyi*. As a result this species turned out to be practically worthless as a food for fish, but it is a potent competitor for fish feeding on zooplankton and a predator on fish eggs and larvae.

Project B2, Molecular Ocean Medicine, was successful to hire Phillipp Rosenstiel as the JRG leader, who started his position October 1, 2007. In collaborative research agendas the group is focusing on epithelial barrier function as one of the oldest autonomous defense mechanisms against foreign substances and/or pathogenic organisms. Function and failure of the immunological barrier integrity are of increasing interest to modern medicine. Chronic inflammatory diseases of the

barrier organs such as the skin or the intestinal tract have seen a steep rise in incidence during recent decades. Ongoing efforts within the group substantially contribute to the comprehensive molecular risk map of human genetic polymorphisms associated with barrier disorders such as Crohn's disease (Nat Genet 2007, PNAS, 2007a, Nat Genet, 2008) and Sarcoidosis (Nat Genet, in revision). Many findings point to a disturbance of ancient defense mechanisms such as NOD-like receptor dependent expression of secreted defense molecules (J. Immunol, 2007) or autophagy, which together with an imbalanced biodiversity of the resident microbiota precipitates into disease. A main agenda is the translation of the findings into marine model to understand trigger factors that initiate and perpetuate chronic inflammatory diseases. Characterization of the variation in innate immune genes (PLOS Biology in revision), the induced-transcriptomal defense programs (the "defensom") and the accompanying changes in the resident microflora (PNAS, 2007b) is sought in algae, polyps, jellyfish, bivalves and sea urchins. In the context of iron homeostasis as a survival and defense mechanism, a genome sequencing project of *T. oceanica* has been initiated together with the platform P3. Using the next generation sequencing platform of the ZMB, state-of-the-art technological approaches such as massively parallel transcriptome tag and microRNA sequencing are developed and have found broad applications also within other groups of the cluster.

In project B3, Seafloor Resources, JRG leader Lars Rüpke started his position at October 1st 2008. The JRG group studies natural geological resources at the ocean floor. Examples of this are deep sea ore deposits that form as a byproduct of hydrothermal activity near mid-ocean spreading centers and off-shore hydrocarbon occurrences

found at passive continental margins. By the end of 2007, the recruitment processes has been completed and three core research projects have been initiated: integrated studies of fossil hydrothermal systems at the Oman ophiolite, joint geophysical and numerical work on the active Logatchev hydrothermal vent field in the Atlantic ocean, and integrated basin modeling of continental break-up and new ocean basin formation.

The Oman project combines geological field work with geochemistry and numerical modeling to better understand the pathways of hydrothermal fluid flow through young oceanic crust. At the Oman ophiolite, a complete section of old (~90Ma) ocean floor is exposed on land. This allows to directly study those structures that are at active vent sites buried deep inside the ocean crust and are inaccessible to direct observations. In early 2008, a first expedition to the Oman ophiolite revealed pervasive networks of hydrothermal flow paths that crosscut the entire oceanic crust. Complementary to the Oman project, joint geophysical and numerical work has been initiated on the active Logatchev vent field. The key objective is to use numerical simulations to test and explore scenarios build upon geophysical and geochemical observations. During the first phase, very high resolution hydrothermal convection models have been designed that are able to resolve those fine scale structures that are evident in geophysical data. The third project uses numerical modeling techniques to explore the geological processes active during continental break-up and new ocean basin formation. In a first case study, the thermal and structural evolution of the Norwegian margin has been successfully reconstructed. This reconstruction allows us to quantify sedimentation rates and to make predictions on changes in deposition systems through time.

The position of a Juniorprofessor in group B4, Submarine Hazards at Continental Margins: Earthquakes, Submarine Slope Failure and Tsunami Generation, could only be filled rather late. In April 1st, 2008 S. Krastel started his position. Up to that point, the Scientists involved in B4 focused their activities in the following two themes. (1) Assessment of the link between the structure and dynamics of subduction zones and the mega-earthquake cycle. Within this research theme, studies were completed, or are in progress, at the tectonically erosive margin of Costa Rica and Nicaragua, including the interrelation of earthquake processes and submarine slope failure. Another area investigated is the Sunda margin off Indonesia, with its recent record of devastating earthquakes and tsunamis. Ongoing work at the South American Pacific margin offshore Chile has the objective to understand the genesis of extremely large earthquake ruptures, the long-term seismogenic cycle there, and the history and dynamics of change in the forearc architecture. (2) The work on passive continental margins, especially concerning the risk of exceptionally large and frequent submarine slope failures, concentrated on three areas of young and repeated sliding mainly endangering communities in Europe and North America: the Yermak Slide in the Arctic North Atlantic, the Northwest African margin off Mauretania, and the Gulf of Mexico continental margin off Texas and Louisiana.

Group B5, Sea-Level Rise and Coasts at Risk, was also successful to fill of the two open junior-professorships. Kerstin Schrottke now leads the JRG B5-1 by January 01, 2008. Her research activities cover nearshore sediment dynamics in relation to environmental changes and sea-level rise. A. Vafeidis took up the lead of JRG B5-2 by February 01, 2008. His research focuses on risk

assessment in the coastal zone driven by climate change and sea-level rise. Both professors are actually installing their working groups.

Joint research activities investigate the impacts of tsunami waves in the coastal zone of western Thailand granted by DFG. Here B5-1 explores tsunami deposits in nearshore and coastal waters while B5-2 concentrates on tsunami risks, vulnerability and resilience. Other current research comprises the hydro- morpho- and sediment dynamics of coastal seas and river-mouth systems in relation to the evolution and migration of shorelines due to changes in sea level. Associated coastal vulnerability, hazards and risks are evaluated by a comprehensive approach for vulnerability assessment and multi-hazard risk modeling.

In group B6, Law of the Sea and Living Resources, Alexander Proelß was appointed effective from 1 September 2007. He immediately initiated the setting up of JRG B6. Since 1 November 2007, the group consists of three research assistants (PhD students). In a joint research project, scientists from the WSI (A. Proelß) and the FTZ (U. Siebert, A. Gilles, H. Herr) focus on topics concerning the distribution and protection of marine mammals. Data on the occurrence, density and habitat use of harbour porpoises in the sanctuary and adjacent waters are currently being assembled from various data sources (incl. aerial surveys, incidental sightings, acoustic investigations, and the stranding network). Based on the factual situation assessed, the applicable legal instruments will then be analyzed and measured against their protection-oriented object and purpose. A further research project, associated with a cluster proposal undertaken together with J. LaRoche et al. deals from group B2 with the legal framework applicable to the marine genetic

resources in areas beyond the limits of national jurisdiction. The project addresses measures to ensure effective preservation of the mentioned resources, the relationship between international environmental law and the law of the sea on the one hand and intellectual property rights on the other, and the controversial application of the common heritage of mankind principle. Further project deals

- a) with the legal regime of drifters and gliders and
- b) with new uses of the deep sea-bed focusing on the applicable legal rules governing the protection and effective management of marine genetic resources

It should be stressed that there are several joint projects across the different groups. One example is a proposal on management of fish in the Baltic sea jointly applied by scientists of B1 and B6, to be started in the fall 2008. The B6 group also works together in several projects with scientists from B2 and B3 and also theme A (see project on drifter and gliders). Further joint projects are already planned.

c. Research Platforms

Introduction

The Cluster has established four overarching research platforms to provide infrastructure and resources for all scientists within the Cluster (Fig. 1-1). They offer a wide range of high-end instrumentation which was mostly acquired over the past few years. Many aspects of Cluster research require access to high performance computing facilities, and modern numerical techniques. Hence, numerical expertise and support will be offered by a network connecting the recently established Interdisciplinary Center for Numerical Simulation, the Seismic Processing Center and the ocean and climate modeling groups with the Computing Centers at Kiel (P1). Research into the ocean conditions of the past and its important role in guiding our understanding of the future ocean requires highly specialized and accurate isotope and trace metal analysis, both currently performed at Kiel. High-end instruments and advanced techniques will be integrated to establish the new virtual Tracer Analysis Center which will offer a comprehensive analytical support for the Cluster (P2). Improved understanding of human diseases by the study of marine organisms and mechanistic studies of pH-sensitive processes in plankton at the molecular level will benefit from the recently established Center for Molecular Biosciences (ZMB). ZMB provides unique expertise in molecular biosciences and access to high throughput molecular techniques (P3). In-situ observations of current conditions and on-going trends in the ocean require an array of specialized oceanographic sampling and observing platforms. The Technology and Logistics Center for Ocean Observations at Kiel serves as the ideal nucleus for a new platform offering cutting edge technology to explore the ocean over space and

time and in remote regions from the oceanic crust to the air-sea interface (P4). The novel platforms set up in the Cluster allow for a more efficient use of resources and will be further developed and strengthened according to the needs of the Cluster.

Activities

A first call of Platform proposals was launched in spring 2007. The goal of this call was to close analytical and instrumental gaps in order to provide a broad range of tools and techniques for the cluster. Based on suggestions by the Cluster Council, the Cluster's Executive Committee decided on grants for high-priority investments of the four platforms (2.9 Mio €) in a first step. However, the call will be closed in autumn to enable the participation of the new JRG leaders. All equipment purchased after the first call is summarized in the appendix.

Platform P1: Numerical Simulation and Data Management

The scientific activities of the research group of theme A will be based on extensive numerical simulation of the CO₂-cycle and climate variability of the Kiel Ocean Climate Model-system. The model computation together with data assimilation for the global ocean and atmospheric circulation and biogeochemistry plays a fundamental role in many Cluster activities, e.g. for the CO₂ uptake or, more generally, for regional developments of physical and biogeochemical parameters.

In order to account for extra computational resources Platform P1 decided on investments to extend the local vector computer system NEC SX-8 (with 5 knots) at the data processing

center of the CAU with 8 CPUs and corresponding storage capacities. This concept is best compatible with existing facilities and will be maintained by available staff. Expected date of delivery is September 2007, installation is scheduled for October 2007. The increasing demand on computational power also requests additional personnel to maintain complex software and databases. A highly qualified data manager will start in October 2007.

To discuss the recent developments in the field of mathematical modelling and simulation of flow problems in geosciences the platform organized the "3rd Scientific Computing Seminar" about Mathematical Modelling and Simulation of Flow Problems in Geosciences held at the "Kunsthalle Kiel" in summer 2007. Topics included: mathematical models, numerical schemes, algorithms, simulation techniques, parameter estimation and data assimilation, coupled processes, reactive transport and free surfaces and partial differential equations with stochastic parameters. The conference with about 55 participants was supported by the DFG-cluster together with the GAMM and the "Innovationsfond des Landes SH" (total cost about 2 500 EUR).

Platform P2: Isotope and Tracer Analysis

Within the excellence cluster a large demand on analytic and in particular on isotope and trace element analysis will be requested. However, the available old mass-spectrometers will not be able to meet the increasing demand on high sample throughput and precision. Therefore, highest priority was given on replacement of old machines by new equipment. Some analytical weakness was also identified in the field of organic geochemistry. Furthermore, Platform 2 also identified lacks of instrumentation for micro-

analytical studies. Accordingly, the Platform council decided to emphasize the replacement of old equipment and the establishing of new capacities for organic geochemistry. Second priority was given to the improvement of micro-analytical capacities.

Following the above approach as decided by the Executive Committee two stable massspectrometers were advertised and are purchased via the DFG (Finnigan MAT253). Both machines will be allocated at the Leibniz Laboratory at CAU providing competent staff for service and maintenance. Both machines have already been ordered and will be installed within the next months.

Platform 2 members continue to discuss the role, management structure and performance of the Tracer Analytical Center (TAC) in order to provide effective analytical support for the excellence cluster, university and the attached institutions.

Platform P3: High-Throughput Molecular Bioscience Technologies

Platform P3 is devoted to strengthen the high-throughput analyses of genetic diversity, systematic expression profiling, robot-assisted cell-based assays, competitive proteome analysis techniques and the availability of a population-representative biobank (PopGen). In order to fill instrumental gaps a Capillary Sequencer (Applied Biosystems, 3730 XL) and a Qiagen Robot for Large-Scale Plasmid Preparation are currently purchased.

A position for an expert in biogeochemical analytics and instrumentation will be installed at the Institute of Zoology.

Platform P4: Ocean observatories

Major tools for the excellence cluster to achieve information about future ocean change are ocean observatories. There is general consensus in the platform council that the already existing capacities have to be completed and extended by new approaches such as enhanced four dimensional ocean observation (glider swarm) and seafloor or open-ocean laboratories for manipulative biogeochemical studies (bottom landers, free-drifting mesocosms, etc.).

Therefore the following new systems and modules are currently purchased: mesocom, Lander, OTIS device, FlowCam, CO₂ manipulation, Shallow Seismic device, Streamer and a CTD. On the Cap Verde basic equipment was purchased for the local long term observatory. To maintain the new instruments a position for a technician is installed at IFM-GEOMAR.

6. Working Panels

a. Family and Employment

The Cluster of Excellence intends to attract more women to a scientific career and to accelerate the process of increasing the number of female professors at the university. A double strategy has been adopted to actively support these goals: i) a declared target was to fill at least half of the new junior research positions with highly qualified women, ii) to further improve family-friendly working conditions at the university, beneficial not only for female, but for early-career scientists in general. Progress and realization of gender-related goals are monitored through a „gender panel“, represented by members of the Cluster of Excellence and supported by the university's delegate for gender equality (Gleichstellungsbeauftragte).

Despite of far reaching formulations in the frame of the Schleswig-Holstein legislation (Hochschulgesetz) numbers of female professors at Kiel University are notoriously low (9% at the full professor W2/W3 levels), however, with more encouraging numbers at the junior professor level (25%). Therefore installation of fourteen new professorships on the Junior Professor and W2-professorship levels, all provided with considerable funds, offered a unique chance to attract highly qualified female candidates to Kiel, and thus to notably increase numbers of female professors at the university. Despite initially low numbers of female applications (35 out of 148, or 24%), percentages of female candidates could be successively increased during the recruitment process (Fig. 4-3). The responsible selection committees pre-selected seventeen female candidates out of 65 candidates (26%) and short-listed twelve (36%). Finally, six positions were

offered to women (43%), and four women could be appointed and have started to build up their working groups at the end of 2007 and the begin of 2008. In summary, though the initial target of 50% could not be fully reached, every third of the new positions is currently held by a female professor. Double-career requests have been responded by offering positions to the partners of some candidates at the institutions involved at the Cluster of Excellence wherever applicable.

At the same time, the Cluster of Excellence intends to further improve family-friendly working conditions at CAU, already rated as a family-friendly university (audit certificate). Here, in particular the demand of child-care facilities for under-three-year old children, still not covered by public institutions, and essential for early-career scientists, has been addressed via the new concept of „Nests“. This concept, launched in 2007 by the university in collaboration with the town of Kiel, offers care facilities for small groups of up to five children, supervised by certified day mothers (Tagesmütter) at the Campus at reasonable fees. Two „Nests“ have recently opened their doors at the campus, a third one is scheduled to do so in 2008. Moreover, a family-service office has been installed at the University, which is currently funded with innovation funds by the federal state of Schleswig-Holstein, and will be continued as a permanent institution.

b. Quality Management

Introduction and Goals

The execution of quality management of the Cluster of Excellence falls into three major categories:

- Monitoring of the quality of science through statistical measures of results and achievements by a Quality Management Panel.
- Financial controlling executed by the central service office.
- Quality criteria for education by the ISOS.

Monitoring of the scientific excellence is a priority task within the Cluster of Excellence. For this purpose a quality management panel has been established. Its goal is to monitor the overall structural development of the project, its results and achievements, as well as the quality of science. To reach these goals standardized monitoring procedures have to be established which allow to draw empirical conclusions about the state and work of the Cluster of Excellence.

The Quality Control is intended to rely on quantitative measured indicators, and allow to view the state of the structural development, fund flow and scientific output (Fig. 6-1). It is intended to collect these data through a yearly questionnaire distributed among all members of the Cluster of Excellence. The first collection of data is intended for 2008. For activities related to the financial controlling see chapter 4.c.

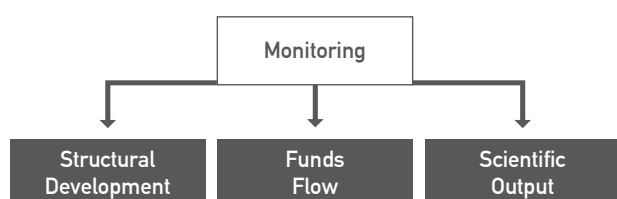


Figure 6-1. Main quality management activities in the Cluster of Excellence.

A quality control system for the cluster graduate education will be established by members of the ISOS. Advice and guidance for the purpose of improving teaching will be given to staff. The ultimate goal is, to recognize teaching as a high-level priority within the cluster as well as within the university and cooperating institutions.

Quality Management Panel

In early 2008 the steering committee established a working group on „Quality Management“. Main tasks for the working group are:

- To secure the high quality in the cluster
- Evaluation of the research progress
- Evaluation of the structural development
- Identification of further steps necessary

In March 2008 the working group had its first meeting. Agenda items were the organization of a regular evaluation process and the possibilities for bench-marking with other research groups and institutions. The first item for the group is the development of a questionnaire that will be distributed among the members of the cluster every summer. Another main task is the identification of equivalent partners for bench-marking. Suggestions are highly welcome.

c. Data Management

From the interdisciplinary research of the cluster of excellence large amounts of data from either observations, laboratory work and numerical modelling need to be stored, archived and also made accessible for scientific purposes and further processing. Controlled data access requires a sophisticated data management. Thus, it has been commonly agreed within the cluster of excellence that data management is an important issue. In autumn 2007 it was decided that a data manager needs to be employed, and additionally, a specific investment in hard- and software needs to be performed. In December 2007 the concept and tasks of data management within the cluster of excellence have been discussed in a workshop organized by the Platform P1, numerical simulation. The data manager has to cover overall different topics and research platforms of the cluster of excellence. 51,000 € have been spent for a data management server, data storage and specific software. The data management post has been advertised in the local newspaper and on web sites of "The Future Ocean" and IFM-GEOMAR. The closing date for applications was set to 31st March 2008. Five applications were received from which three persons were invited for an interview. Two applicants out of the three were suitable for the data manager position, however, both rejected the offer. A second announcement for the data management position will be sent out in July 2008.

Appendix A - Projects of Research Theme A: Greenhouse Oceans

Research Topic A1: Ocean Acidification

Principal Investigators: U. Riebesell, M. Bleich, T. Eisenhauer, F. Melzner

Introduction

If global CO₂ emissions continue to rise in accordance with current trends, the average pH of the oceans will fall by 0.5 units by the year 2100. It will take thousands of years for ocean chemistry to return to a condition similar to that of the pre-industrial era. Projected acidification is likely stronger than has been experienced for tens of millions of years and, critically, is at a rate of change 100 times greater than at anytime during this period. For any given CO₂ emission scenario the magnitude of ocean acidification can be predicted with a high level of confidence. The impacts of ocean acidification on marine organisms and ecosystems, however, are largely unknown. The strongest effects have thus

far been documented for calcifying organisms, where declining seawater pH impairs the ability of these organisms to form calcareous shells and skeletons (Raven et al. 2005). Most studies carried out to date relied on abrupt and short-term CO₂ perturbations, leaving the potential for adaptive responses and compensatory processes unaddressed. Also unknown are possible synergistic effects with other environmental changes, such as ocean warming. The development of predictive capabilities for the impacts of ocean acidification on the marine biota requires a mechanistic understanding of CO₂/pH-sensitive processes. This is addressed by the Junior Research Group (JRG) by combining molecular, biochemical, and cell-physiological techniques with CO₂ perturbation studies at a variety of scales ranging from the cellular to the ecosystem level.

Junior Research Group

In October 2007, Frank Melzner was hired as head for the JRG. Melzner, formerly a Postdoc at the Alfred Wegener Institute for polar research (AWI) in Bremerhaven, is a marine animal physiologist, with experience in marine animal thermal- and CO₂ tolerance mechanisms (e.g. Melzner et al. 2006, 2007). The new research group focuses on marine animal ion- and pH-regulation mechanisms. They seem to be the key points in tolerance of high sea water CO₂ partial pressures. CO₂ tolerant (cephalopods) and sensitive model organisms (sea urchins, mussels) will be studied using molecular biological, biochemical and physiological techniques. The group will focus on gaining information on current marine animal tolerance mechanisms and also hopes to provide new insights on which animal groups might be characterized by some level of pre-adaptation to future ocean acidification.

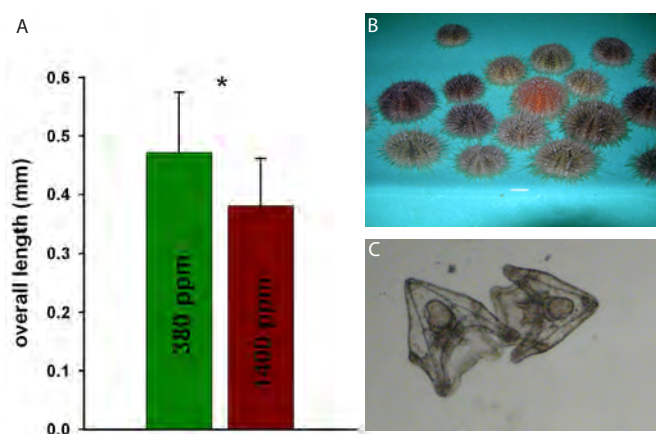


Figure A1-1. (A) Larval development and growth in sea urchin larvae reared under control (380 ppm, N=100) and high-CO₂ (1,400 ppm, N=100) conditions. *Strongylocentrotus purpuratus* pluteus larvae grow significantly slower under high-CO₂ conditions. (B) Sea urchin cultures at IFM-GEOMAR, (C) sea urchin pluteus larvae reared at IFM-GEOMAR (Stumpp & Melzner, unpublished).

Three PhD students, one assistant medical technician (MTA), one 50% Postdoc have been hired. In addition several diploma students are supervised. Initial research efforts focus on establishing sea urchin, mussel and cephalopod culturing systems. First experiments on mussel acid-base regulation and calcification as well as on sea urchin larval development have been performed (Fig. A1-1). The JRG has also successfully applied for additional cluster funding, thereby strengthening ties to the JRG of Research Topic B2 (Marine Medicine) and the group of Research Topic A2 (Seafloor warming).

Activities

Within the Research Topic A1 "Ocean acidification" research focuses on both, auto- and heterotrophic systems. Research is highly interdisciplinary, encompassing molecular biological, biochemical, biogeochemical and isotope-geochemical approaches. Organisms and communities are being exposed to elevated $p\text{CO}_2$ mostly in laboratory settings for extended periods of time to study stress responses and adaptation mechanisms. Researchers within A1 heavily rely on infrastructure supported by platforms P2, P3 and P4.

Infrastructure

In 2007, two important infrastructure developments have been successfully implemented: the CO_2 -manipulation system and the Boron-free laboratory. They allow the following sophisticated research approaches in the coming years:

(i) CO_2 manipulation system (Clemmesen et al.): As most research in group A1 is based on manipulative CO_2 -studies, considerable efforts were directed towards establishing a CO_2 -mixing



Figure A1-2. The Members of JRG A1. From left to right: Agnes Heinemann (PhD student), Katja Trübenbach (MSc student), Ulrike Panknin (MTA), Julia Saphörster (MSc student), Marian Hu (PhD student), bottom: Frank Melzner, Jörn Thomsen (MSc student), Martina Langenbuch (Postdoc), Meike Stumpp (PhD student).

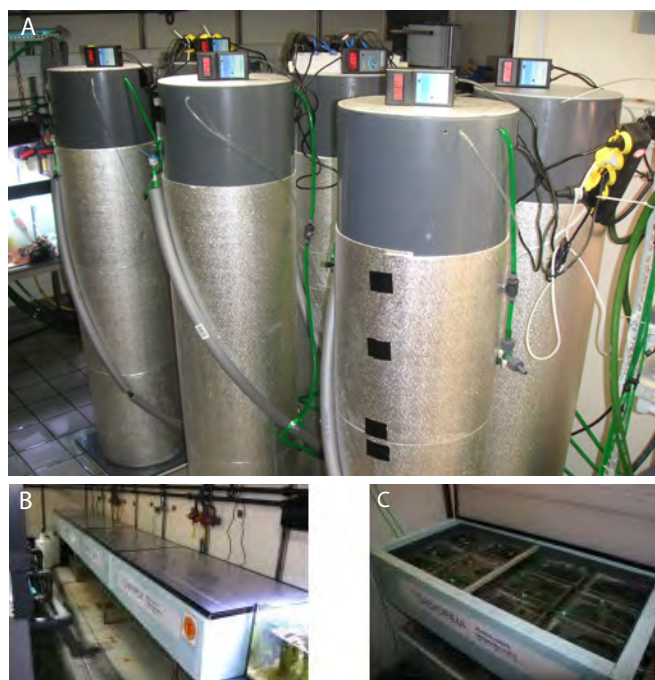


Figure A1-3. Experimental setup for long-term incubation of blue mussels (*Mytilus edulis*) and Ocean Quahogs (*Arctica islandica*) at different temperatures and seawater $p\text{CO}_2$ values. (A) The tall cylinders shown in the image are used to equilibrate Kiel Fjord sea water at different temperatures with gas mixtures supplied by the new gas mixing facility. (B, C) Mussel culturing tanks that receive water from the equilibration columns (Hiebenthal, Wahl & Eisenhauer, unpublished).

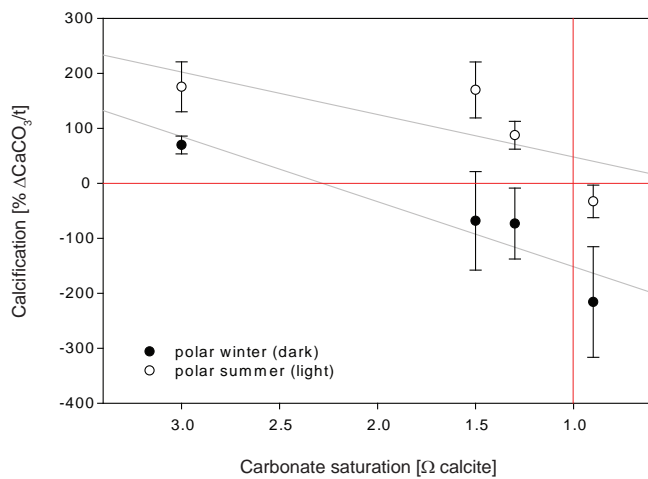


Figure A1-4. Calcification rate in the Arctic encrusting algae *Lithothamnium sp.* from Svalbard normalized in percent against baseline calcification (unchanged conditions; Form & Büdenbender, unpublished).

facility to supply the IFM-GEOMAR culture rooms with appropriate gas mixture to simulate the carbonate system likely to be encountered in future oceans. The mixing unit (HTK Hamburg and Linde Gas AG) was successfully installed in January 2008, supplying six temperature constant culturing rooms with five different gas mixtures each. First long- and medium term incubation experiments are currently running (C. Hiebenthal, M. Wahl, F. Melzner, C. Clemmesen, Fig. A1-3.) and the system's precision seems to be fully sufficient to provide highly stable gas mixtures between 380 and 4000 ppm CO₂.

(ii) Boron-free laboratory (Eisenhauer et al.): Within the cluster funded project "Boron Isotopes (δ¹¹B) as a Proxy for pH decrease and pCO₂ increase" (Platform P2), a Boron free laboratory was developed and established for the chemical extraction and purification of Boron from carbonates (e.g. corals, sclerosponges, foraminifera). The determination of B/Ca and B-isotope measurements will allow the reconstruction of present and past pH-variations important to better constrain future marine pH-changes due to global climate change.

General Research Lines in A1

A1 research in 2007 mainly focused on the dependence of calcification, pH regulation and carbon acquisition in several marine taxa (coccolithophores, coralline red algae, scleractinian corals, teleost fish) on elevated seawater pCO₂. An emphasis was and will be placed on understanding the biochemical and physiological mechanisms of isotope fractionation in carbonate shells of marine organisms and their potential use as proxies for past abiotic conditions. Field studies on changes in the community structure of calcifying plankton organisms and their nutrient cycling stoichiometry were also initiated.

1) Calcification rates of encrusting red algae (A. Form & J. Büdenbender): Arctic encrusting algae (*Lithothamnium sp.*) from Svalbard were exposed to elevated partial pressures of CO₂ in order to investigate their sensitivity towards decreasing carbonate saturation, an effect of ocean acidification that is progressing fastest in polar regions. During polar summer simulations (24 hrs light), unabated calcification rates were measured even when the carbonate saturation was reduced by half (corresponding pCO₂: 980ppm). Below a saturation of Ω_{calc}=1,3 (1135 ppm), calcification rates slowly declined, and below a saturation of Ω_{calc}=0,9 (subsaturation, 1880 ppm), dissolution of the calcareous structures was measured. During polar winter simulation (24 hrs dark), however, there still was some calcification at natural saturation levels. Remarkably, when carbonate saturation was reduced by half, but still was well above Ω_{calc}=1 (supersaturated), calcium carbonate dissolution could be observed (Fig. A1-4).

2) Calcification performance and shell composition in bivalves (C. Hiebenthal, M. Wahl & A.

Eisenhauer): To examine the effects of ocean acidification and temperature increase on the performance of two bivalve species (*Mytilus edulis*, *Arctica islandica*), their shell (elemental and Ca isotope) composition and growth will be assessed in long-term incubations. An experimental flow-through setup has been constructed (Fig. A1-3.), providing CO₂ and temperature equilibrated Kiel Fjord seawater to rearing tanks. Mussels Bivalves will be grown for several months at fifty-three different temperatures and thirty-five different CO₂ levels, to study potential synergistic effects of both abiotic stressors. Results will give information on the acclimation potential of mussel bivalve calcification rates and their use as pH and temperature proxy archive for oceans of temperate regions.

3) Cellular mechanisms of pH regulation in coccolithophores (M. Bleich et al.): The effects of changes in ambient pH and pCO₂ on protoplasts of *Emiliania huxleyi* were investigated by microfluorimetry. Protoplast isolation has been established and validated for cell viability. Confocal imaging was used to verify intracellular dye distribution patterns (Figure A1-5). A detailed characterization of active and passive membrane permeabilities influencing cytosolic pH has been performed. The results suggest that *Emiliania huxleyi* has a low capacity to counter regulate acute external pH or pCO₂ challenges (see also separate report on Cluster Proposal CP0602, Appendix D). Lab space and equipment has been expanded to start the investigation of a second species.

4) Carbon capture mechanisms in coccolithophores (R. Schulz et al.): Closely related to the work of M. Bleich and colleagues, this project focuses on characterizing the carbon concentrating mechanism (CCM) inherent to

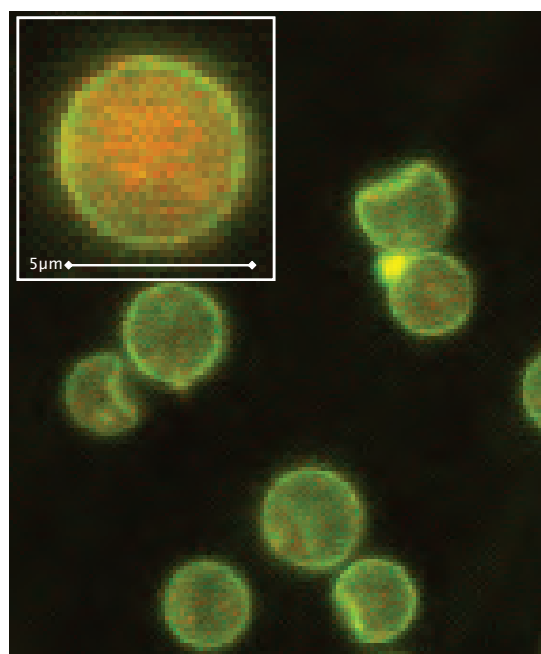


Figure A1-5. Microfluorimetric measurement of cytosolic pH. Confocal image of *Emiliania huxleyi* protoplast after fluorescent dye loading (Suffrian & Bleich, unpublished).

coccolithophores. Little is known at present, how this CCM supplies inorganic carbon for calcification and how its function may be affected by ocean acidification. So far, *Emiliania huxleyi* total membrane samples could be isolated, from which protein-complexes were separated in blue-native gels. Using specific antibodies and western blot techniques, a subunit of Complex 1 of the CCM could be identified. Further investigations aim at determining the exact structure and cellular location of these compounds and will in more detail investigate carbon transport regulation in response to environmental changes (see also separate report on CP0704, Appendix E).

5) Species richness and ecological niches for calcareous planktonic organisms in the surface ocean (J. Schönfeld et al.): Species richness, ecological niches, and life cycle of calcareous plankton in the surface ocean are threatened by the increasing influence of rising CO₂ levels and temperature rise in course of climate change. Within this project, the current status is related to literature data and historical samples from the

1960s-1980, using living and subfossil planktonic foraminifera as a model group. First results are available from southern Ireland, where living planktonic foraminifera were collected with a sediment trap and subfossil assemblages from surface sediments were studied to assess the recent variations of faunal assemblages. The faunal composition from the sediment trap samples is similar to subfossil assemblages from surface sediments, but the species proportions are different. In particular, the subtropical to tropical species *Globorotalia hirsuta*, which was frequent in 2004, was rare or absent from surface sediment samples. We extended our investigations to the equatorial Atlantic and participated in a *R/V Atalante* cruise in January 2008. Surface waters were sampled on transit between South America and Africa by using an Apstein net and the ship's pump. The samples are currently analyzed, and the results will be compared with earlier investigations in the tropical Atlantic in order to constrain the change in planktonic communities and oceanographic conditions during the last decades (see also separate report on Cluster Proposal CP0725, Appendix E).

and in particular increase our understanding of trace element transport from the seawater via the cytosol to the site of calcification (see also separate report on Cluster Proposal CP0710, Appendix E).

6) Variations of trace element fluxes at Ca^{2+} -Channels/ Ca^{2+} -ATPases (A. Eisenhauer et al.):

In the framework of this project, the effects of simulated ocean acidification on scleractinian corals are being investigated. This is important because it is yet unclear to what degree ocean acidification will influence the rate of biomineralization and trace element partitioning in these corals. For this study, hard and soft corals are currently being cultured under controlled laboratory conditions. After finishing the culturing experiments, growth and CaCO_3 precipitation rates, as well as trace element and isotope ratios will be determined. These data will then help to better constrain models on biomineralisation

Research Topic A2: Seafloor Warming

Principal Investigators: K. Wallmann, M. Wahl, T. Treude

Introduction

The subproject "Seafloor Warming" investigates the impact of temperature increases in bottom-near water on benthic organisms as well as on the stability of submarine gas hydrates. We expect shifts in benthic community structures caused by temperature-dependent physiological changes of benthic organisms amplified by changes in biotic interactions. The stability of gas hydrates is expected to reach critical levels especially in high-latitude low-water-depth regions such as coastal submarine permafrost in the Arctic Ocean as well as along deep-water stability limits at continental margins (~500 m water depth). Dissociation of gas hydrates and subsequent increase of methane emissions from the oceans would lead to a rise in radiative forcing and therewith create further global warming.

Junior Research Group

Since December 2007, T. Treude (Fig. A2-1.) is leading the junior research group (JRG) within the Seafloor Warming subproject. Tina Treude

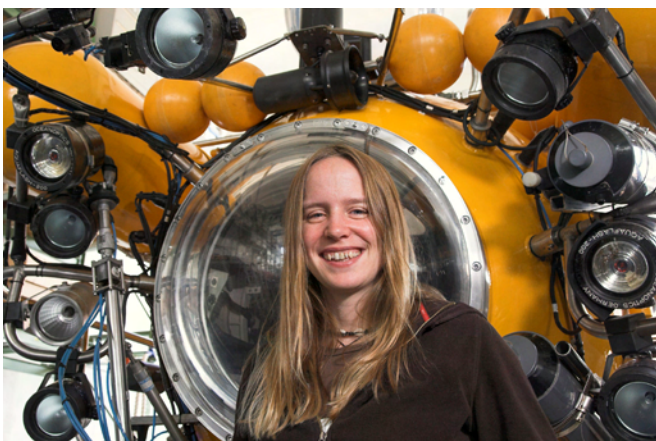


Figure A2-1. Head of the junior research group „Seafloor Warming“ T. Treude.

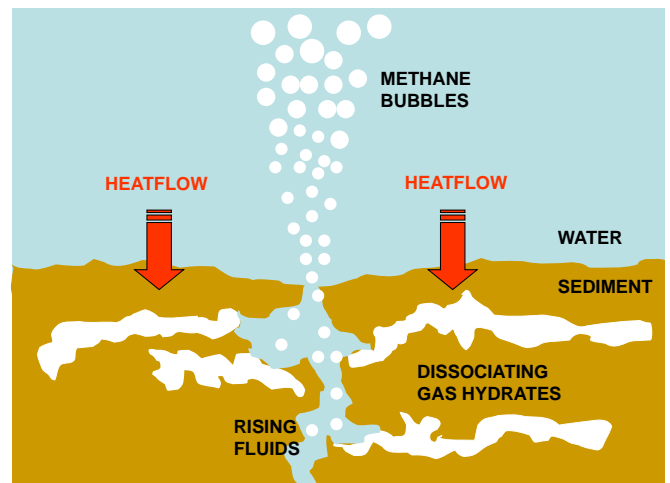


Figure A2-2. Scenario of gas hydrate destabilization and enhanced methane releases into the hydrosphere.

studied biological oceanography, zoology and physical oceanography in Kiel, where she finished her diploma thesis on scavenging deep-sea communities in 1999. For her PhD thesis (2000-2004) she moved to the Max Planck Institute for Marine Microbiology in Bremen, where she worked intensely on a microbial process called anaerobic oxidation of methane (AOM). One focus of her studies was the investigation of AOM in cold-seep systems with gas hydrates. AOM is considered to be an important sink of the greenhouse gas methane in marine sediments. During postdoctoral studies at the Max Planck Institute in Bremen (2004-2005) and at the University of Southern California in Los Angeles (2005-2007) she continued her career with biogeochemical investigations of cold seeps and deep-sea whale falls. Her expertise is "being a marine ecologist at the boundary between biology and geology". Her main interests are to understand modern and ancient biogeochemical processes in aquatic sediment systems, most of them being related to microbial activity.

Within the subproject "Seafloor Warming" the JRG will mainly focus on the effect of bottom-near temperature increase on the stability of submarine gas hydrates (Fig. A2-2). A combination of (1) oceanographic modeling of bottom

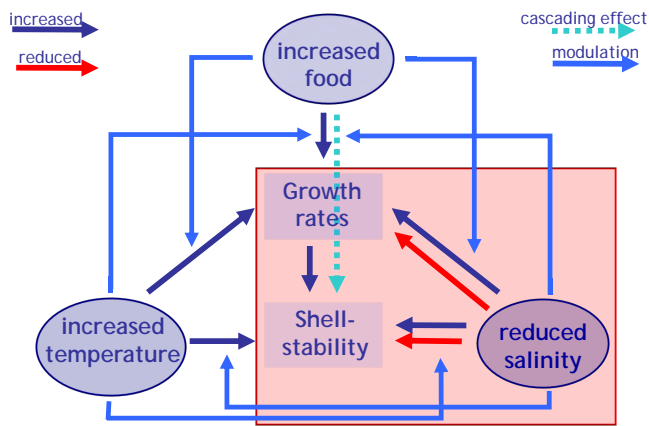


Figure A2-3. Warming enhances growth and shell stability of mussels but interacts intensely with other global change variables such as eutrophication and desalination.

water temperatures (in collaboration with the group of Claus Böning), (2) numeric reaction-transport modeling, and (3) biogeochemical field and laboratory studies will be applied to gain a better understanding of gas hydrate dissociation and environmental consequences. Modeling of heat flow, gas hydrate dissociation, methane fluxes, and changes in biogeochemical reactions will be supported by field measurements and laboratory experiments. One special topic will be the understanding of AOM as methane and CO₂ sink through the precipitation of authigenic carbonates as well as the sensitivity of these microbe-mineral interactions to changes in temperature and pH.

Activities

In the course of a PhD project (Ute Kossak) the effects of warming on growth and shell stability of mussels was investigated under various scenarios of eutrophication and desalination (Fig. A2-3). All three factors interacted intensely. Warming accelerated growth only when food was abundant and salinity was between 15 and 30 (Fig. A2-4). Shell stability related directly to mussel size. Based on current climate change predictions at the regional scale, we expect mussels to become more sensitive to predation in the eastern parts

and less sensitive in the western parts of the Baltic Sea during the next 50 years.

The cluster project CP07A54 (involving subprojects A2, A1, and Platform P4) is studying the metabolic response of the cold-water coral *Lophelia pertusa* (Scleractinia) to variations in ambient temperature and pH by measuring the oxygen consumption of coral stocks in laboratory experiments. Main questions addressed were (1) how do benthic organisms respond to changes in temperature and pH in terms of their metabolic performance, and (2) whether there are synergistic effects of both environmental factors on metabolic rates of benthic organisms.

The cluster project CP0610 on effects of ambient temperature on the metabolism of benthic organisms has been completed at the end of 2007. The project was strongly associated with one of the major research topic within A2 by directly addressing consequences of seafloor warming on the structure and metabolic activity of the benthic ecosystem. In the course of the project, sediment community oxygen demand (a proxy of benthic metabolism and carbon demand), was monitored during a six-month period from spring to fall 2007 in a small-scale field study in Kiel Fjord. The study provided evidence that variations in food availability (approximated by measuring

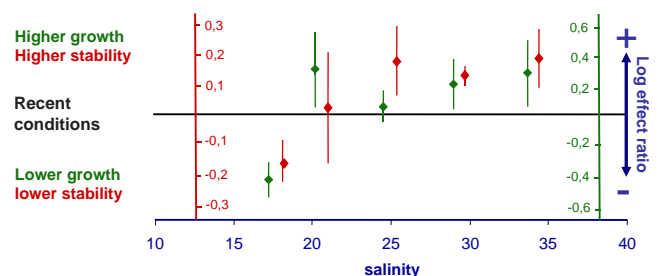


Figure A2-4. Effects of the predicted warming (+5°C, green) and desalination (-5, red) on growth rates and shell stability of the mussel *Mytilus edulis*. Log Effect Ratios (predicted / recent conditions), x + 95% CI. Vulnerable to consumers (slow growth, fragile shells) will increase in the central and eastern Baltic mussels and decrease in the western Baltic and North Sea.

sediment pigment concentrations) had a greater impact on benthic community metabolism than temperature changes. For more information see report of cluster proposal CP0610 in Appendix D. In addition, this project also involved pilot-study lab measurements on the respiration of cold-water corals (*Lophelia pertusa*) and provided valuable methodological experience used in the preparation and implementation of the on-going project CP07A54 (see above).

Within the research topic "gas hydrate stability" the release of methane from melting hydrates was addressed by numerical modelling. Input of methane and CO₂ into oceans and atmosphere -generated by hydrate melting- were quantified for the mid-Cretaceous oceanic anoxic event (OAE) 1b applying a new box model of the global carbon cycle (Wagner et al. 2007). A new 3-D model was developed to simulate the ascent of methane gas bubbles through sediments (Haeckel et al. 2007). Moreover, gas and fluid fluxes at cold seep sites were studied to better understand the mechanisms and rates of methane release at the seafloor (Lu et al. 2007, Reitz et al. 2007).

Research Topic A3: Oceanic CO₂ Uptake

Principal Investigators: C. Böning, A. Srivastav, T. Slawig

Introduction

The goal of Research Topic A3 is to improve the quantification of future oceanic CO₂ uptake by exploring advanced methods to constrain uncertain parameters in coupled physical-biogeochemical models. The project fundamentally builds on a linkage of the expertise in global ocean modeling at IFM-GEOMAR with the expertise in innovative algorithmic methods for large-scale optimization problems at the Interdisciplinary Center for Numerical Simulation (ICN). The activities in 2007 concentrated on two broad objectives: 1) continued development of the physical and biogeochemical oceanic components of the Kiel Climate Model (KCM) as the main model framework for global ocean climate simulations across several of the Cluster activities and 2) investigation of alternative algorithmic strategies

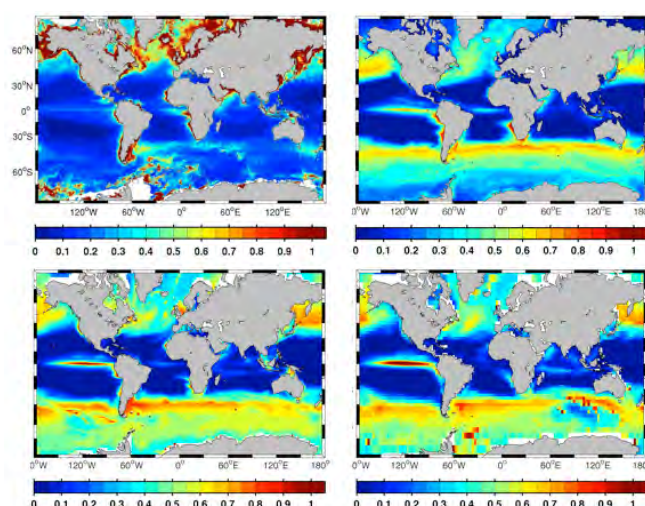


Figure A3-1. Top left panel: Annual mean distribution of chlorophyll a as estimated from the SeaWiFS satellite composite 2005 observations. Top right, bottom left and bottom right panels: Modeled annual mean phytoplankton concentration in the surface layer corresponding to the Kiel Climate Model (KCM), Modular Ocean Model 4 (MOM4) 1°, and MOM4 3° respectively. Units in all panels are mg Chl a m⁻³.

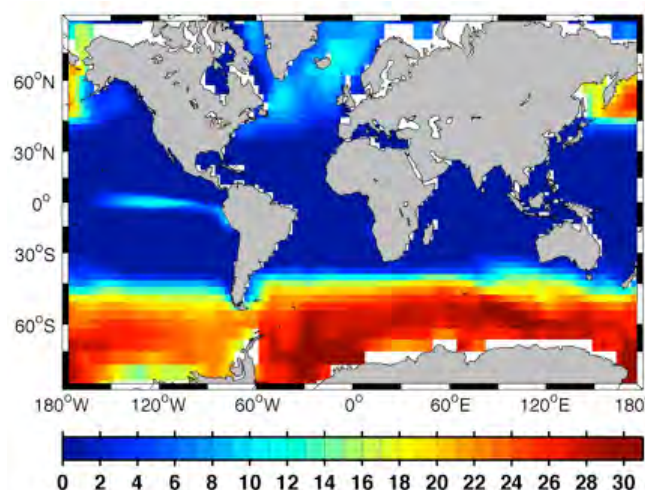


Figure A3-2. Modeled annual mean nitrate concentrations ($\text{mmol}\cdot\text{m}^{-3}$) with the modified grazing parameterization in the biogeochemical NPZD module.

to design an efficient parameter optimization method.

Activities

Some specific results of these two main threads of research and development are summarized in the following.

1) Physical-biogeochemical model components

Work in the ocean modelling group of C. Böning/A. Biastoch was directed at refinements in the capabilities of the physical circulation model component. Through close collaboration with the french Nucleus for European Modeling of the Ocean (NEMO) core team in Paris and partner groups in Brest and Grenoble (in the framework of the DRAKKAR effort), significant advancements could be made in high-resolution modeling capabilities utilizing a new two-way nesting scheme. First successful applications focused on the Agulhas Leakage regime, a particularly challenging region with intense mesoscale processes; our studies could now unravel new aspects of dynamics relevant for the interocean exchange and dynamical repercussions of this regime on the large-scale circulation in the Atlantic Ocean (Biastoch et al., 2008a; Biastoch

et al., 2008b), thus supplementing model results on the mechanisms of the Atlantic MOC variability (Biastoch et al., 2008c).

An initial coupling of the KCM with a typical Nutrient-Phytoplankton-Zooplankton-Detritus (NPZD) type biogeochemical model of nitrogen and carbon cycles showed substantial deviations from available observations. In particular, the coupled model exhibited the typical flaw of simple ecosystem models with respect to the nutrient and phytoplankton distributions in the eastern tropical Pacific and in the southern Ocean (often referred to as HNLC regions), a problem generally attributed to the limiting effect of iron deficiency (Fig. A3-1).

In order to investigate possible causes of the significant model-data misfits, a simple NPZD type model was modified such that zooplankton does graze not only on phytoplankton but also on detritus. An additional model parameter now describes the food preference of zooplankton and can be tuned such that the representation

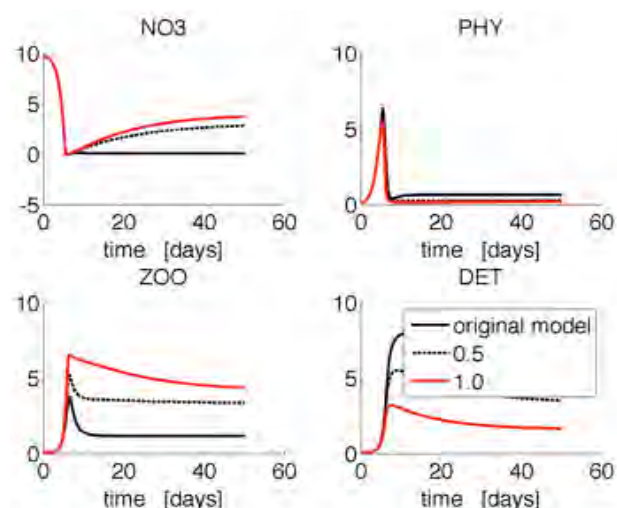


Figure A3-3. 0-D Sensitivity study: nitrate, phytoplankton, zooplankton and detritus time evolution in three grazing parameterizations experiments. In the original model (solid black lines) zooplankton does not feed on detritus. The red lines correspond to a simulation in which zooplankton feeds on both phytoplankton and detritus without any food preference. The dashed black lines refer to a model in which zooplankton prefers phytoplankton to detritus.

of HNLC regions is improved while phytoplankton and macronutrient dynamics during blooms remain almost unchanged (Fig. A3-2).

The sensitivity of the biogeochemical module towards changes in the grazing parameterization has been further studied in a zero-dimensional study (Fig. A2-3). While this is only a single attempt to subjectively change the ecosystem model and its parameters, the large sensitivity of the simulated nutrient fields is viewed as promising in terms of ongoing attempts to develop model assessment criteria based on model-data misfit metrics. Such metrics will be required for successful applications of data assimilation methods, development of which is ongoing in Theme A3.

2) Efficient parameter optimization strategies

Two algorithmic strategies are investigated. The group of A. Srivastav has developed an efficient evolutionary algorithm incorporating ideas from quantum computing, while the junior research group (JRG) of T. Slawig is working on gradient



Figure A2-4. Thomas Slawig, 46 years, since September 2007 leader of the JRG A3 Oceanic CO₂ Uptake and professor at the Department of Computer Science, CAU Kiel. Born in Hattingen/Ruhr, mathematician, research and teaching scientist at TU Berlin and the Potsdam Institute for Climate Impact Research, PhD in 1998 in Optimization with Partial Differential Equations, Habilitation 2005 in Algorithmic Differentiation and Optimal Control.

based local optimization using automatic differentiation. Its goal is to combine and merge both methods in order to design the most efficient algorithms for the problem.

i) Within the project "Mathematical and Algorithmic Challenges in Modelling Biochemical Cycles" (CP0614, 2007–2008, see Appendix E) funded by the Cluster of Excellence "Future Ocean" the new quantum evolutionary algorithm has been designed in joint work with Prof. C. Patvardhan (Dayalbagh Educational Institute, Deemed University, Agra, India). It was parallelized and implemented on the Opteron-Cluster network of the computing center (Rechenzentrum) of the university in Kiel. The computer cluster was funded by the Cluster of Excellence through its research platform P1. The parallelization of the code is done using MPI programming extensions in cooperation with Prof. G. S. Adhar (University of North Carolina, USA). Both scientists visited Kiel in May/June 2008.

The testing of the algorithm is an ongoing research. In the current setting, the optimization is done for one location in the western North Atlantic Ocean near Bermuda named BATS, where the genetic algorithm (GA) considerably improves the initial solution. The next step will be the optimization over all three available BATS locations. Implementation on the NEC vector computer and on the Silicon Graphics machines in the high-performance computing network of the northern German universities (HLNR) is ongoing work.

The project uses the infrastructure laid down by the short-term project „Mathematische Optimierung in der Meeresforschung" (9 months in 2007) which provides a software library containing implementations using free optimi-

zation libraries and a practical manual. The library is now open and accessible for the Cluster of Excellence "Future Ocean".

(ii) A crucial challenge for parameter estimation in coupled ocean-biogeochemical models is the efficient computation of steady periodic states. For this purpose, alternatives to the widely used pseudo-time-stepping approach (running the transient model in the steady state) have been studied. These are based on so-called inexact Newton-Krylov methods. An implementation based on a scientific software library has been started. Moreover, the design of a software framework providing a common interface for a wide range of biogeochemical models has begun.

For parameter optimization it is important to embed the simulation run into an efficient optimization framework. The use of local, gradient-based methods in combination with this new simulation approach has been started. Exact derivative computation using modern software of algorithmic differentiation has been performed in test cases for ocean simulation.

Another coupled simulation-optimization approach is investigated through the project "Automated Extension of Fixed-Point PDE Solvers for Optimal Design with Bounded Retardation" in the German science foundation's (DFG) Priority Program SPP 1253 "Optimization with Partial Differential Equations". It is conducted jointly with the Humboldt University Berlin since 2007. It has also been studied for application on the parameter estimation in Research Topic A3, and the results can be transferred. The combination of global (e.g. genetic algorithms) and local (e.g. quasi-Newton methods) optimization methods has been successfully used in test cases.

Research Topic A4: Ocean Circulation and the Hydrological Cycle

Principal Investigators: R.R. Schneider, B. Schneider, M. Latif

Introduction

The Earth's climate is a complex interplay between atmosphere, ocean, terrestrial and marine biosphere that underlie external and internal forcing mechanisms. Although the ultimate driving forces are often not completely understood, natural climate variations at different time scales, are well documented by paleoclimate reconstructions. Furthermore, there is little doubt about the existence of a human influence on future climate due to fossil fuel emissions and land use changes. For the study of causes and effects of climate variability, including feedbacks and non-linearities of the system, the Junior Research Group (JRG) in Research Topic A4 uses state of the art coupled ocean-atmosphere or climate-carbon cycle models. To gain confidence in future climate predictions such models should be able to represent past climate variability. On one hand, the application of a model to past climate conditions allows for model validation by comparison with paleoreconstructions, while on the other hand existing climate hypotheses can be tested.

Activities

Research Topic A4 concentrates on linkages between oceanic and atmospheric climate modes, their impact on the hydrological cycle, as well as on past changes in tropical ocean circulation and biogeochemical cycles (Subproject A6 at the Collaborative Research Center (SFB) 754). The research addresses very different time scales

from sub-decadal to millennial climate variability, comparing model results with historical data series and geological climate proxy records, or testing different model approaches for ocean change predictions. See Fig. A4-1 as an example for the latter.

The JRG in Research Topic A4 started in October 2007 with the appointment of Birgit Schneider at the Geosciences Institute of the CAU. In early 2008 the Research Topic A4 was represented by B. Schneider in a round table meeting organised by the JSPS (Japan Society for Promoting Sciences) and the German Science Foundation (DFG) that aimed to foster collaborations between Japanese and German young researchers in climate sciences. With new theme-related projects the group is participating in the new Priority Program SPP 1266: "Integrated Analysis of Interglacial Climate Dynamics" (INTERDYNAMIK) of the German Science Foundation (DFG) and in several subprojects of the new Kiel Collaborative Research Center (SFB) 754 on: "Climate-Biogeochemistry Interactions in the tropical Ocean". In addition, several PI's of Research Topic A4 are engaged as co-proponents of the new Graduate School

"Human development in landscapes" that was awarded to the CAU as the third project of the excellence initiative in 2007. It is mainly related to archeology and historical sciences, which will provide strong links between both activities in the field of climate research and more structured education of joint graduate students.

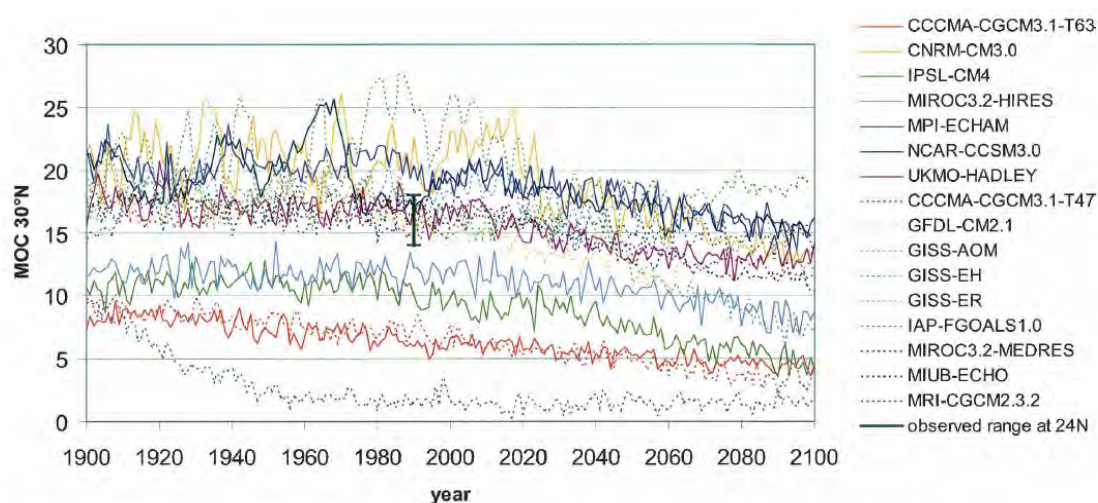


Figure A4-1. MOC rates at 30° N of all models used in the current study. There is considerable spread between individual models, even in the year 1900, which is still close to initial conditions. Half of the models match observation-based mass transport estimates for present day (14-18 Sv). Indicated by the black bar. Dashed lines indicate models where the average of two or more ensemble runs were used (from Schneider et al., J. Clim., 2007).

Research Topic A5: CO₂ Sequestration

Principal Investigators: B. Hartke, A. Körtzinger

Introduction

The capture and storage of CO₂ from large scale emitters has recently come under evaluation as an additional measure to mitigate future global warming (IPCC, 2006). Oceans constitute the largest long-term sink for anthropogenic CO₂. Given this predominant role in the global carbon cycle, the question arises as to whether the natural uptake of the oceans can be accelerated through the additional injection of carbon dioxide into the deep ocean or below the seabed surface. Phase transitions of CO₂ at the deep-sea floor, sediment-CO₂ interactions and the ensuing changes in bulk geophysical properties remain, however, vastly unknown. This includes the formation and stability of CO₂ hydrates with and without the presence of impurities in sea water and sediments, the mobilization and fixation of pH-sensitive and ecologically relevant compounds, as well as the precipitation of authigenic phases and their effects on reservoir permeability. The new JRG to be established in A5 was meant to address the key reactions at CO₂-seawater-sediment interfaces down to the molecular level, with emphasis on the mechanisms and kinetics of the phase transition processes. To achieve this goal, the group would have used cutting-edge methods including molecular dynamic modeling, advanced scattering techniques, and high pressure experimental simulations of oceanic *in-situ* conditions building on, extending, and interlinking the unique infrastructure which currently exists in Kiel.

Activities

After approval of the Cluster of Excellence "Future Ocean", the project members of the Research Topic A5 advertised the available junior professor position. Five applicants were interviewed and a shortlist of two suitable candidates was formed. After considering the offer for a several months, numerous visits to Kiel, and even being involved in the planning of the laboratories for this project the first candidate finally rejected the offer in favour of a permanent research position at her current institute.

The temporary position of the second listed candidate had meanwhile expired. In search for a new occupation he had been hired by industry, when the position was offered to him. This candidate as well took some time to decide his move. Finally, he rejected the offer from the university, partly because the salary that could be offered was not competitive to what he earned in industry, partly because the temporary position with the Cluster of Excellence couldn't compare to the essentially unlimited position he had in industry.

This development took up about the first year of the funding period. Most of the time the project coordinators were left with the impression that either of the candidates would accept, and the conditions were rather a matter of negotiations. Since the research foci of the candidates were quite different, it was not possible to start working into a specific direction without knowing who would be hired. Therefore, Research Topic A5 was in a pending state for about one year.

After the second candidate had ultimately rejected the offer in early 2008, the remaining funding period of the Cluster of Excellence was too short

to advertise the position again as planned. The alternative solution, to continue the original project plan with one or two post-doc researchers did not seem feasible, considering the workload of the project and the lack of suitable candidates. During a group meeting about the continuation of Research Topic A5 several alternative project options were discussed, including e.g. biomineralization, but no convincingly better suited theme than carbon capture and storage (CCS) could be identified.

After a brainstorming meeting across many disciplines related to CCS, new ideas involving an improved topical setup and innovative ways of implementing it within the cluster have surfaced. The declared goal is, to set up a new proposal on CSS soon.

Research Topic A6: Sea Surface Chemistry

Principal Investigators: F. Temps, D. Wallace, G. Friedrichs

Introduction

Research Topic A6 aims to link expertise from physical chemistry and marine chemistry in order to study processes at the ocean surface including microlayers, ice, and aerosols. Understanding of the complex heterogeneous and photochemical processes at these phase boundaries will help to assess the biogeochemical response of the surface ocean to changes of the future ocean, e.g. changes in the atmospheric composition, radiation, and dust input.

Junior Research Group

A new junior research group (JRG) was established within Research Topic A6 at the Institute of Physical Chemistry of Christian-Albrechts-University with the goal to explore chemistry at the ocean/air interface. Following an advertisement of the position in the Fall of 2006, six candidates from Germany, the United Kingdom and the United States were invited. A short list with two candidates was formed, and after successful negotiations, G. Friedrichs was appointed in August 2007. He received satisfying funding, office and laboratory space in the institute of physical chemistry, including space for a postdoctoral fellow and several PhD and diploma students. The institute provides access to its chemistry lab and to the fine mechanics and electronics workshops needed to set up several different experiments dedicated to specific problems in marine surface chemistry, kinetics of exchange and reactive processes at the ocean/air interface, and marine isotope analysis. The JRG

benefits from the stimulating research climate in the Institute of Physical Chemistry, the Chemistry Department of the Christian-Albrechts-University and the Marine Chemistry Group at IFM-Geomar with many opportunities for cooperation with existing research groups, especially in laser spectroscopy and theoretical chemistry.

Activities

JRG A6 "Ocean Surface Chemistry/Reaction Kinetics" aims (1) to identify and study chemical processes occurring at the water/air interface in microscopic detail by using sensitive laser spectroscopic methods, and (2) to provide modern optical detection techniques for use in other marine research applications. As it is typical for an experimentally working physico-chemical workgroup, an extended period of time is needed for supply, technical development and installation of the new experiments. Luckily, the secure funding situation within the Cluster of Excellence helps to shorten this initial set-up

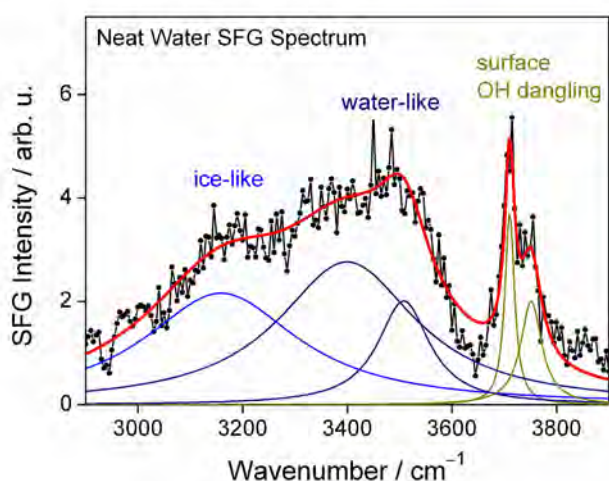


Figure A6-1. A measured test spectra of neat water. Note that the detected signal originates from the upper few molecular layers of water and thus directly reflects the molecular structure of the water/air interface. The spectrum can be assigned to free surface OH dangling bonds and to water molecules present in the hydrogen bonded network (ice-like and water-like structures). Such high spatial and spectral resolution as shown here could not have been achieved by alternative reflection or evanescent-wave based spectroscopic techniques.

phase. Currently, a new laser laboratory is established providing two main spectrometers: a continuous-wave cavity-ringdown spectrometer (cw-CRDS) to perform ultra-sensitive absorption measurements, and a sum-frequency-generation spectrometer (SFG, co-financed by the Cluster of Excellence Platform P2) to perform surface sensitive detection with sub-monolayer detection sensitivity. Additionally, a state-of-the-art frequency-modulation spectrometer (FMS, funded by the German Science Foundation, DFG) is ready for use in another laboratory. Multiple standard ultraviolet-visible (UV/VIS), Fourier transform infrared (FTIR) - and fluorescence spectrometers, equipment of the institute of physical chemistry and the workgroup of F. Temps - can be used on a shared basis. Hence the JRG will have access to a fully equipped optical detection facility by mid 2008. Next to the JRG group leader, the group consists of four scientists: K. Lass (postdoc, SFG), C. Fehling (PhD student, cw-CRDS), J. Bock (diploma student, CO₂ isotope ratio measurements) and J. Dammeier (FMS, combustion chemistry), the latter being funded through a separate DFG research project.

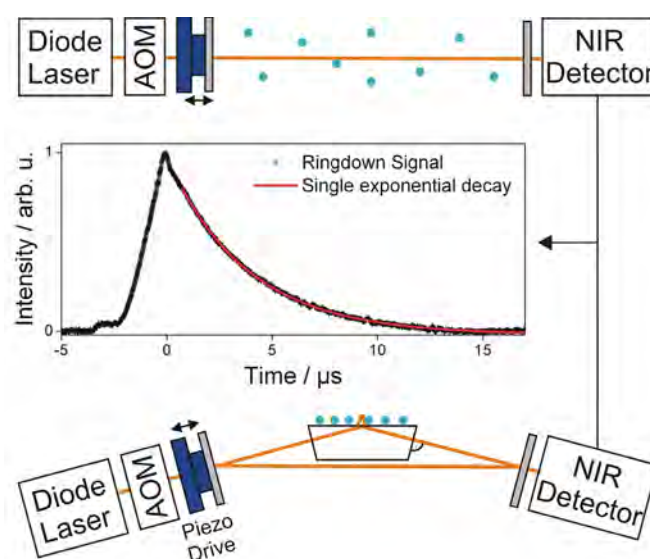


Figure A6-2. Operation of the spectrometer both in the gas-phase (upper scheme) and in the surface-mode (lower scheme) is planned. A plot of a raw ringdown signal is shown in the center.

SFG provides sub-monolayer sensitivity for probing surface composition and structure. It is surface specific (nonlinear polarization of interface vs. isotropic bulk), species selective (measurement of vibration spectra), and orientation sensitive (polarization dependence of SFG signal). See Fig. A6-1 for an example spectrum. Currently, measurements are performed on well-characterized phospholipid, long chain alkyl alcohol, and fatty acid monolayers to assess the sensitivity and reproducibility of the spectrometer and to test appropriate sample handling procedures. In a next step, a reaction chamber will be added to the experimental setup, which will enable us to study reactive gas uptake of such surface microlayers. Surface reactivity, e.g. the reaction with gaseous ozone, is discussed to have a direct impact on the oxidation capacity of the lowermost troposphere. Another project aims to gain insight into the role of surface specific reactions of halides that have been recently confirmed to be present directly at the water/air interface. Consequently, surface reactions such as $\text{O}_3 + \text{I}^-$ may play an important role for the release of gaseous bromine and iodine compounds from halide enriched water samples as they are present in the marine boundary layer.

The design detection wavelength range of the new cw-CRDS spectrometer ($\lambda = 1610\text{--}1690\text{ nm}$) was chosen to facilitate the detection of CH-bond overtone vibrations in the presence of rather high H_2O partial pressure backgrounds as they are inevitable above water samples (H_2O shows comparably small absorptions at wavelengths around $\lambda = 1650\text{ nm}$). Research targets are the gas phase detection of alkanes and short-lived alkyl halides (Fig. A6-2), and the investigation of gas-solid interactions of HOCl and HOBr on "wet quartz surfaces". Studies of heterogeneous reactions on ice surfaces are also feasible.

The high sensitivity of CRDS allows for accurate isotope ratio measurements as well. In the joint cluster project CP07A58 "The Potential for Field Measurement of Surface Water pCO_2 and $\delta^{13}\text{CO}_2$ on Volunteer Observing Ships using CRDS" (G. Friedrichs, N. Andersen, A. Körtzinger, A. Oschlies, F. Temps, D. Wallace) the performance of a commercial cw-CRDS CO_2 analyzer is tested and the spectrometer is modified to enhance its sensitivity. First laboratory tests on air streams equilibrated with surface seawater will be conducted soon and equilibration time and the requirements for constant temperatures will be addressed.

Other collaboration projects are in the field of optical instrumentation development. Spectroscopic characterisation of biofilms by means of UV/VIS, fluorescence, and IR detection are performed as a prerequisite for the design of an optical biofilm sensor (M. Fischer, M. Wahl, G. Friedrichs, F. Temps). Moreover, acting as a co-supervisor of a PhD project "Evaluation and Optimization of an Underwater Membrane-Compound-Sensor for the Measurement of Dissolved Carbon Dioxide" (P. Fietzek, CONTROS Systems & Solutions GmbH, A. Körtzinger), expertise in the field of molecular spectroscopy is transferred to application.

Research Topic A7: Valuing the Ocean

Principal Investigators: G. Klepper, T. Requate, K. Rehdanz

Introduction

In the global carbon cycle, oceans constitute the largest sink for carbon dioxide and significantly slow atmospheric changes and the impacts of climatic change. At the same time, climate change reduces the uptake of greenhouse gases in the oceans, increases ocean acidification which, in turn, impacts the commercial uses of the ocean's biological resources, and by contributing to the warming of the oceans may also increase emissions of other greenhouse gases, such as methane. The oceans therefore play an important role in the interplay of climate change and climate mitigation with social welfare and sustainable development, but are often ignored in economic analyses of carbon management.

Activities

The research topic features several subtopics as outlined:

1) Economic valuation of the ocean's role in the carbon cycle and consequences for abatement and mitigation strategies (cluster proposal CP0718). Within this research field two papers are in progress: a) Optimal carbon management with Ocean Sequestration by Wilfried Rickels and Thomas Lontzek, and b) Ocean Sequestration and the Oceanic Carbon Storage Index by Thomas Lontzek and Wilfried Rickels

2) Carbon Capture and Leakage: In this research field Gernot Klepper and Bob van der Zwaan investigate the effectiveness of ocean seques-

tration with respect to different leakage rates and discuss the role of discounting in the evaluation of carbon capture and storage (CCS) activities.

3) Ocean Accidification: In this research field Katrin Rehdanz and Richard Tol investigate the consequences of anthropogenic carbon emissions on other carbon reservoirs than the atmosphere, in this case the ocean. The increasing level of carbon in the atmosphere lead to increasing carbon concentrations in the ocean which correspond to decreasing pH-values and thereby to the problem of ocean acidification which is so far almost unconsidered in the assessment of carbon emissions. Paper in Progress.

4) Iron Fertilization: In this research field Katrin Rehdanz, Alexander Proelß, Mirjam Gleßmer and Wilfried Rickels want to investigate the potential of iron fertilization to enhance the sink activity of the ocean. It is planned to assess if the enhancement of the organic matter pump may just temporarily bind more carbon as more iron is added to this cycle or if the enhancement substantially increases the amount of organic matter which sinks to the seabed and is buried in the sediments. It is also planned to consider the necessary economic incentives and the legal aspects of iron fertilisation.

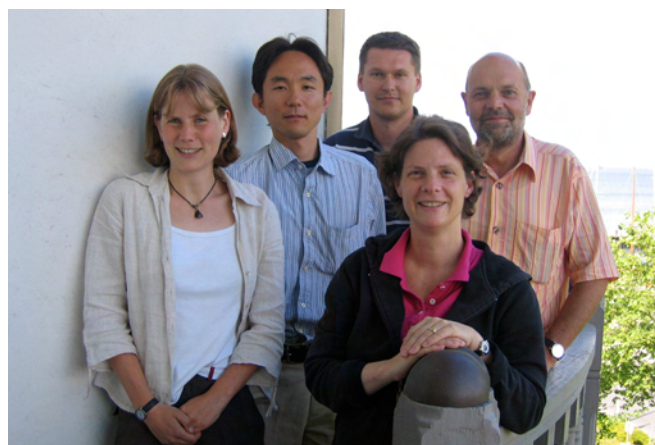


Figure A7-1. Members of the working group of Research Topic A7. From left to right: Sonja Peterson, Daiju Narita, Thomas Lontzek, Katrin Rehdanz, Gernot Klepper.

5) Carbon Sequestration and Emission Allowance Trading: In this research field Sonja Peterson, Katrin Rehdanz and Wilfried Rickels want to investigate the economic aspects of carbon sequestration in a general equilibrium analysis. In research field 1) and 2) carbon sequestration is considered more in a partial analysis whereas in this research field it is planned to model the interaction of energy and carbon markets with carbon capture and storage in the global economy with the IfW's computable general equilibrium model on dynamic applied regional trade (DART).

Other activities included invitations of guest researchers:

- Eric Naevdal (University of Oslo), November, 2007
- Daiju Narita (Columbia University), February, 2008
- Bob van der Zwaan, (Energy research Centre of the Netherlands (ECN), Harvard University, Columbia University), March, 2008.

Appendix B - Projects of Research Theme B: Resources and Risks

Research Topic B1: Living Resources and Overfishing

Principal Investigators: R. Froese, M. Quaas, T. Requate, U. Sommer

Introduction

Fishery exerts a prominent influence on marine ecosystems with direct effects on utilized and nonutilized species and their habitats (Pauly et al. 1998). Poorly defined property rights, the failure of international coordination and distorting subsidy policies have led to extremely high fishing capacities and stock levels near the risk of extinction. The lower food web is influenced by anthropogenic environmental change affecting energy transfer from primary to fish production. Despite the obvious policy failure, there is agreement that future management regimes must deal with rebuilding healthy ecosystems and new forms of governance. The aim of the new junior research group (JRG) is to apply a multidisciplinary approach toward new fishery management, focusing on advanced system analysis and a system of ecological and economic indicators which permit scrutiny of the success of fishery management scenarios. Major issues are combining dynamic ecosystem interactions, the stochastic nature of processes and climatic trends in a common modeling framework. The approach uses modern biological models to substitute Gordon-Schaefer-based models for the management of renewable resources and to include tuning procedures based on simple ecological and economic indicators. Intertemporal and optimal exploitation paths must be charac-

terized, and decentralized management rules and policies which are suitable for the implementation of these paths must be explored.

Junior Research Group

The JRG of Research Topic B1 started working on November 1, 2007 with M. Quaas filling his position at the University of Kiel. The research of the JRG is directed at the development of new concepts of fishery management that promote a sustainable fishery in order to counter the present massive overfishing of the sea. The JRG pursues an interdisciplinary approach where marine biologists collaborate with economists. Accordingly, three PhD students in Economics and one post-doc in marine biology have been recruited.

Activities

General

Research started in two directions. Firstly the management of an age-structured fish population shall be analyzed in cooperation with a small proposal project (CP0605, see Appendix D) led by T. Requate and R. Froese, and an international partner from the University of Trondheim, Norway. Initial results suggest that it may be beneficial to harvest a certain fraction of younger age classes of fish, although it is generally preferable to direct fishing effort more to the older age classes. Moreover, simulations indicate that the optimal steady state is periodically oscillating, with several overlapping frequencies under some parameter settings.

Second, the effects of consumer's preferences for food fish diversity are studied in a multispecies fishery model. Analyzing both the long-run equilibria and the dynamics of an open-access fishery it is found that the outcome is generally

less sustainable the stronger preferences for diversity are. We show that even without biological interactions the optimal landing fees for the different species are dynamically interdependent and have to be adjusted in a non-monotonic way. One policy implication is that substantial landing fees should be levied also on a fish species with a healthy stock if it is a substitute for an endangered species. These findings have already been accepted for presentation at two international conferences.

Cluster of Excellence Proposal

In 2006 the Cluster of Excellence approved funding for the proposal "Managing Cod and Sprat in the Central Baltic Sea – A Bio-Economic Multi-Species Approach with Stochastic Regeneration Functions". This project was carried out in 2007 (CP0605, see Appendix D).

Other Projects

R. Froese's research focused on further development of basic equations underlying mortality, somatic growth, reproduction and population increase of marine populations. It will facilitate the biological-socio-economic modeling aimed for in B1. He also coordinated the further development of AquaMaps (www.aquamaps.org), i.e., standardized distribution maps for now over 8000 species, including most marine fish, all marine mammals, and over 1,000 invertebrates. The mapping includes predictions for species distributions in 2050. This is relevant for the spatial component of Research Topic B1 and will contribute to the outreach and exhibition activities of the Cluster of Excellence. Contacts were developed with German retailers and several tools were developed to assist consumers and retailers in purchasing sustainable seafood.

U. Sommer has performed mesocosm experiments to study the effects of winter/spring warming on the spring development of plankton and the proliferation of food to zooplankton feeding fish. It was of particular interest, to see whether shifts in the seasonal growth and activity patterns of planktonic organisms would lead to a loss of synchrony between demand and supply in food-chain links ("mismatch") and thus to an interruption of upward energy and matter transfer in food-chains. As a result it turned out that a shortage in the supply of nauplii can seriously impact the development of a fish year class, because then nauplii are the only suitable food for first feeding fish larvae and fish larvae cannot survive without adequate food supply.

A second project focuses on ecosystem wide effects of cod exploitation in the Baltic Sea. A survey of long-term data on cod, sprat, zooplankton and phytoplankton revealed, that depletion of cod caused an increasing abundance of sprat because of reduced predation of cod on sprat. The increase of sprat feeding on zooplankton led to reduced zooplankton biomass and thus less grazing on phytoplankton. The increased biomass of phytoplankton is associated with an increased risk of harmful algal blooms associated with water quality problems (Casini et al. 2007).

A third project studies invasion by the ctenophore *Mnemiopsis leidyi*: Since fall 2006, this species has successfully established itself and reached population maxima of 500 ind·m⁻³ during the summer/fall period. Because of the high water content of its biomass (>99%) this species is practically worthless as a food for fish, but it is a potent competitor for fish feeding on zooplankton and a predator on fish eggs and larvae.

Research Topic B2: Marine Medicine: Interactions between Complex Barriers and Microbiota in the Ocean

Principal Investigators: S. Schreiber, J. LaRoche, T. Bosch, R. Schmitz-Streit, R. Schulz-Friedrich, U. Kunzendorf, J. Imhoff, E. Maser, P. Rosenstiel

Introduction

The collaborative research agenda of the Research Topic B2 is focusing on epithelial barrier function as one of the oldest autonomous defense mechanisms against foreign substances and/or pathogenic organisms. Function and failure of the immunological barrier integrity are of increasing interest to modern medicine. Chronic inflammatory diseases of the barrier organs such as the skin or the intestinal tract have seen a steep rise in incidence during recent decades. Ongoing efforts within the group substantially contribute to the comprehensive molecular risk map of human genetic polymorphisms associated with barrier disorders such as Crohn disease (*Nat Genet* 2007, *PNAS*, 2007a, *Nat Genet*, 2008) and Sarcoidosis (*Nat Genet*, in revision). Many findings point to a disturbance of ancient defense mechanisms such as NOD-like receptor dependent expression of secreted defense molecules (*J. Immunol.*, 2007) or autophagy, which together with an imbalanced biodiversity of the resident microbiota precipitates into disease.

A main agenda is the translation of the findings into marine model to understand trigger factors that initiate and perpetuate chronic inflammatory diseases. Characterization of the variation in innate immune genes (*PLOS Biology*, in revision), the induced-transcriptomal defense programs (the "defensom") and the accompanying changes in the resident microflora (*PNAS*, 2007b) is sought in

algae, polyps, jellyfish, bivalves and sea urchins. In the context of iron homeostasis as a survival and defense mechanism, a genome sequencing project of *T. oceanica* has been initiated together with the Cluster of Excellence Platform P3. Using the next generation sequencing platform of the Center for Molecular Bioscience in Kiel (ZMB), state-of-the-art technological approaches such as massively parallel transcriptome tag and microRNA sequencing are developed and have found broad applications also within other groups of the cluster.

Activities

The applicants have joined in this project to build a unique interdisciplinary research network on the phylogeny of host/microbial interactions in marine organisms and its relevance for human barrier disorders. Biological barriers are of pivotal importance for the defence of the organism against facultative pathogens of a hostile environment. Under normal conditions, such barriers are maintained without any development of inflammatory damages. However, in humans most of the barrier organs can be affected by chronic inflammatory disorders (skin: atopic dermatitis, psoriasis; gastrointestinal mucosa: Crohn's disease, ulcerative colitis (inflammatory bowel disease); lung mucosa: asthma, sarcoidosis, tuberculosis; oral mucosa: periodontitis). Chronic inflammatory barrier disorders affect at least 20% of the population in Western industrialized countries; more than 30% suffer from allergic diseases. The rising incidence in some of the diseases (e.g. Crohn disease, atopic eczema, asthma) suggest a strong influence of today's living conditions as trigger factors. All inflammatory barrier diseases result in a large negative impact on quality of life. They are chronic diseases leading to destruction of the affected organ and

eventually significant disability and mortality. Due to the young manifestation age in Crohn disease, ulcerative colitis, atopic eczema, asthma, sarcoidosis and tuberculosis these disease are a significant burden for economies in general.

In the last year, the group has substantially contributed to the comprehensive molecular risk map of human genetic polymorphisms associated with barrier disorders such as Crohn disease (*Nat Genet* 2007, *PNAS*, 2007a, *Nat Genet*, 2008) and Sarcoidosis (*Nat Genet*, in press). Many findings point to a disturbance of evolutionary ancient defense mechanisms already present in lower (oceanic) animal phyla such as NOD-like receptor dependent expression of secreted defense molecules (*J. Immunol.*, 2007), Annexin-dependent apoptotic signalling or autophagy. Although the exact trigger factors for the diseases are unknown, the general hypothesis is accepted that on the background of the genetic

risk factors, an imbalanced crosstalk of host and residing microbiota pivotally contributes to the initiation and perpetuation of chronic inflammatory responses.

As most molecular components of immunological barrier function that shield unicellular and complex organisms against environmental stress or invading microbiota evolved in the ocean, the consortium is focusing on functional and genomic annotation of orthologues of human disease susceptibility genes in aquatic organisms. Furthermore, microbial communities on surfaces of lower metazoans are characterized in order to understand how genetic variation in the host affects the commensal flora. As cnidaria are among the simplest animals at the tissue grade of organization, a better understanding of the microbiota associated with phylogenetically ancient epithelia was sought. Two species of the cnidarian *Hydra* were identified on the basis of rRNA comparisons. We analyzed individuals of *Hydra oligactis* and *Hydra vulgaris* from both laboratory cultures and the wild (Fig. B2-1). It could be shown that in these animals the microbial communities are species-specific. The unexpected observation that microbial communities were similar in *Hydra* polyps taken from the wild and polyps cultured for >30 years in the laboratory points to coadaptive radiation of *Hydra* and its microbial communities (*PNAS*, 2007).

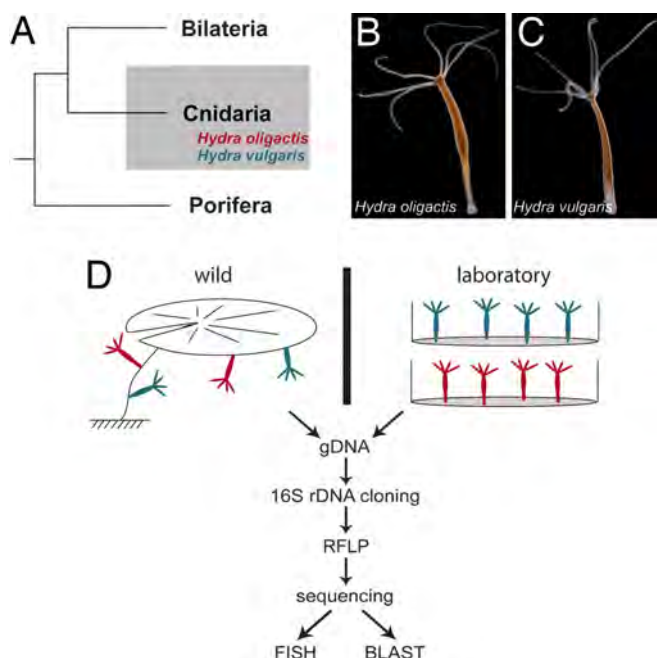


Figure B2-1. Analysis of *Hydra*-associated bacteria. (A) Phylogenetic position of the cnidarian *Hydra*. (B and C) Morphological characteristics of the two *Hydra* species analyzed. (D) Schematic representation of the approach. Bacterial microbiota were compared between *H. vulgaris* (blue) and *H. oligactis* (red) from laboratory culture (right; drawn in plastic dishes) and the wild (left; attached to water lily). Figure from *PNAS* Fraune and Bosch, 2007.

Cnidaria occupy an important evolutionary position for understanding direct host-microbe interactions. We have shown recently that the cnidarian immune system has evolved an elaborate mechanism to delete or suppress pathogenic intruders. Research into molecules of the innate immune response in Cnidaria has identified pattern-recognition receptors, most notably the Toll-like receptors, allowing



Figure B2-2. The bivalve *Arctica islandica*.

permanent surveillance of resident microbiota and intruding pathogens (*Genome Biology*, 2007 and *PLOS Biology*, in revision). Further insights into innate immunity are developed using next generation sequencing to delineate-transcriptomal defense programs (the "defensome") and the accompanying changes in the resident microflora in algae, polyps, jellyfish, bivalves (Fig. B2-2) and sea urchins (together with the JRG of Research Topic A1).

Vice versa, genes of marine organisms, which are regulated under stress conditions or by host/microbiobial interactions could be of utmost importance for the understanding of human barrier disorders. This approach has led to the identification of Deleted in Malignant Brain Tumors 1 (DMBT1), a soluble scavenger receptor and innate immune exclusion molecule first described in sea urchins upon LPS challenge, as a NOD-like receptor (NLR)-dependent defense mechanism in the human intestinal epithelium (Fig. B2-3; *J. Immunol.*, 2007). In this context, iron homeostasis and steroid metabolism have been identified as two conserved survival and defense mechanisms. *T. oceanica* is highly tolerant to iron limitation in contrast to two other diatoms for which genome sequences are available (PNAS, in press). Here, a genome sequencing project

of *T. oceanica* has been initiated together with the Cluster of Excellence Platform P3. Using the next generation sequencing platform of the ZMB, state-of-the-art technological approaches such as massively parallel transcriptome tag and microRNA sequencing are developed and have found broad applications also within other groups of the cluster (see also proposal CP0727 in Appendix E).

Steroids were identified by the group as evolutionary ancient signal molecules and play multifunctional regulatory roles in physiological processes like mineral, lipid or glucose homeostasis. Important diseases including diabetes type 2, obesity, hypertension, osteoporosis etc. are linked to a malfunction of the steroid hormone system. From an evolutionary point of view, it is anticipated that precursors of the vertebrate steroid signalling system do already exist in bacteria and that steroids serve

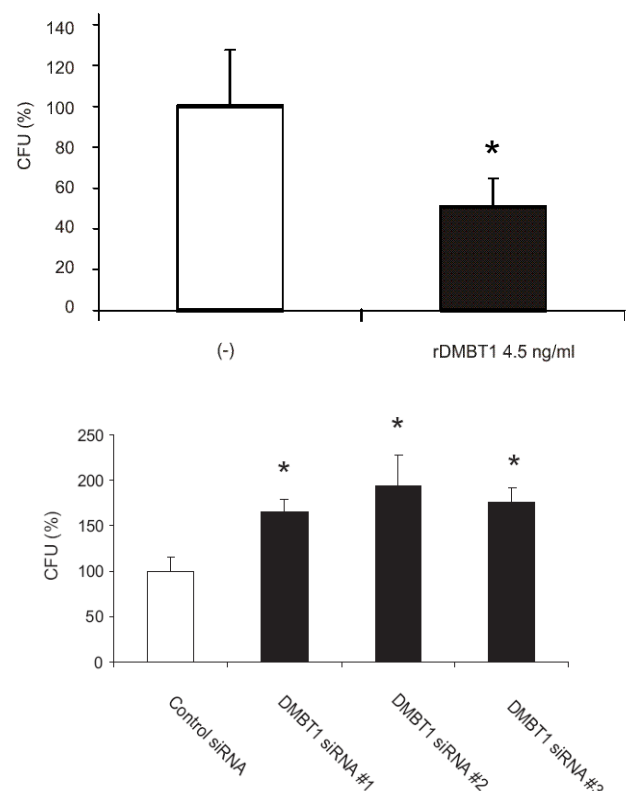


Figure B2-3. Consequences of the human orthologue of the sea urchin SRCR DMBT1 on bacterial invasion in intestinal epithelial cells were determined using Gentamycin-Protection assays. (from Rosenstiel et al., *J Immunol* 2007).

as interspecies signal molecules at procaryotic/eucaryotic interfaces. This part of research will elucidate how marine bacteria have evolved the steroid system to defend their ecological niche (biofilm in copepod) and which mechanisms they use to expand their capacity, diversity and adaptability to colonize eukaryotic epithelia (see also proposal CP0709 in Appendix E).

Junior Research Group

Barrier organs like the intestinal tract are the primary site of interaction between the immune system and surrounding microbiota. The immunological barrier is composed of cellular (epithelia and mesodermal immune cells) and non-cellular components (e.g. extracellular matrix and anti-microbial peptides). Recent studies demonstrate that genetic variants impairing barrier function are associated with a variety of chronic inflammatory diseases. A substantial contribution has been made to the understanding of a compre-



Figure B2-4. Philip Rosenstiel is Junior Professor for Molecular Marine Medicine at the Christian Albrechts University Kiel. Before his appointment he has worked as physician researcher with a clinical background in internal medicine and was leader of a cell biology group in Kiel and at the MPI for Molecular Genetics, Berlin. He was born in Düsseldorf, got his primary education in Bremerhaven and studied medicine in Kiel and Boston. After a 1 year research scholarship at the Jackson Laboratories (Maine, USA), he graduated from medical school in 2001.

His special interest is the interplay of mucosal immune responses and epithelial barrier integrity, with a focus on the functional genomics and evolution of innate immunity.

hensive molecular risk map of human genetic polymorphisms associated with barrier disorders such as Crohn's disease (Nat Genet 2007, PNAS, 2007, Nat Genet, 2008) and Sarcoidosis (Nat Genet, in revision). As many of the susceptibility genes can be found in evolutionary ancient pathways of self-defense and most of these gene families evolved in the oceanic environment, the JRG led by Dr. Philip Rosenstiel (Fig. B2-4) is interested in the phylogeny of innate immune recognition and protective cellular programs in marine animals.

The multidisciplinary team (marine biology, molecular biology, medicine and computational biology) has joined using different marine model organisms to unveil the complex genetic and genomic (patho-) physiology of epithelial barriers, stress reactions and host/microbiota interactions. Besides analyses of primordial innate immune receptors in cnidarians together with the Department of Zoology (T. Bosch), a major focus is the evolutionary origin of epithelial-mesenchymal interaction as a defense mechanism using a combination of unbiased ultra high-throughput sequencing-based expression profiling and in vivo immune perturbation in sea urchins and bivalves. The simplicity of the animals and the availability of new technology enable experimentation in the context of the intact organism. Together with microbiological collaborators (R. Schmitz-Streit) sequence variations of key innate immune mediators are studied and microbial consortia in different sea urchin populations characterized. The approach will delineate the immune programs that carry out barrier function and the evolutionary pressures that shape immune diversity.

Research Topic B3: Seafloor Resources

Principal Investigators: C. Devey, K. Hoernle, L. Rüpke

Introduction

Seafloor resources, such as polymetallic sulfides and gas hydrates, are formed by fluids percolating through and interacting with the igneous and sedimentary rocks of the ocean crust. Polymetallic sulfides are characterized by high contents of copper, zinc as well as of gold, silver and other industrial trace metals which are potential metal resources. Gas hydrates may become an important energy resource in the near future. The resource elements are extracted from the subseafloor, transported in fluids and subsequently precipitated close to the seafloor in response to changing physical-chemical conditions. Although the physical properties and composition of these fluids are well known, there is a substantial gap in our worldwide knowledge of the mechanisms which drive and control three-dimensional, time-dependent reactive fluid flow through the ocean crust. This knowledge is essential for a proper understanding of the formation of these seafloor resources and thus their potential exploration. The junior research group (JRG) determines geologically relevant boundary conditions and to model transient three-dimensional fluid flow in the ocean crust in order to improve our understanding of the formation of these seafloor resources.

Junior Research Group

The JRG Seafloor Resources studies natural geological resources at the ocean floor. Examples of this are deep sea ore deposits that form as a byproduct of hydrothermal activity near

mid-ocean spreading centers and off-shore hydrocarbon occurrences found at passive continental margins.

During 2007 the recruitment processes has been completed and all positions in Research Topic B3 are now filled. In October 2007, Lars Rüpke has started as the new JPG leader. Lars Rüpke's main expertise is in numerical modeling of geological processes. He holds a degree in geophysics from Brest University, France, and a PhD in geophysics from Kiel University, Germany. Before joining the Cluster of Excellence Future Ocean, he was a senior researcher and leader of the geodynamics group at Physics of Geological Processes in Oslo, Norway.

In early 2008, three new scientists, Sonja Theißen, Karthik Iyer, and Nasser Bani Hassan have started their positions in the Seafloor Resources group. Karthik Iyer, born in India, holds a PhD in Geology from Oslo University and a degree in Mineralogy from the University of Hamburg, Germany. His main expertise is in alteration processes occurring during fluid flow through the Earth's crust and mantle. In addition to his background in mineralogy, he is experienced in numerical modeling. He will explore the feedback between reactions, deformation, and fluid flow in hydrothermal systems. Sonja Theißen holds a degree in geology from the University of Bochum, Germany and joined the group as a PhD student. Building on her experience in numerical modeling gained during her master thesis work, she will develop new models of continental break-up and ocean basin formation. The newest member of the group is Nasser Bani Hassan from Iran who also joined as a PhD student. Nasser Bani Hassan holds a degree in geophysics from Teheran University, Iran, and has several years of experience in seismic processing from his



Figure B3-1. The Seafloor Resources group in front of the "5 o'clock Moho" at the Oman ophiolite. From left to right: Sonja Theißen, Karthik Iyer, Volker Schenck, Dominique Lattard, Kaj Hoernle, Francoise Boudier, Lars Rüpke, Larry Cathles, Adolphe Nicolas (photographer). In the background the exposed boundary between the Earth's crust and mantle is visible.

previous appointment with the Iranian national oil company. During his PhD work, he will develop new models of hydrothermal convection, help to acquire new seismic data, and work on the integration of geophysical data into the numerical models.

Activities

In relation to the new appointments, three core research projects have been initiated: integrated studies of fossil hydrothermal systems at the Oman ophiolite, joint geophysical and numerical work on the active Logatchev hydrothermal vent field in the Atlantic ocean, and integrated basin modeling of continental break-up and new ocean basin formation.

Hydrothermalism in fossil oceanic crust

Deep sea hydrothermal systems belong to the most exciting discoveries in oceanography. At young ocean floor, seawater penetrates deep into the crust, reacts with magmatic intrusions, and is vented back into the oceans as a mineral rich high temperature hydrothermal fluid at so called black smokers. Vast ore deposits form in

the environment of these deep sea vent sites and the extreme environmental conditions have led to the development of unique ecosystems. Much has been learned from direct observations at active vent sites but the processes occurring deep inside the young ocean floor remain inaccessible to direct studies.

To learn more about these deeper processes, the Seafloor Resources group has initiated a research project on the Oman ophiolite (Fig. B3-1). The unique geology of Oman, where complete sections of old ($\sim 90\text{Ma}$) ocean floor are exposed at the surface, allows us to directly study those structures that are at active vent sites buried deep inside the ocean crust and are inaccessible to direct observations. In early 2008, the Seafloor Resources group organized a first expedition to the Oman ophiolite that was carried out in collaboration with the Universities of Montpellier, France and Cornell, U.S.A. During this expedition, it was possible to study and sample fluid flow structures that crosscut the entire oceanic crust. In addition, pervasive serpentinization of mantle rocks and the presence of hydrous melts well below the crust-mantle boundary may indicate that seawater circulates to great depths and



Figure B3-2. ROV images of a black smoker and pillow basalts at the ocean floor near the Logatchev active vent field in the Atlantic Ocean. On the right hand side, exposed analogs at the Oman ophiolite are shown.

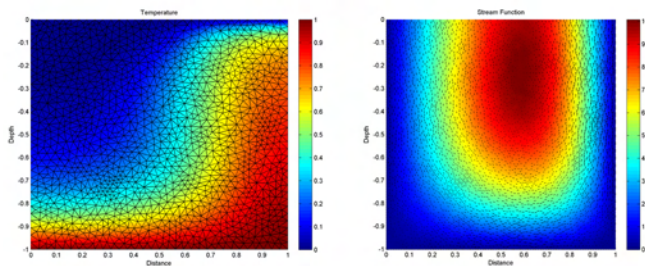


Figure B3-3. Benchmark simulation of convection in porous media. The two plots show the temperature field and the stream function for open-top porous convection. The developed code builds upon the Milamin code (Dabrowski et al. 2008) and solves up to a million degrees of freedom in less than a minute.

reaches and reacts with mantle rocks. Combined geochemical, petrological, mineralogical, and numerical studies will be carried out to shed light on the details of hydrothermal circulation through young oceanic crust.

Logatchev Active Vent Field Hydrothermalism

Complementary to the Oman project, joint geophysical and numerical work has been initiated on the active Logatchev vent field (Fig. B3-2). Logatchev is a mantle hosted hydrothermal vent field slightly off-axis from the mid-Atlantic ridge at 14° 45'N. Multiple previous scientific cruises and projects, including several with participation from members of the Seafloor Resources group, have assembled a wealth of geophysical and oceanographic data that we can build upon. The key objective of this project is to use numerical simulations to test and explore scenarios build upon geophysical and geochemical observations. During the first phase, very high resolution hydro-

thermal convection models will be designed that are able to resolve those fine scale structures that are evident in geophysical data. For this purpose we have modified a high-performance finite element code called Milamin, developed at Physics of Geological Processes in Oslo, Norway (Dabrowski et al., 2008), to solve for hydrothermal convection in porous media (Fig. B3-3). Already in the first test runs we have performed porous convection simulations with over a million nodes with time steps taking less than a minute. This efficiency of the code will allow us to implement complex equation of states and to resolve fine scale structures.

Continental Break-up and Ocean Basin Formation

The third project uses numerical modeling techniques to explore the geological processes active during continental break-up and new ocean basin formation. Continental margins are the principal regions where deformation of the Earth's lithosphere localizes. Strain localization in response to extensional tectonic forces results in continental rifting and ultimately the formation of a new ocean basin. But continental margins

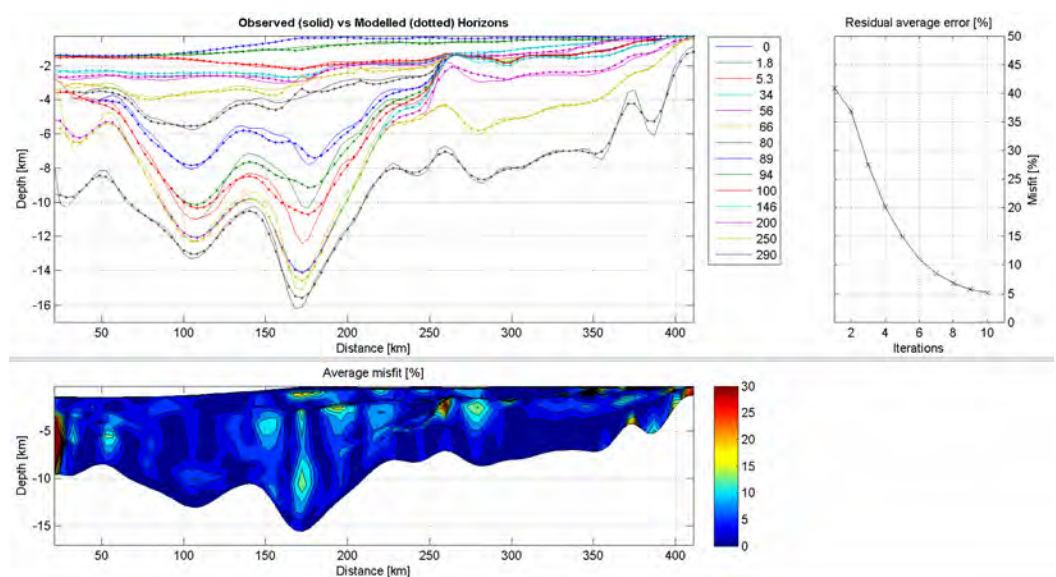


Figure B3-4. Reconstruction of a transect across the Norwegian continental shelf. The solid line represents the input stratigraphy while the lines with symbols show the modeled stratigraphy. The good match between the two shows that the reconstruction is a valid approximation to structural evolution of the Norwegian volcanic margin.

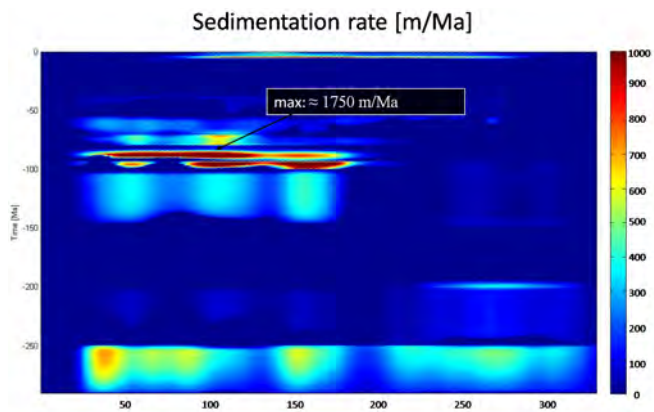


Figure B3-5. Predicted sedimentation rates through time along a transect across the Norwegian continental shelf (Euromargin transect 2). The reconstruction reveals strong variations in sedimentation rates and possible changes in deposition systems through time.

and sedimentary basins are not only studied by Earth scientists to better understand the tectonic processes that shape the surface of the Earth; sedimentary basins also host most of the world's hydrocarbon resources and are of prime interest to the exploration industry.

The Seafloor Resources group studies the geological processes active during continental break-up with numerical models. In a first case study, the thermal and structural evolution of the Norwegian continental margin has been successfully reconstructed (Fig. B3-4). The reconstruction approach is based on the method presented by Rüpke et al. (2008) and permits to simultaneously resolve for lithosphere and basin scale processes. This allows us to quantify sedimentation rates, make predictions on changes in deposition systems through time, and explore the links between deep and shallow processes at continental margins (Fig. B3-5).

Research Topic B4: Submarine Hazards

Principal Investigators: J. Behrmann, E. Flüh, W. Rabbel, S. Krastel

Introduction

Scientists involved in Research Topic B4 „Submarine Hazards at Continental Margins: Earthquakes, Submarine Slope Failure and Tsunami Generation“ focused their activities in the following two themes.

- (1) Assessment of the link between the structure and dynamics of subduction zones and the mega-earthquake cycle, with studies completed, or in progress, at the active margins of Costa Rica and Nicaragua, the Sunda margin off Indonesia, and the South American Pacific margin offshore Chile.
- (2) Slope stability issues at passive continental margins, especially regarding the risk of exceptionally large and frequent submarine slope failures. Work is concentrated on three areas of young and repeated sliding mainly endangering communities in Europe and North America: the Yermak Slide in the Arctic North Atlantic, the Northwest African margin off Mauretania, and the Gulf of Mexico continental margin off Texas and Louisiana.

Junior Research Group B4, headed by Sebastian Krastel, has been set up and will be at full operational strength (1 Postdoc, 3 PhD-students) by October 2008. The work of the group will focus on the question “Why do some continental slopes slide, whereas others are stable?” using a combination of geophysical, sedimentological and geotechnical methods.

Research Topic B4 of the Cluster of Excellence "Future Ocean" maintains strong and productive links with the recently extended German science foundation (DFG) collaborative research project (SFB) 574 "Fluids and Volatiles in Subduction Zones".

Activities

In the following we briefly report progress on the two major research themes outlined above.

Structure and dynamics of subduction zones, and the mega-earthquake cycle

The analysis of the seismicity of the outer rise in the down going oceanic plates off Chile and Nicaragua was completed. For the first time ever, local seismological networks were deployed on the Outer Rise to monitor earthquake activity there. This was found to be much higher than previously assumed, and faults cut up to 10-km deep into the Earth's mantle. The change from extensional to compressional regime is found to coincide with the 450°C isotherm. Seismological studies of the subduction zones in Central America and Chile have resulted in detailed images of these zones. It was learned that the Central American subduction zone is highly variable, subducted seamounts were discovered and it was possible to detect the steeply dipping slab in Southern Costa Rica.

The seismic and volcanic activity in Central Java related to the subduction of the Indo-Australian plate was studied. In the framework of the Merapi Amphibious Experiment (MERAMEX) network more than 100 seismographic stations were installed onshore and offshore in Central Java and operated for more than 150 days. In addition, three-dimensional active seismic experiments

were carried out offshore. The tomographic inversion of this amphibious set of active and passive seismic data provided high-resolution images of the crustal and upper mantle structure, which is relevant to the investigation of the origin of natural hazards. Evidence for an exceptionally strong low-velocity anomaly (-30%) was found in the back-arc crust northward of the active volcanoes. In the upper mantle beneath the volcanoes, we observed a low-velocity anomaly inclined towards the slab, probably reflecting the fluids pathways and partially melted material in the mantle wedge. The large volume of the anomaly suggest that it represents the image of a super-volcano in the making. So-called super volcanoes may erupt between 2000-5000 km³ of magma in a single event and are typically associated with subduction zones. The crust in the Central Java forearc appears to be strongly heterogeneous. The onshore part consists of two high velocity blocks separated by a narrow low-velocity anomaly, which can be interpreted as a weakened contact zone between two rigid crustal bodies. The recent Java Mw = 6.3 earthquake (27.05.2006) occurred at the lower edge of this zone. In order to understand the tectonic framework aftershocks of the May 2006 event were measured by the German Earthquake Task Force, using a temporary seismological network. First results suggest that the aftershocks cluster at the eastern edge of the elongated low-velocity zone located in this region.

Currently our seismological and seismic data collected in the Antilles and Tonga-Kermadec subduction zones in 2006/2007 are analyzed. Seismic data were recently collected off South-Central Chile. Amphibious seismological networks are currently in operation in and offshore South-Central Chile and the Ligurian Sea.

Slope stability at passive continental margins

An integral part of this research topic are the post-cruise science activities of IODP Expedition 308, a program dedicated to the study of overpressure and fluid flow on the Gulf of Mexico continental slope. It was examined how sedimentation, overpressure, fluid flow, and deformation are coupled in a passive margin setting. The expedition investigated the model of how extremely rapid deposition of fine-grained mud leads to rapid build-up of pore pressure in excess of hydrostatic (overpressure), under-consolidation and sedimentary mass wasting. Expedition 308 tested this model by measuring physical properties, pressure, temperature, and pore fluid compositions within low-permeability mudstones that overlie permeable, overpressured aquifers in the Brazos-Trinity and Ursa Basins, offshore Texas and Louisiana, U.S.A. Drilling at Ursa documented severe overpressure in the mudstones overlying the aquifer, and a related history of repeated (on an approximate 5000 year time scale) large-scale submarine sliding. IODP Expedition 308 science provided the foundation to implement long-term in situ monitoring experiments in the aquifer and bounding mudstones in a future expedition. The most important achievement of IODP Expedition 308 is to have successfully recorded in situ formation pressure and temperature in an overpressured basin. This is the first time that a coherent data set of such measurements has been obtained

New working areas for JRG B4 will be the NW-African Continental margin, the continental margin off Uruguay and Argentina, and the Yermak/Hinlopen Slide in the Arctic Ocean. Previous investigations off NW-Africa were carried out by S. Krastel at Bremen University prior to his appointment as head of the JRG.

His investigations demonstrated that sediment transport at the NW-African continental margin operates with different rates and styles, including significant transfer of land-derived terrigenous and hemipelagic sediment to the deep sea. Four mega-slides, each affecting over 30,000 km² of seafloor, were identified along the continental slope off NW-Africa. All slides are complex and show a stepped headwall pattern typical for retrogressive sliding. Several buried mass wasting events are found beneath the youngest slide complex for all slides, revealing that these sections of the continental margin have been unstable for a long period of time. Stacking of mass wasting events and the alignment of buried scarps with much younger headwalls suggest that sediments deposited above buried scarps are potentially unstable especially due to differential compaction and oversteepening, and therefore remain unstable after the initiation of land sliding. Especially the young (ca. 10ka) Mauritania Slide Complex represents a formidable geological hazard, as the current focus of hydrocarbon exploration offshore Mauritania is centered directly upon the upper part of this slide. Ongoing work off NW-Africa is focused on the preparation of an IODP-proposal 'Paleoclimate and sediment transport at the continental margin off NW Africa'. A pre-site survey is scheduled for Spring 2009. Available data sets off Uruguay and Argentina are currently investigated as preparation for another research cruise to take place in early Summer 2009. The main objectives of this cruise are process-orientated investigations of mass wasting events.

The Yermak/Hinlopen slide was analyzed by the new post-doc in the JRG, D. Winkelmann, during his PhD thesis at the Alfred-Wegener Institute, Bremerhaven. The investigations were done under the framework of the European Science

Foundation (ESF) EUROMARGINS program and within the collaborative project SPACOMA („Slope Stability on Europe's Passive Continental Margins”).

This submarine slide was mapped in detail and classified as a megaslide event at 30.000 years BP. Its dynamics and genesis has been investigated further. The results are the revised and now established true geometry with an area of more than 10.000 square kilometers and a volume of the slide debris of approximately 2400 km³. These numbers put the Yermak Megaslide among the largest exposed submarine slides worldwide, with headwalls up to 1600-m high. Its extremely over-thickened deposits and the environmental conditions during its genesis mark this slide as special (an end-member) justifying further investigations. Future tasks at the Yermak Megaslide include the completion of mapping in the Nansen Basin and investigations of its distal structure by seismic methods to establish the crucial parameters for numerical modeling. In this context, the identification and examination of related tsunami deposits are of high priority to evaluate the slide's dynamics and its tsunami potential. Further emphasis will be put on the headwall region to elucidate the role of potential gas hydrates for the evolution of Hinlopen/Yermak Megaslide.

Junior Research Group

In March 2008, Sebastian Krastel has started as leader of the JRG B4. S. Krastel's main expertise is the analysis of sediment transport processes and fluid flow structures by means of high resolution acoustic imaging techniques. He holds a degree and a Ph.D in geophysics from Kiel University. During the past six years he worked as 'Wissenschaftlicher Assistant' (Assistant Professor) at Bremen University, Germany. D. Winkelmann

started as post-doc in May 2008. He owns a Ph.D from Bremen University. His main expertise is the sedimentological and geotechnical analysis of slide sediments. Three Ph.D positions will be filled until October 2008.

The group will focus on the analysis of mass wasting and associated hazards at passive and active margins using a combination of acoustic, sedimentological, and geotechnical methods. Central questions will be: How stable is a slope? What are the dominant processes and environmental controls of mass wasting? What is the frequency of mass wasting at continental margins? Why are some slides tsunamigenic, while others are not? What interactions exist between tectonic processes in subduction zones and near surface sediment failure at the slope? In addition lakes will be used as 'models for oceans' where mass wasting can be studied on small scales.

Research Topic B5: Sea-Level Rise and Coasts at Risk

Principal Investigators: K. Stattegger, W. Rabbel, K. Schrottke, A. Vafeidis

Introduction

Many coastal zones can suffer from the destructive impacts of tsunamis, storm surges and waves, particularly in densely populated river-mouth systems. Climate change and related sea-level rise (SLR) will strongly modify hydro-, sediment- and morphodynamics in coastal environments, forward saltwater intrusion into ground water and soils, and aggravate coastal hazards for many cities and societies. Two Junior Research Groups (JRGs) were established under Research Topic B5:

B5(1) "Sea- Level Rise and Physical-Morphological Changes in Coastal Seas" analyzes the interaction of the three land-sea, freshwater-saltwater, and water column-seafloor coupled interfaces. Combined water column and seafloor surveys at high-resolution timescales integrate information on sediment dynamics and on migrating freshwater/saltwater transition zones. This constitutes a new, multifaceted approach referred to as Change Analysis. The JRG is positioned at the interface between marine sedimentology and marine geophysics and bridges the gaps between measurements of present-day hydro- and sediment-dynamic processes and reconstructions from the sedimentary record.

B5(2) "From Coastal Hazards and Vulnerability to Risk Management" integrates this information, along with data on the socio-economic and ecologic vulnerability on the landward side, to establish a quantitative and model-based

multihazard risk assessment tool. The primary objectives of the new JRG in B5(2) are to identify possible hotspots of risk in selected regions, to quantify potential damage versus the economic benefits of response options and to improve the feasibility of decision-making processes in risk mitigation in the presence of considerable uncertainties.

Activities

The most important issue in 2007 was the filling of the two open junior-professorships: K. Schrottke took up the junior-professorship of B5 (1) by January 01, 2008. Her research activities cover water column – sea bottom interaction in coastal areas and river mouth systems in relation to environmental changes and sea-level rise. A. Vafeidis took up the junior-professorship of B5 (2) by February 01, 2008. His research focuses on risk assessment in the coastal zone driven by climate change and sea-level rise. Both professors are currently setting up their working groups.

The head of the JRG B5(1), K. Schrottke, has started her job in January 2008. Her main focus is on process-related sediment dynamics at coastal sites, which are severely influenced by anthropogenic impact, to name river mouths systems in particular. High amounts of suspended particulate matter combined with high sediment accumulation rates especially of soft cohesive sediment often cause large economic as well as ecologic problems within these complex coastal systems. Detailed knowledge of sediment movement, morpho- and hydrodynamics especially at the water-sediment interfaces is thus strongly needed for future prediction of coastal evolution, in particular with regard to a change in forcing conditions e.g. sea-level rise and increase in storm activity.

In a first step, office facilities had to be set up by room organizing, renovation and refurnishing. Activities to build up a new laboratory for laser based sediment analytics are ongoing. Highly sophisticated measuring equipment, such as the SES2000, the C3D sidescan-sonar and the LISST system has been bought on behalf of the Cluster of Excellence Platform P4. Morphodynamic processes on time scales down to seconds and spatial scales down to millimeters are successfully measured in a first project investigating dredging effects on sediment dynamics in the Weser estuary in cooperation with Senckenberg Institute of Wilhelmshaven. M.Sc. Svenja Papenmeier has started her PhD studies in March 2008. A new technician will support the hydro-acoustic laboratories from July 2008 on. Another PhD student will start in summer 2008. Another postdoc position will be filled within summer 2008.

The head of the JRG B5(2), Athanasios Vafeidis, joined the Cluster of Excellence and the Institute of Geography in February 2008. Expanding his scientific approach on coastal-risk research he developed the project proposal COMPASS on the assessment of coastal vulnerability which has been submitted to the newly established European Union Framework Program 7 (EUFP7) programme IRSES. COMPASS involves collaboration with the Potsdam Institute of Climate Research (PIK), the University of the Aegean and institutions from Argentina, Chile and Brazil. The project has been evaluated and received an overall mark of 92% while the decision on whether it will be funded is expected within July 2008. In addition proposal IRMA, in the context of the EU Interreg programme, under the co-ordination of LANU and the participation of the Geography department has been submitted to the EU.

Organization of the office facilities (purchase of office and technical equipment, computing facilities etc) has been nearly completed. Additionally, positions for staff (post-doc and doctoral) have been advertised internationally. One PhD student (M. Schürch) joined the Group in April 2008. Two post-docs and two doctoral students are expected to commence within the next few months.

Joint research activities investigate the impacts of tsunami waves in the coastal zone of western Thailand granted by DFG. Here B5(1) explores marine tsunami deposits (Project Tsunami deposits in nearshore and coastal waters of Thailand) while B5(2) concentrates on tsunami risks, vulnerability and resilience (Project Tsunami-related risk/management research in Thailand). Other current research comprises the hydro- morpho- and sediment dynamics of coastal seas and river-mouth systems in relation to the evolution and migration of shorelines due to changes in sea level, coastal erosion due to anthropogenic impacts as well as the geophysical exploration of archaeological sites under water. Associated coastal vulnerability, hazards and risks are evaluated by a comprehensive approach for vulnerability assessment and multi-hazard risk modeling. A special topic of B5(1) focuses on sea-level change and coastal evolution of tropical river-mouth systems in SE Asia and Brazil (three projects funded by DFG, see Appendix). Another key-region is the southern Baltic and North Sea, where B5(1) investigates basement structures, evolution, hydro- and sediment-dynamic processes, exploitation, use and protection of the coastal zone (seven projects) while B5(2) concentrates on the assessment of climate change impacts and adaptation strategies (six projects).

Research Topic B6: Law of the Sea and Marine Resources

Principal Investigators: A. Zimmermann, F. Colijn, A. Proelß

Introduction

Most activities at sea have a legal dimension. At the same time the oceans offer an extremely wide range of possible (traditional and innovative) uses, including fishery, the exploitation of hydrocarbons, mineral and non-mineral resources ("blue biotechnology"), alternative energies, climate change-related uses, such as the sequestration of CO₂, and transport. Against this background the proposed junior research group (JRG) and the proponents of Research Topic B6 focus on the interrelationships between the technical feasibility of these and other uses, their domestic and international legal and economic dimensions, and their possible ecological impacts. The group focuses both on the current regulation of ocean uses under the United Nations Convention on the Law of the Sea (UNCLOS; and customary international law) as well as on possible future developments in the area in light of the aforementioned ecological, economic and natural science-based requirements. These studies do take account of the varying degree of sovereign rights exercised by coastal states over their internal waters and territorial seas, their respective continental shelves and exclusive economic zones, in particular those of the high seas and the deep-sea floor.

Activities

In July 2007, the Walther-Schücking-Institute for International Law (WSI) hosted a workshop on international law aspects of maritime security. The results were published as a conference

volume (A. Zimmermann/C. Tams [eds.], *Seesicherheit vor neuen Herausforderungen*, Kiel 2008). The proceedings contain contributions by scientists, including the directors of the WSI, as well as practitioners from federal authorities and members of the German Navy. The two central points of debate discussed in the contributions are the international legal requirements relevant to combating terrorism at sea and the national division of competence between the Federation and the States on that field. It is envisaged to continue cooperation with the German Navy during a workshop organized by the German Navy in the fall of 2008.

Two PhD projects funded from successful internal applications are ongoing. The first project deals with the legal regime of drifters and gliders (K. Bork). First results are soon to be presented in an article by K. Bork et al. ("The Legal Regulation of Floats and Glides – In Quest of a New Regime?"), which has been accepted for publication in "Ocean Development and International Law". The paper concludes that the provisions of the UNCLOS are not, or at least no longer, adequate to regulate the deployment of free floating equipment, and that, in particular, marine scientific research projects using floats and gliders are seriously hampered by Part XIII UNCLOS on marine scientific research.

The second project addresses new uses of the deep sea-bed (T. Müller) and focuses on the applicable legal rules governing the protection and effective management of marine genetic resources. In this respect, the candidate does not only analyze the scope of application of the principle of common heritage of mankind, but also examines the sensitive issue of intellectual property rights resulting from marine scientific research with deep sea-bed organisms.

U. Jenisch, being a co-opting member of B6, has recently published two articles in "Natur und Recht" (2008, pp. 227 et seq.) and "Marine Forum" (2008, pp. 24 et seq.), which focus on international law of the sea aspects of climate change on the one hand and the legality of sea-bed carbon capture and storage on the other.

The Research and Technology Center Westcoast (FTZ) in Büsum, Germany, generally fulfils tasks in an interdisciplinary way with emphasis on marine and coastal ecology. The research group "Ecology of marine birds and mammals" performed research on cetaceans since 1990. Since this time, the division has been conducting a monitoring program on investigations on the zoology and health of cetaceans and seals in the German North and Baltic of Schleswig-Holstein. The studies included research on reproduction, nutrition, age determination, pathology, abundance, distribution, migration, telemetry, and bioacoustics. Results of the research conducted are used to detect important habitats of and to evaluate effects of anthropogenic activities on marine mammals. Scientists of the marine mammal division of the FTZ have been participating in different international meetings and associations for many years. This includes the Trilateral Seal Expert Group of the Common Wadden Sea Secretariat, the Working Group of Marine Mammal Habitat, the Working Group of Marine Mammal Population Dynamics and Trophic Interactions of the International Council for the Exploration of the Sea, meetings of ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas) and the IWC (International Whaling Commission). In 2007, the FTZ has conducted surveys for the abundance and distribution of harbour porpoises in the German Exclusive Economic Zone (EEZ) in the North Sea and Baltic Sea. The results are used

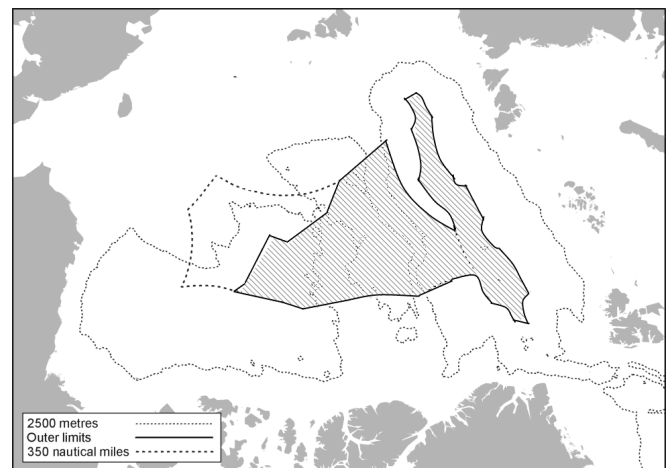


Figure B6-1. New evaluation of outer limits of the continental shelves in the Arctic Ocean (A. Proelß and T. Müller 2008, based on maps by Macnab et al. 2001)

as the basis to decide where critical habitats need to be protected, and where conflicts of anthropogenic activities are expected. In this context A. Proelß and T. Müller submitted an article on "The Legal Regime of the Arctic Ocean" which has been accepted for publication in "Zeitschrift für ausländisches öffentliches Recht und Völkerrecht" (Fig. B6-1, Heidelberg Journal of International Law).

In the Baltic Sea a strong increase in number of stranded harbour porpoises has been observed by the stranding network; investigations on the health status of the animals concerned were undertaken. The sampled data indicates that harbour porpoises are under continuous pressure by anthropogenic activities and require efficient protection. Having said that, the reasons for the process identified are still unclear and, thus, call for further investigations.

Junior Research Group

Staffing

A. Proelß was appointed as university professor effective from 1 September 2007 and has immediately initiated the set up of the JRG for Research Topic B6. Since 1 November 2007, the group consists of three research assistants (PhD

students), one office assistant and four student assistants, all of whom being members of the WSI. Additionally, two research assistants assigned to the FTZ, being involved in a joint research project on marine mammals, were employed as from January 2008. Due to the participation of the JRG in the internal proposal "Alternative Scenarios for European Fisheries" which is likely to start in the summer of 2008, it is planned to recruit at least one further research assistant.

Research

Since September 2007 members of the JRG have undertaken the following research projects:

A. Proelß and T. Müller submitted an article on "The Legal Regime of the Arctic Ocean" for publication (review process pending). The paper addresses continental shelf delineation in the Arctic, the competences of the UN Commission on the Outer Limits of the continental shelf, the question of passage through the North West Passage, and the protection of the Arctic environment in a comprehensive manner. The authors conclude that the dispute over the control of the North West Passage as well as the struggle over the resources of the Arctic sea-bed are adequately addressed by the existing legal framework enshrined in the UN Convention on the Law of the Sea (UNCLOS). Especially, contrary to what has been argued as to date, a rather large portion of the sea-bed underlying the Arctic Ocean cannot be claimed as extended continental shelf and is, as forming part of the deep ocean floor, subject to the regime of the "Area".

In a joint research project, scientists from the WSI (A. Proelß) and the FTZ (U. Siebert, A. Gilles, H. Herr) focus on topics concerning the distribution and protection of marine mammals. At first, it

was evaluated in which parts of the German EEZ protection areas for marine mammals are already in place or proposed. The small cetacean sanctuary west of the islands of Sylt and Amrum, nominated as Special Area of Conservation (SAC) in 1999, was chosen as a first study area. In this respect, a detailed analysis concerning the relevant legal and biological aspects as to the status and protection regime of the species concerned will be undertaken in the course of the next year. To this end, data on the occurrence, density and habitat use of harbour porpoises in the sanctuary and adjacent waters are currently being assembled from various data sources (incl. aerial surveys, incidental sightings, acoustic investigations, and the stranding network). Special focus is put on the age structure of harbour porpoises which are either observed in situ or examined after being stranded or caught as incidental by-catch in fishing nets. In a next step, an overview of anthropogenic activities in the area will be compiled and evaluated as to their potential negative effects on harbour porpoises. Based on the factual situation assessed, the applicable legal instruments will then be analyzed and measured against their protection-oriented object and purpose.

Following an invitation by the University of Oslo, A. Proelß has written an article on "Rescue at Sea Revisited: What Obligations exist towards Refugees?" which will be published in the Scandinavian Institute of Maritime Law Yearbook 2008. The paper, while focussing on the law of the sea aspects of rescue at sea, includes an examination of the interplay between the law of the sea and refugee law. It concludes that even under the revised relevant conventions (namely the 1979 International Convention on Maritime Search and Rescue [SAR Convention] and the 1974 International Convention for the Safety of Life at Sea

[SOLAS]), obligations relating to search and rescue do not include a duty to transport the rescued to a safe place, and that, thus, the existing legal regime is far from constituting a comprehensive body of rules which effectively addresses the protection needs of rescued persons. Therefore, further amendments to the relevant agreements are necessary. A. Proelß and A. Zimmermann have also given a joint evaluation on a recent larger study on refugees at sea conducted by the Deutsches Institut für Menschenrechte/German Institute of Human Rights during a conference held in Berlin focusing on both law of the sea and human rights issues.

A further research project which has been initiated at the end of 2007 deals with the legal framework applicable to the marine genetic resources in areas beyond the limits of national jurisdiction. The project is associated with a cluster proposal undertaken together with J. LaRoche et al. First results include a lecture held by A. Proelß at the occasion of an international workshop on the access and benefit sharing regime of the Convention on Biological Diversity in Bremen, the results of which will be published in the form of an article. The paper will address measures to ensure effective preservation of the said resources, the relationship between international environmental law and the law of the sea on the one hand and intellectual property rights on the other, and the controversial application of the common heritage of mankind principle. Additionally, it will follow up with discussions held in the UN ad hoc open-ended informal working group to study issues relating to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction. Future steps will be based on the scientific results of a collection of deep sea microbial community samples which will be carried out during the next

planned cruise to a hydrothermal field later in 2008. The report shall contain recommendations as to a future regime for the sustainable management of these resources which satisfies the legitimate requirements of ecology, economy, and scientific research.

Two PhD projects on the "International Legal Regulation of Operational Emissions of Ocean Going Vessels" (K. O'Brien) and "Transboundary Pipelines in the Baltic Sea Region in the Light of International Law of the Sea, International Environmental Law, and European Law" (M. Krivickaite) essentially started in January 2008. First material results are likely to be available in the course of 2008.

Informal co-operations of the JRG have been established with the University of Oslo (Scandinavian Institute of Maritime Law), the International Foundation for the Law of the Sea, the University of Rostock (Ostseeinstitut für Seerecht, Umweltrecht und Infrastrukturrecht), and the Federal Maritime Agency (Bundesamt für Seeschifffahrt und Hydrographie). Within the Cluster of Excellence, the JRG is participating in working groups on European fisheries, carbon capture and storage, continental shelf delimitation, and iron fertilization.

Appendix C: Research Platforms

Research Platform P1: Numerical Simulation

Speakers: A. Srivastav, C. Boening

Task and Goals

Numerical simulation and data management are key issues in the Cluster of Excellence. It requires an infrastructure for high-performance computing, development of interfaces for algorithms and software from different areas, in particular marine science and numerical mathematics, the ability to store and manage data in an efficient way, and to provide expertise from mathematics and computer science for large-scale numerical problems in the Cluster. The goal of the first phase of the Platform has been to lay down the foundation for the computing infrastructure of the Cluster (hardware and software), to provide software interfaces and to set up a concept for the data management.

Computing Infrastructure

In May 2007 the Council of the Cluster of Excellence decided to grant 470.000 € for the extension of the vector machine NEC SX-8 located in the computing center (Rechenzentrum, RZ) of the university. The extension consists of an additional node for the vector machine for applications in the Cluster. In September 2007 the Council released further funds for the following computing infrastructure:

- 1) Hard- and software for data management (51.000 €)
- 2) Extension of the Opteron-parallel machine in the computer center (max. 130.000 €)

- 3) A server for the processing of seismic data
- 4) Memory extensions (65.000 €)
- 5) Software for algorithmic data assimilation (50.000 €)

All hardware and software components have been installed and made available by Fall 2007 to support the research groups of the Cluster of Excellence. The NEC SX-8 and the Opteron-machine are strongly used for modelling needs by several JRGs. With these investments the basic computing infrastructure of the Cluster has been established.

Personnel for Numerical Simulation

In May 2007 the Cluster Council also released the funding of a position for a technical assistant for numerical simulation for 18 months (July 2007 - December 2008). The position was filled in December 2007 with a mathematician with a strong expertise in the handling of numerical and optimization software. The work in the time period December 2007 - June 2008 focused on the following topics:

Parallelization of Mathematical Algorithms with MPI (Message Passing Interface)

A main task is the efficient parallelization of codes from numerical simulation and optimization on the Opteron-parallel Machine with MPI and the vector machine NEC SX-8. In cooperation with Profssor G.S. Adhar from the University of North-Carolina at Willmington, MPI interfaces have been installed for a number of algorithms. Professor Adhar visited Kiel for 4 weeks in May/June 2008 and taught a course on OpenMPI for members and students of the Cluster of Excellence. The visit was supported by the Integrated School of Ocean Sciences (ISOS).

Development of Code-Interfaces and Code-Optimization

Integration of codes from biogeochemical modelling (FORTRAN) with C++-Implementations of evolutionary algorithms and other optimization algorithms along with appropriate interfaces to support the ongoing joint work of A. Oschlies, T. Slawig and A. Srivastav within A3.

The existing code for modelling biogeochemical cycles from the group of A. Oschlies with 3500 lines has been rewritten and condensed in 2000 lines of plain C based on the Portable, Extensible Toolkit for Scientific Computation (PETSc) to facilitate the communication interface between other C programs in use.

Tracer Simulation on the Opteron-Parallel Machine and the NEC SX-8.

The Biogeochemical Cycles (BGC) modellers have to deal with nonlinear time dependent diffusion and convection equations in three dimensions. These equations are additionally dependent on velocity fields which come from solving General Circulation Models (GCM), mainly governed by the Navier-Stokes equations. Due to their complexity it is nowadays still not possible to use GCMs for efficient tracer simulation. A technique called Transport Matrix Method (TMM) has been developed by S. Khatiwala, M. Visbeck and M. A. Cane to benefit from the newest GCMs with an acceptable payoff between accuracy and speed-up.

Data Management

The accumulation of data in the Cluster in various formats has already become a project in its own right and complexity. The advisory board recommended to hire a central data manager for the

Cluster of Excellence. Within the platform P1 A. Lehmann (IFM-Geomar) and B. Thalheim (Department of Computer Science) developed an integrated concept for the central data management. On this basis the Cluster Council funded a position for the whole project period. A separate report for this position is attached.

Future Work

While the hardware and software infrastructure of the platform is sufficient for computational support, the expiry of the position of the technical assistant for numerical simulation by December 2008 will cause a bottleneck in building the interdisciplinary interfaces between codes from mathematics and marine science.

This position is essential for the continuation of the ongoing research and further steps towards high-performance computing for example in the North German Alliance for the Advancement of High-Performance Computing (Hochleistungsrechner Nord, HLRN).

The testing of optimization algorithms on the new SGI platforms in HLRN has been started. The implementation of climate modelling software on massive parallel SGI machines with 10 000 to 15 000 processors is an open and challenging problem. Here technical support as well as scientific expertise in software engineering is required.

We further aim for the development of an efficient parallel tracer simulation framework to enable and ease the usage of TMM by other researchers. Moreover optimizing parameters within biogeochemical models (see other report) should benefit from this work too.

A cooperation with the JRG of Research Topic A3 of T. Slawig is conceived to work on faster and more efficient Newton-Krylov subspace methods to simulate tracers.

We aim for a close cooperation of the data manager and the assistant in numerical simulation to provide a user-friendly interface for the access of data in the Cluster for numerical simulation algorithms. This is due to the widely spread data formats a difficult and challenging task.

Research Platform P2: Isotope and Tracer Analysis

Speaker: A. Eisenhauer, P. Grootes, J. Grote-meyer

Significance of the investments

In a strategic decision the steering committee of platform P2 decided to give priority to those investments necessary to satisfy the instrumental and analytical needs of the junior research groups (JRG) within the Cluster of Excellence Future Ocean. Second priority was given to the replacement of old but necessary equipment for basic analytical supply. Third priority was given to investments which are innovative and original, providing future perspectives for the project and which are new in Kiel. In particular, it was decided to support organic geochemistry as well as to strengthen the micro-analytical capabilities of the carrying institutes.

Following this approach ~745.000 € were granted for P2 investments, which were used to purchase the instrumental and analytical equipment presented in the following. With highest priority a mode-locked picoseconds neodymium-doped yttrium aluminium garnet (Nd:YAG)-pump laser and a optical parametric generator were purchased for the JRG of subproject A6 (Prof. Gernot Friedrichs).

In order to establish organic geochemistry as a new research field at the Geological institute and also for the Cluster of Excellence a gas chromatograph (GC)-coupled isotope-ratio-mass-spectrometer (GC-IRMS) MAT 253 with a gas-chromatography interface was purchased and installed at the Leibniz-Institute for Radiometric Dating and Stable Isotope Research.

In order to extend the analytical capabilities in the field of high spatial resolution measurements of trace element and isotope ratios, P2 decided to acquire a Quadrupol-Mass Spectrometer (MS; Agilent 7500cx™). In an innovative approach, a Laser will be coupled to this Quadrupol-MS and a Multi Collector-Inductively Coupled Plasma-Mass Spectrometer (MC-ICP-MS) at the same time. This coupling will allow simultaneous measurements of trace element concentrations and isotope ratios at high spatial resolution. This approach is new and innovative providing a major step ahead in the analytical capabilities of Kiel University and the Cluster of Excellence.

Carbon ($\delta^{13}\text{C}$) and Oxygen ($\delta^{18}\text{O}$) isotopes are major tools applied in paleoceanography and other fields of science. Usually, several thousand samples are processed and measured routinely at the mass-spectrometer facilities of the Leibniz-Laboratory for radiometric dating and stable isotope research. However, the existing mass-spectrometer is now more than 10 years old and needed to be replaced by a modern system. Platform P2 supported the purchase of an ultra sensitive ($<5\mu\text{g CaCO}_3$) high capacity ($>10,000$ samples/year) mass spectrometer (MAT 253) for the analysis of stable isotopes in carbonates.

The determination of the spatial distribution of trace elements in natural materials is becoming increasingly important and a major task of the analytical facilities of the Geology department of Kiel University. In order to remain compatible with international standards an older laser system had to be replaced by a new one. This was supported by P2 with the purchase of a 193 nm Excimer Laser Ablation system for microanalytical studies. In order to further support and strengthen the capabilities in organic geochemistry a GC combustion system for an IR mass-

spectrometer at IFM-GEOMAR was supported by P2.

In order to complete and extend existing analytical facilities at the Physical Chemistry Department the purchase of a nanoLC for nano ESI source was supported by P2.

P2-Investment: Broadband Laser Light Source

Compared with mass-spectrometry, optical detection methods are less frequently used in marine sciences so far. In recent years, however, many promising laser based techniques have been developed with high potential for marine research applications. These methods offer unique sensitivity (e.g., detection of gas phase species in the ppt-ppb range) combined with high spectral and spatial resolution (e.g., sub-monolayer surface sensitivity).

The investment of platform P2 into a broadband laser light source is part of the efforts of the Cluster of Excellence's JRG A6, Sea Surface Chemistry, to establish a laser laboratory for optical detection. A picosecond (ps) laser system was purchased consisting of two main components, a mode-locked ps-Nd:YAG pump laser with harmonic

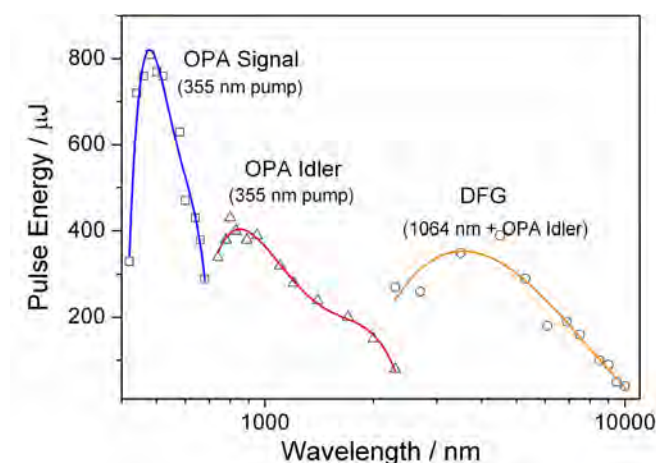


Figure P2-1. The tuning curve of the laser output reveals the broad wavelength coverage of the newly installed laser system.

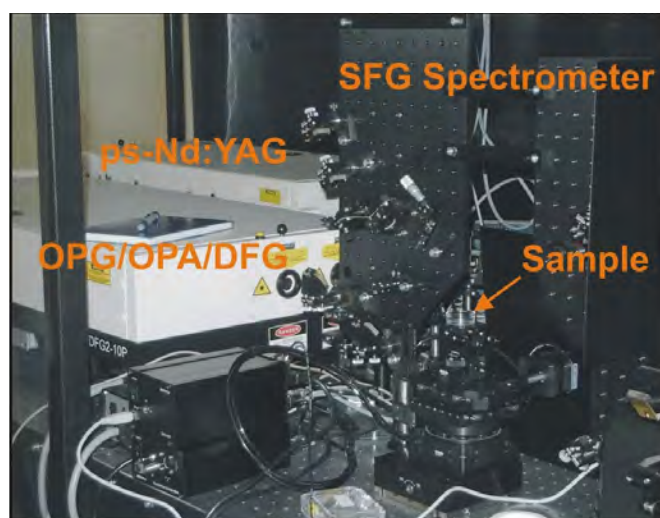


Figure P2-2. The broadband laser light source (left), which is used to operate a sum frequency generation spectrometer (right), enables water surface layer studies.

frequency conversion unit (EKSPLA, PL2241A), and an optical parametric generator/amplifier (OPG/OPA) with difference-frequency generation (DFG) option (EKSPLA, PG401/DFG2-10P). The laser system combines good spectral resolution (bandwidth $< 6 \text{ cm}^{-1}$) with very wide detection wavelength coverage (VIS – IR spectral range) and thus acts as a versatile light source. Figure P2-1 displays the pulse energy performance of the laser system as it has been measured during installation. The distinct wavelength dependence originates from the non-linear frequency conversion processes utilized for light generation. If UV light is required for future experiments, another (optional) harmonic unit can be added to the system extending the total wavelength coverage to 210 – 10000 nm (with two small gaps around $355 \pm 15 \text{ nm}$ and $710 \pm 30 \text{ nm}$). The detection light is delivered in form of short ($\Delta t < 40 \text{ ps}$) light pulses with a repetition frequency of 10 Hz. The broadband laser light source, which is shown together with the setup of a sum-frequency generation spectrometer (SFG) shown in figure P2-2, is located at the institute of physical chemistry in the laser laboratory of JRG A6. The main application of the laser system is the operation of an SFG experiment, which was

funded separately from JRG A6 resources. SFG relies on the availability of short pulses of VIS and IR radiation and provides surface specific sensitivity as needed for studying molecular processes occurring directly at the water/air interface. Other potential fields of application include cavity-ringdown spectroscopy (CRDS) for gas phase molecule detection or aerosols studies and the development of innovative optical sensors (e.g., CRDS based HPLC sensors). Moreover, the system is ideally suited to perform time-resolved photolysis studies with picosecond time resolution.

P2-Investment: GC-coupled Isotope-Ratio-Mass-Spectrometer (GC-IRMS) MAT 253 with Gas Chromatography-Interface

This state-of-the-art GC-IRMS system enables measurements of H(D), C, and N stable isotope ratios in organic molecules that are characteristic for certain marine algae or derived from land plants (specific compounds or biomarkers) and can be extracted from marine sediments. Stable isotope ratios of D, C, N from long-chained fossil hydrocarbon molecules provide very sophisticated paleoenvironmental indicators for the marine and terrestrial biosphere. Time series of variance in such isotope ratios quantitatively record past changes in atmospheric humidity and CO_2 levels, in surface ocean salinity and dissolved inorganic carbon concentration, as well as in nitrogen cycling. Stable isotope ratios of organic biomarkers thus allow investigation of climate related variance in biochemical cycling between the atmosphere, ocean and continents much better than previous studies based on bulk organic matter. This is particularly important for comparison of past biochemical-climate linkages in the marine and terrestrial environment with ongoing changes induced by increasing atmospheric CO_2 levels and

related climate change. The purchased system will be an important tool for innovative research. It will support the calibration of so-called paleo-equations that are based on the response of modern planktonic and benthic organisms to changes in sea-water dissolved CO_2 which is investigated in theme A1, ocean acidification. It will assist to better describe environmental conditions in the geological past that were similar to what is expected and investigated in themes A2, seafloor warming, and A3, Oceanic CO_2 uptake, as marine conditions under deep-ocean warming and massive release of methane from gas hydrates or for a "high- CO_2 pressure ocean" in the future. Since the carbon isotope ratios of certain compounds reflect also metabolic processes of bacteria associated with hydrothermalism, fluid flow or venting including migration of methane, GC-IRMS application can be a very useful tool also for B3 studies. Particularly, for themes A4, Ocean Circulation, and B5(1), sea-level rise, such an instrument will provide novel isotope methods on organic biomarkers for the reconstruction of changes in ocean salinity and changes in the hydrological cycle over the continents. In paleoclimatology these methods are still at the start of their application but the range of past environmental conditions that can be reconstructed with these molecular proxies has tremendously expanded within the last few years. For example, the combined use of C and N stable isotopes in marine plankton biomarkers will be the next step to investigate linkages between nitrogen and carbon cycling under low-oxygen conditions in the paleo-ocean, a subject very relevant to the theme of the new SFB 754 "Climate-Biogeochemistry Interactions in the Tropical Ocean".

Together with the new installation of the multi-dimensional and preparatory gas-chromatography (to be used for compound-specific radio-

carbon dating) at the IfG, and with the new implementation of the GC-coupling to existing mass-spectrometers in the biology section of the IFM-GEOMAR, the investment into this GC-IRMS system will strongly support our attempt to close an unfortunate gap in cutting edge organic isotope geochemistry at Kiel University and the IFM-GEOMAR. In this respect we also foresee the investment as a support for a professorship in organic geochemistry to be hopefully established at the IfG in 2008.

P2-Investment: Quadrupol MS

In order to evaluate the influence of global change (pH increase, ocean bottom warming, etc.) on the shells of calcifying marine organisms, their chemical and isotopic composition will be examined in several cluster projects in the frame of field studies and culturing experiments (A1, A2, and A4). The anticipated reconstruction of those marine parameters predicted to change as a function of global warming is possible by the use of trace metal to calcium ratios (e.g. V/Ca, Mg/Ca, Sr/Ca, Mo/Ca, Ba/Ca, etc.) and certain isotope ratios ($\delta^{13}\text{C}$, $\delta^{18}\text{O}$, $\delta^{11}\text{B}$, $\delta^{44/40}\text{Ca}$, $\delta^{88/86}\text{Sr}$, $\delta^{25}\text{Mg}$, etc) which can be applied as proxies for the spatially resolved reconstruction of the environmental evolution of the oceans chemical and physical properties (water temperature, pH, nutrient supply, etc). In order to meet the anticipated cluster goals high precision measurements the investment into new and state of the art equipment and instrumentation was highly desirable.

High precision measurements are required to resolve the influence of controlled temporal changes in physical and chemical conditions on marine calcifying organisms during cultural studies or to monitor environmental changes

in field studies. However, besides precision also high spatial resolution is essential because coccolithophorides and foraminifera have only very small shells on the order of 0.1 mm and below. Concerning corals and bivalves the growth increments per day are very small, ranging from about 1 μm to about 10 μm . In order to combine high precision measurements with high spatial and temporal resolution among other technical possibilities a Laser Ablation system can be coupled with a Quadrupol-ICP-MS for trace metal/calcium ratio measurements and with a Multicollector-ICP-MS for simultaneous isotope ratio measurements. This combination will allow the simultaneous determination of up to 30 trace elements to calcium ratios and certain isotope ratios at high spatial resolution. We intend to use this technical approach for the determination of trace element and isotope ratios in coccolithophores, foraminifera, corals and bivalves in order to gain detailed information on spatial and temporal changes of trace metal ratios. This approach is unique, new and innovative completing and extending the structural development of the marine research and analytics in Kiel. Hence, the purchase of the Quadrupol-MS system strengthens the analytical infrastructure of Kiel University to a very large degree.

The System was purchased (Agilent™ 7500cx) but has not been installed up to now. Because of the Quadrupol-MS coupling with a laser system and a MC-ICP-MS two laboratories have to be remodelled and redesigned in order to meet the requirements for air-conditioning, temperature and humidity in these rooms. For this purpose additional support by the Cluster of Excellence and IFM-GEOMAR was necessary. The remodelling will start in September 2008 and will be finished in October 2008.

P2-Investment: Ultra sensitive ($<5\mu\text{g CaCO}_3$) high capacity ($>10,000$ samples/year) mass spectrometer (MAT 253) for the analysis of stable isotopes from carbonates

Highest resolution time series are an increasing request for innovative studies in earth sciences like paleoceanography and paleoclimatology. This requires continuous improvement of mass spectrometry for (1) high sample and data throughput and (2) highest possible sensitivity without any decrease in precision. High sensitivity translates into small sample size, which allows a higher sampling density, enhancing time resolution of the oceanic sediment records to the limits set by sedimentation/bioturbation, and thus providing better understanding of ocean dynamics. Continuous records are an important pre-requisite for innovative multi-species analyses e.g. on different foraminiferal species, that provide habitat dependent isotope data for these species and thus vertically and seasonally resolved local oceanographic data over the time period covered in the core. Without the highest possible sensitivity it is often impossible to produce continuous parallel records of certain species of microfossils from sediment cores, because they can be very rare in parts of a core. To provide the necessary data density in a sufficiently short time obviously a high sample throughput is indispensable.

The new development to use individual species of coccolithophorids as an additional paleoarchive has been promoted within the Cluster of Excellence by the acquisition of a 'SPLITT'-system to effectively separate coccoliths of different size and shape. For optimal usage of this approach the highest sensitivity and a high capacity in stable isotope mass spectrometry is needed.

Further demand for stable isotope analysis of carbonates arises from different sub-projects of the Cluster of Excellence, e.g., for studying the effects of acidification on calcifying organisms in A1, for quantifying local methane carbon contributions to DIC and carbonates in A2, for the reconstruction of past ocean circulation in A4, for studying glendonites as past archives of carbon storage in A5, for studying hydrothermal fluid circulation at sea floor vents in B3, and for the reconstruction of past sea-level rises in B5 (1).

With the purchased ultra sensitive mass spectrometer samples in the range $<5\mu\text{g CaCO}_3$ will be analyzed without significant decrease in precision. With the internationally recognized expertise in the field of stable isotope analyses of carbonates existing in the Leibniz Laboratory since decades the commercially available system will be improved with the instrument builder and in-house development of the sample handling process has already started. For instance the well-known Kiel carbonate preparation device was an in-house development in co-operation with Thermo Fischer Scientific™. With the new system a routine service of high quality and high sample throughput will be continued, as it has successfully been accomplished since 1985 with more than 250,000 analyses. These analyses have been an indispensable basis for research in geosciences at the CAU, e.g. on paleoclimate and oceanic circulation, and the education and promotion of young scientists as documented by a multitude of Diploma and PhD theses within the Earth sciences including these data. This service can now be provided with significant increase in sensitivity offering also new fields in research to the Cluster of Excellence.

P2-Investment: 193 nm Excimer Laser Ablation Microanalysis

The chemical composition of many natural (and artificial) materials is not homogenous but varies as function of space. Controls on the material's composition at a given point can be due to physiological processes as in biomaterials or due to concentration gradients and/or temporal variation in environmental parameters during „growth“, secondary diffusion etc. Materials that continue with the accretion of new matter over time represent valuable archives of chemical information. Examples for such materials are tree rings, fish otoliths, mussel shells, teeth, exoskeletons, speleothems, sponges, corals, manganese nodules, laminated sediments, authigenic minerals and minerals with growth zonation, secondary overgrowths, inclusions of foreign materials and fluid inclusions, and many, many more. However, high-resolution micro-sampling techniques (e.g., micro-drilling) and - more straightforward - *in-situ* microanalysis are needed for the deciphering of this chemical information. Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) is now widely accepted as an accurate and precise micro-analytical technique for *in-situ* multi-element analysis of solid samples, with spatial resolution down to $<5\text{ }\mu\text{m}$ and detection limits in the ppb range. Investment and running costs of LA-ICP-MS are low, and precision of elemental ratios is better when compared to other established micro-analytical techniques (e.g., proton-induced x-ray emission, electron microprobe, secondary ion mass spectrometry, synchrotron radiation x-ray fluorescence).

Until recently, the only available analytical tool for quantitative elemental *in-situ* microanalysis in Kiel was electron-probe microanalysis (EPMA),

complemented by synchrotron radiation x-ray fluorescence spectrometry (SYRFA) at Hasylab in Hamburg. Both techniques have either limited detection power (EPMA) or limited multielement capabilities (SYRFA). The existing LA-ICPMS at IFG Kiel was technically outdated. The new installation of the 193nm Excimer LA-ICPMS fills this gap of a missing *in-situ* multielement technique with ultra-low detection limits for the determination of trace elements in solids. This improves the analytical infrastructure and strengthens the competitiveness of the cluster significantly. Today, LA-ICPMS is state-of-the-art and widely used in many analytical laboratories with international reputation in marine geochemistry. Our system is the only LA-ICPMS on the market providing $>45 \text{ J}\cdot\text{cm}^{-2}$ energy density and superb microscopic imaging using a standard-type research microscope.

Early in December 2007, a new 193nm Excimer ArF Laser, Type COMpex-pro 102 (Coherent/ Lambda Physik, distributed in Germany by S-Prep GmbH, Überlingen) was installed and combined with a beam-delivery system for laser beam homogenization and a research microscope (CETAC Technologies, Omaha, USA, and OLYMPUS). Additional adjustments were done in February and March 2008. Since then work concentrated on the physical and electronic coupling of the laser to the ICP quadrupole mass spectrometer (gas lines, electronic synchronisation and triggering) and methods development. Recently, experiments have been conducted aiming at optimization of ablation parameters for the analysis of foraminifera.

P2-Investment: GC combustion system for an IR mass-spectrometer

Stable isotopes of C and N and essential organic

compounds, such as specific fatty acids and amino acids, are widely used as tracers for the reconstruction of marine food webs. However, their resolution is limited because of widely overlapping signal between different groups of organisms. A higher degree of resolution is expected from the combination of both approaches i.e. of measuring stable isotopes in specific organic compounds instead of bulk biomass. Examples are the measurement of ^{13}C in specific fatty acids and of ^{13}C and ^{15}N in specific amino acids. Applications span from their use as reliable biomarkers of dietary sources, exceeding the use of bulk measurements to determining rates of nutrient uptake or incorporation of dietary sources into specific compounds (fatty acids, amino acids). Given the complexity of trophic and non-trophic interactions in marine systems, the application of this advanced technique will allow novel approaches to food web and physiological tracer studies within the cluster. Latter techniques are in particular important for subproject A1 and A2 of the Cluster of Excellence Future Ocean.

The new system strengthens the analytical capacities available for organic geochemistry and is in line with the platform P2 strategy to support new and innovative technology in Kiel.

Future developments will improve the sampling process to perform the fractionation of fatty acid methyl ester (FAME) from zooplankton for esterification efficiency and clean-up procedure to get reliable stable isotope values for target compounds (individual fatty acids). So far, we are able to measure ^{13}C in bulk lipids of zooplankton, because concentrations in individual fatty acids are too low at realistic sample sizes.

Thereafter, we plan an analogous method development for amino acids. The conversion of the

installed GC system to measure the ^{15}N abundance in amino acids compounds includes a complete reconfiguration of the GC-column system. The sample clean-up process for $\delta^{15}\text{N}$ amino acid analysis has to be improved to separate impurities from the sample matrix. This will be done in after completion of the method development for fatty acids.

A new gas chromatograph system (GC) coupled with a combustion unit was purchased and successfully connected as an additional periphery to an already existing stable isotope mass spectrometer. The gas chromatography system is equipped with a "moving capillary switching system" (MCSS) which enables us to separate target compounds for $\delta^{13}\text{C}$ abundance measurements during the sample run by a simultaneously improvement of peak resolution.

P2-Investment: NanoLC for nano ESI source

The nanoLC is intended to act as sample injection system on an existing ICR-MS. This instrument is equipped with MALDI, ESI and nanoESI sources. In general masses from 270 to 10000Da can be analyzed. In ESI mode masses of even higher values may be analyzed due to multiple charges. Several 10kDa are accessible (BSA, etc.). Due to its tremendous resolving power ICR-MS is able to get isotopic resolved peaks even from such high masses. Natural isotopic patterns or patterns resulting from labeling remain visible.

The nanoESI technique extends the abilities of the P2 in terms of analytic mass spectrometry. Using nano spray the needed sample amount is reduced 100 to 200 times. Thus, sensitivity is improved. Typical conditions are injections containing 50fmol to 4pmol. Furthermore mainly

for organic or biologic samples the nanoLC gives the opportunity to purify and/or separate complex mixtures in front of MS analytics.

The main purpose of the acquisition of a nanoLC is to strengthen the analytic capabilities of the P2 in the Cluster of Excellence. Additionally some research concerning building processes in aerosols shall be conducted. Comparison of nanoESI and ESI processes can give valuable insight into the composition and decomposition processes during shrinking of droplets. These investigation shall help to understand chemical processes at ocean surface or layers beneath.

An Agilent 1200 nanoLC-System including degasser, autosampler, nano-pump and UV-Detector was purchased in December 2007. During the ordering process technical problems on the ICR instrument arose. These could not be solved before end of April due to the time schedule of Bruker Daltonics. First possible installation date for the Agilent system was 2.6.2008. The system was set up but specification measurements could not be performed completely. Main reason was some problems in conditioning the system. Although flow rates and pressure remain constant no reproducible data could be achieved.

Especially the injection parameters are crucial. While the molecular peak (of cytochrome C) was detected at retention times of ca. 26min several times, digest products tend to give unstable results. This may be caused by pressure changes during injection or still ongoing equilibration of the column. The installation will be accomplished during the next weeks.

Research Platform P3: Molecular Technology

P3 High-Throughput Molecular Bioscience Technologies

Speakers: T. Bosch, S. Schreiber

Summary

The Platform 3 provides cutting-edge high-throughput molecular technologies to the marine biology projects of the Cluster of Excellence Future Ocean. Key molecular technologies are located in the Centre for Molecular Biosciences (ZMB) and are available to cluster scientists as a centralized service. To complement the existing ZMB infrastructure according to the needs of the involved cluster scientists from the groups A1, A2 and B2, three new instruments/technologies have been approved by the Council to be acquired in 2007: (1) An integrated DNA preparation and sequencing system for the central sequencing facility; (2) BiaCore System X100; and (3) Sea-going molecular biology equipment (RNA/DNA Purification System for Field Samples; Metagenomic Filtration system).

First objective of P3 was to enlarge the pre-existing standard DNA sequencing capabilities of the platform. Therefore, the Qiagen BR8000 as a workstation capable of high-throughput, walk-away DNA purification from a variety of biological specimen was acquired together with a 96-capillary 3730xl DNA Analyzer (Applied Biosystems). The additional large-scale sequencing capabilities are of relevance for all cluster scientists that work with biological material. At present, they are used in scientific projects relevant for A1 (micro-evolutionary influences of acidification, analysis of field samples from the mesocosms), A2 (influences of methane

discharges on the genetic diversity of benthic microbiota) and B2 (complex host/microbiota interactions on oceanic barrier organs) groups.

The Biacore X100 System with its label-free surface plasmon resonance (SPR) based technology allows studying biomolecular interactions in real time. Protein-protein interaction, protein-ligand interaction or any biomolecule of interest interacting with a specific binding partner can be studied with high sensitivity. This allows understanding biological processes at the molecular level and gains insights into binding events that drive them. The system was delivered in January 2008 and is located in the ZMB of the CAU. For the first training course in spring 2008 about a dozen coworkers of groups within B2, but also of others groups within the University (structural biology; Institute for Botany; Institute for Zoology) enrolled to get introduced in the sophisticated system offering the cutting edge technology of SPR-analysis. The system will be essential for one of the central themes within B2, i.e. to understand the dynamic and the complex interplay of host-microbiota and naturally occurring crosstalk and attack/counterattack mechanisms (e.g. the interference of bacterial steroids with immunological defense reactions of the host; immune receptor and effector).

Finally, since the limiting factor in the processing of the field samples for normal and qPCR is the nucleic acid extraction step, "sea-going molecular biology equipment" has been acquired for preparation of field samples: the Maxwell™ 16 System as small automatic purification system for genomic DNA, RNA and protein that can process up to 16 samples in 30 minutes that can be taken into the field, for example, on board a ship, to process DNA/RNA samples as they are collected, and (2) a metagenomic filtration system to rapidly collect

size fractions of planktonic organisms. This system is essentially a copy of the system used to collect the Genomic Ocean Survey (GOS, Venter institute) and is used regularly by members from A1, A2 and B2.

Integrated DNA preparation and sequencing system for the central sequencing facility

Genomic analyses of oceanic organisms have a high potential for innovative findings. The complex interplay of multiple organisms in a given habitat under specific environmental conditions leads to selective evolutionary pressures, which affect the diversity of the genetic repertoire of species. Thus, genomes and metagenomes may be used as dynamic blueprints of life to understand the influences of today's changing habitats on ecological systems. Biological principles identified by sequence analysis (e.g. metabolizing enzymes) may generate enormous intellectual property and lead to commercial spin-offs from the cluster.

The instrument combination acquired in 2007 allows the platform to fulfill the growing needs of cluster members for the automated large-scale purification of (plasmid-based) libraries and standard sequencing. This is especially important for complex metagenomic approaches used to describe the complex dynamics of marine microbial communities or to delineate host-microbial interactions.

The system is located in the sequencing facility of the ZMB. Integrated into running infrastructure, the substantial investment into the sequencing capacities enables cluster scientists to rely on local sequence generation, instead of outsourcing the projects to external collaborators. The synergism with the existing infrastructure of the

sequencing facility at the ZMB creates a competitive advantage with a transparent work-flow and fast accessibility of generated data. Also, the further development of a local expertise in functional genomics of marine organisms will enhance the visibility of the marine biological focus of the cluster, which will attract international students and scientists.

Biacore X100 System

The label-free surface plasmon resonance (SPR) based technology of the Biacore system allows studying biomolecular interactions in real time. Real time binding data are essential to understand the dynamic interactions between proteins and other biomolecules that drive and regulate biological processes. It can be further used to define structure/function relationships and understand the dynamics of molecular pathways.

The system is located within the ZMB established at the University in Kiel and is essential Research Topic B2: Signal transduction within the complex interplay of host-microbiota and naturally occurring crosstalk and attack/counterattack mechanisms (e.g. the interference of bacterial steroids with immunological defense reactions of the host; immune receptor and effector).

Since until recently no Biacore X100 system or a comparable system was available in Kiel, potential users of the system are not only all the groups within B2, but also others groups within the University (Prof. A. Scheidig, PD. Dr. C. Plieth, structural biology; Profs. M. Sauter, K. Krupinska, D. Ober, Institute for Botany; Profs. M. Leipe and T. Röder, Institute for Zoology; Profs. M. Bleich (B1) of the medical Department) and the IFM-Geomar (Prof. U. Riebesell, A1).

Sea-going molecular biology equipment (RNA/DNA Purification System for Field Samples; Metagenomic Filtration system)

This was needed for the growing needs of metagenomic studies supported in the Cluster of Excellence and also allows the exploitation of open ocean water column genetic resources which are available to anyone wishing to exploit it (no legal restrictions). This is one aspect of marine resources that is at the moment under-developed in Kiel.

The Maxwell™ 16 System is a small automatic purification system for genomic DNA, RNA and protein that can process up to 16 samples in 30 minutes. The preprogrammed instrument utilizes pre-filled reagent cartridges and delivers consistent purification that saves time and labor. The instrument is compact and can be taken into the field, for example, on board ship, to process DNA/RNA samples as they are collected. This instrument is relevant for any research that requires nucleic acid extraction on the scale of 50-250 samples per experiment/field campaign. The instrument is versatile and can be used for DNA, RNA and protein extraction from marine organism. The Maxwell instrument is a very simple instrument, with small dimensions (31X37 X29 cm). It can be moved between laboratories and taken into the field if needed. The current users are all of the groups and cluster members who perform nucleic acid or protein extractions. A metagenomic filtration system to rapidly collect size fractions of planktonic organisms is part of the Sea-going molecular biology equipment. This system is essentially a copy of the system used to collect the Genomic Ocean Survey (GOS, Venter institute) and is also already established and regularly used by the groups and cluster members who perform nucleic acid or protein

extractions. In particular, this includes A1, A2 and all of the B2 members.

Research Platform P4: Ocean Observatories

Speaker: A. Körtzinger, M. Visbeck

Introduction

The Research Platform "Ocean observatories" has the mandate to provide multi-faceted observational capabilities that meet the wide range of requirements for research to be carried out within in the Cluster of Excellence. From the beginning a strong focus was placed on the needs of the Junior Research Groups (JRG) that are a centerpiece of the cluster's research portfolio. As most of these groups were not established before the end of the first year, only one concrete request (JRG B5/1) had been made to P4 in 2007 from the newly established Junior Research Groups. At the same time the very same fact caused significant free funds within the project. A decision was therefore made to allocate a significant amount of these unused funds to the four research platforms to enable them to strategic investment into the improvement and broadening of the observational infrastructure.

Proposals

During 2007, two calls for investment proposals within all four research platforms were issued. Proposals were invited according to a template and with a two-page limit. Prioritization of incoming funding requests within the P4 platforms was based on the following guidelines:

- 1) Requests from Junior Research Groups (highest priority);
- 2) Cost-benefit ratio from cluster perspective; leveraging between cluster and other sources;
- 3) Size of user base; connectivity to existing infrastructure;
- 4) Urgency of the request;
- 5) Balance across disciplines within the cluster consortium.

In both investment rounds all proposals were presented to and openly discussed among all platform members and proponents. On the basis of these deliberations a ranked list of proposals was agreed upon and presented to the council. The transparent and rigidly criteria-driven approach was acknowledged by the council and lead to the approval of a total of approx. 1.77 Mio € for Research Platform P4. An overview of funded requests is given below.

The following items were approved during the first call in February 2007. They account for about 50 % of requested funds:

- Salary (15 months) of mechanical engineer for new Remotely Operated Vehicle "Kiel 6000" for ROV hydraulics/mechanics as well as design and integration of new scientific modules - 85.000 €
- Sixteen Mesocosms (300 L) for replicated shipboard plankton studies with manipulative experiments - 24.000 €
- two benthic mesocosms with oxygen exchange systems for integration into existing bottom landers - 132.000 €
- "Ocean Tracer Injection System" (OTIS) built by experts from Woods Hole Oceanographic Institute for injection of artificial tracer into ocean interior - 174.500 €
- Continuous imaging flow cytometer (FlowCAM) for real time monitoring of particles in fluids - 70.000 €.
- Controlled aeration system for CO₂ manipulation of seawater in laboratory, mesocosm and field experiment - 50.000 €
- Shallow-water side-scan-sonar and

- low-voltage mini-boomer for hydroacoustic imaging in coastal applications - 110.000 €
 - Repair of existing streamer and upgrade of seismic and high-frequency acoustic recording units for high-resolution 2.5D seismic imaging - 100.000 €
 - Sensors (temperature, conductivity, oxygen) and components (sample bottles, pumps, computer) for upgrade of existing, salinometer for CTD calibration - 174.200 €
 - Research infrastructure for *R/V Islandia* at Cape Verdean long-term ocean observatory (10' laboratory container, radio detection finder, plankton net) - 58.000 €
- Grand total - 977.700 €

The following items, which represent 100% of the funding requests from Platform P4, were granted during the second call in July 2007:

- Parametric sub-bottom profiler (SES-2000) for shallow water applications (JRG B5/1 request) - 148.800 €
- Optical instrument for *in-situ* measurement of particle size spectra (LISST-100) for characterisation of suspended matter (JRG B5/1 request) - 40.500 €
- 600 kHz Acoustic Doppler Current Profiler (ADCP) for shallow water applications, permanent installation on *R/V Alkor* - 32.500 €
- Upgrade of *R/V Islandia* at Cape Verdean long-term ocean observatory (second hand hydrographic winches, J-frame) - 69.300 €
- Video Management System for installation in control unit of *ROV Kiel 6000* - 46.500 €
- Five Watchdog Systems for autonomous applications (e.g. subsurface moorings, seafloor landers etc.) - 39.000 €
- Oxygen optode sensors and sensing foils for high-quality long-term oxygen measurements

- in autonomous applications - 44.000 €
 - Six seismometers with 8000-m depth capability - 34.800 €
 - Edit/Archive System for handling and storage of HD videos primarily from ROV missions - 44.700 €
 - Seismic and hydroacoustic sources (GI and G airguns) for high-resolution seafloor investigations - 143.000 €
 - Benthos C3D side-scan-sonar for seabed mapping - 149.900 €
- Grand total - 793.000 €

This significant investment provided by Research Platform P4 represents a major strengthening and broadening of the observational infrastructure within the Cluster of Excellence. This has been done in such a way that a broad user base exists particularly among the new JRGs. The cost-sharing nature of many of these investments make them of mutual benefit to the cluster and existing research projects in Kiel. We see it as a fortunate situation that this significant investment opportunity at an early stage was possible and we are sure that it will impact very positively on the future success of the Cluster of Excellence Future Ocean.

In addition, major progress has been made with respect to large infrastructure which has been (or will be) purchased from funds outside the Cluster of Excellence but will be available to the Network of the Project. This includes the following components:

- The *Kiel 6000* Remotely Operated Vehicle (ROV) with 6000 m working depth and multi-purpose science capabilities for world-wide operation was acquired and passed tests and sea trials successfully. The official commissioning will take place on June 16, 2008.

- The order for an Autonomous Underwater Vehicle (AUV) has been placed. The AUV is currently under construction and delivery is scheduled for September 2008.
- Major progress on the development and constructions of Open-ocean pelagic mesocosm facilities has been made through the Technology and Logistics Centre of the IFM-GEOMAR. The facilities were tested during an *R/V ALKOR* cruise in summer 2007. After further improvement they will be deployed again during summer 2008.
- Firm plans exist at IFM-GEOMAR to acquire a glider swarm in 2009 that can be used for physical and biogeochemical observations in the open ocean in an unprecedented way.

These large pieces of infrastructure represent a major step forward in the operational and experimental capabilities that are available to the Network of the Cluster of the Excellence Future Ocean.

Summary of Platform Expenses in 2007

First Round

P1: Numerical Simulation

| | |
|--------------------------|------------------|
| Array Processor NEC SX-8 | 470.000 € |
| Technician | 80.000 € |
| <u>Gesamtumfang:</u> | <u>550.000 €</u> |

P2: Tracer Analysis

| | |
|--|------------------|
| Isotope Ratio mass spectrometer and GC-interface | 420.000 € |
| Isotope mass spectrometer and CarboPrep | 450.000 € |
| <u>Gesamtumfang:</u> | <u>870.000 €</u> |

P3: Molecular Technology

| | |
|---|------------------|
| Capillary Sequencer (Applied Biosystems, 3730 xL) | 350.000 € |
| Qiagen Robot for Large-Scale Plasmid Preparation | 110.000 € |
| Technician | 80.000 € |
| <u>Gesamtumfang:</u> | <u>540.000 €</u> |

P4: Ocean Observatories

| | |
|----------------------------------|------------------|
| ROV/ Technician | 85.000 € |
| Mesocom | 24.000 € |
| Lander | 132.000 € |
| OTIS | 174.000 € |
| FlowCam | 70.000 € |
| CO2 manipulation | 50.000 € |
| Shallow Seismic | 110.000 € |
| Streamer | 100.000 € |
| CTD | 174.200 € |
| C. Verde (long-term observatory) | 58.000 € |
| <u>Gesamtumfang:</u> | <u>977.000 €</u> |

Second Round**P1: Numerical Simulation**

| | |
|---------------------------------------|------------------|
| Datenmanagement: Hard- / Software | 51.000 € |
| Erweiterung des Opteron- | |
| Parallelrechner im RZ d. CAU | 130.000 € |
| Server f. Seismik-Datenprocessing | 58.000 € |
| Speichererweiterung | 40.000 € |
| 7,5 TB RAID Plattenspeicher | 25.000 € |
| Software zur Algor. Datenassimilation | 50.000 € |
| Gesamtumfang: | 354.000 € |

P2: Tracer Analysis

| | |
|---|------------------|
| Laser Ablation (193nm) System | 100.000 € |
| Laser Beam Delivery System | 143.000 € |
| Quadrupole MC-ICP-MS (modular) | 180.000 € |
| GC comb. syst. for IR mass spect. | 86.000 € |
| nanoLC for nano ESI source | 70.000 € |
| Broadband Laser Light Source | 84.000 € |
| Mode-locked picosecond Nd:YAG- pump laser | |
| Broadband Laser Light Source | 82.000 € |
| Optical Parametric Generator (OPG + DFG) | |
| Gesamtumfang: | 745.000 € |

P3: Molecular Technology

| | |
|--|------------------|
| Biacore X100 Plasmon Resonance | 185.000 € |
| (Protein/Ligandwechselwirkungen) | |
| Sea going molecular biology system | 49.000 € |
| (Filtration system for Metagenomic studies & purification) | |
| High-content plate confocal microscope (Opera LX) | 250.000 € |
| Thermo multidrop dispenser for automated isolation/seeding of primary cells and cell lines | 11.000 € |
| Gesamtumfang: | 495.000 € |

P4: Ocean Observatories

| | |
|---|------------------|
| SES2000 | 148.800 € |
| LISST-100 | 40.500 € |
| 600 kHz ADCP for R/V ALKOR | 32.500 € |
| Winch, J-Frame for R/V ISLANDIA | 69.300 € |
| ROV Video Management System | 46.500 € |
| 5 watchdog systems for autonomous platforms | 39.000 € |
| 8 multi-purpose autonomous oxygen loggers | 44.000 € |
| 6 seismometers for water depths up to 8000m | 34.800 € |
| Video edit/archive system | 44.700 € |
| GI- and G-airguns incl. operation units | 143.000 € |
| Side Scan Sonar | 149.900 € |
| Gesamtumfang: | 793.000 € |

Appendix D:
Reports from Proposals 2006

Cluster Project CP0602: „Effect of Increased CO₂ on Cellular Ion Transport Mechanisms”

Funding period: 08.11.2006 – 07.11.2008

Project period: 15.3.2007 – 15.3.2009

Aims

The project aims are to investigate the effects of changes in ambient pH and pCO₂ on marine model organisms at the cellular level. Membrane transport and compensatory mechanisms for cellular pH homeostasis are investigated by electrophysiological and microfluorimetric techniques.

Progress

According to the work plan and schedule Dipl. Biol. Kerstin Suffrian as a doctoral fellow under supervision of PIs Markus Bleich and Ulf Riebesell is working on the project. She has been trained in physiology and specifically in techniques of electrophysiology and microfluorimetry. She is associated to the integrated school of ocean sciences (ISOS) within the cluster of excellence and participated in courses, seminars and workshops to improve her skill set.

The selected two marine calcifying organisms (*E. huxleyi* and *C. pelagicus*) are continuously cultured in the lab and the respective conditions haven been optimized to obtain highly viable cells in a regular fashion. The original cell preparation for measurement of cytosolic pH (pHi) has been modified to obtain protoplast preparations with improved dye loading and which can

be used in parallel for patch clamp investigations. Cells were loaded with the dye BCECF-AM and fluorescence intensities are recorded by video imaging and confocal microscopy (Fig. CP0602-1). Calibration and dye loading were optimized for time constancy.

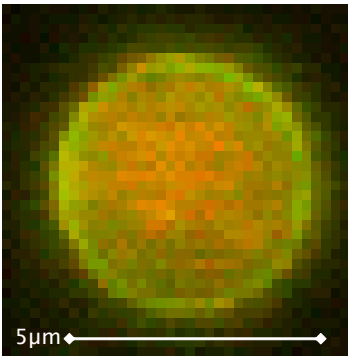


Figure CP0602-1. Microfluorimetric measurement of cytosolic pH. Confocal image of *Emiliania huxleyi* protoplast after fluorescent dye loading.

In the framework of our collaboration with Dr. Alison Taylor, Department of Biology and Marine Biology, The University of North Carolina, Wilmington, she will visit our lab to perform joint experiments from June 21-29, 2008. The visit is funded by a grant of the CAU Kiel to support this project.

Results and Perspectives:

Protoplast isolation has been established and validated for cell viability. Confocal imaging was used to verify intracellular dye distribution patterns. A detailed characterization of active and passive membrane permeabilities influencing cytosolic pH has been performed. The results suggest that *Emiliania huxleyi* has a low capacity

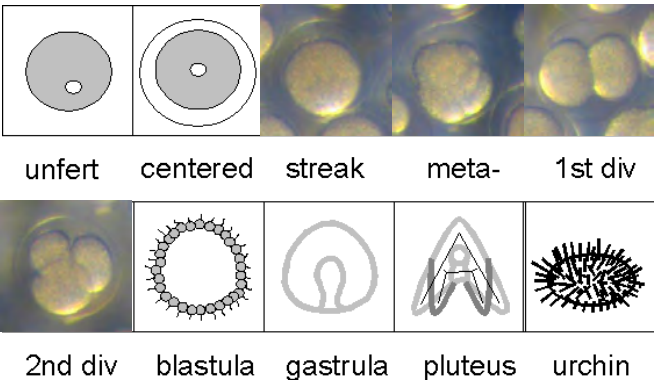


Figure CP0602-2. Developmental stages of *Strongylocentrotus droebachiensis* cultured in A1 facilities by JRG.

to counter regulate acute external pH or $p\text{CO}_2$ challenges.

The results from microfluorimetric measurements have now been expanded to characterize the properties of these model organisms with respect to CO_2 and HCO_3^- permeability. Pharmacological tools will be included into the investigations to identify transport proteins involved. In collaboration with the Taylor lab, the fluorescence data will be complemented by measurements of membrane voltage and conductance in June 2008.

Lab space and equipment has been expanded to start the investigation of a second species. In close collaboration with JRG Melzner, *Strongylocentrotus droebachiensis* (Fig. CP0602-2) has been collected and bred for experimental use of embryonic stages under different $p\text{CO}_2$.

Cluster Project CP0603: "Boron Isotopes (^{11}B) as a Proxy for pH Decrease and $p\text{CO}_2$ Increase"

Lead Proponent: A. Eisenhauer

Within this cluster funded project we developed and established a Boron free laboratory for the chemical extraction and purification of Boron from carbonates (e.g. corals, sclerosponges, foraminifera). The determination of B/Ca and B-isotope ($\delta^{11}\text{B}$) measurements will allow the reconstruction of present and past pH-variations important to better constrain future marine pH-changes due to global climate change. The laboratory design and manufacturing are terminated and the chemical preparation of first samples starts. First data are already processed and have been measured at the mass-spectrometer facilities of the IFM-GEOMAR.

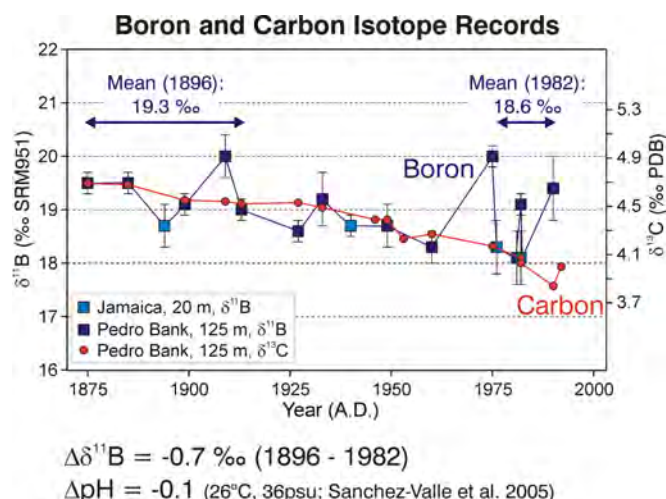


Figure CP0603-1. Boron Isotope ($\delta^{11}\text{B}$) and Carbon ($\delta^{13}\text{C}$) isotope measurements on a well dated sclerosponge from the Caribbean clearly record a decrease in the $\delta^{11}\text{B}$ - and $\delta^{13}\text{C}$ -values which is indicative for a rise of atmospheric $p\text{CO}_2$ and a decrease of marine pH.

First B-isotope measurements from Caribbean sclerosponges clearly show a decrease trend of the $\delta^{11}\text{B}$ and $\delta^{13}\text{C}$ values from 1875 to 1996 which correspond to a decrease of the surface water pH in the order of about 0.1 unit. The second order fluctuations of the B-isotope values most likely represent superimposed centennial and decadal pH-variations as a function of regional and local changes of temperature, salinity and upwelling conditions.

Cluster Project CP0605: Managing Cod and Sprat in the Central Baltic Sea - a Bio-economic Multi-species Approach with Stochastic Regeneration Functions

Biological Part

During the first phase of the project historic multi-species stock and spawning stock sizes as well as estimates of recruitment were generated by application of an area-disaggregated, multi-species virtual population analysis (MSVPA). In the present reporting period, the effect of environmental conditions, i.e. adverse oxygen conditions, on physiological stress and resulting decreasing ingestion rates on consumption rates of cod are

included. These changes were then translated to stock size estimates. According to laboratory experiments, a hockey stick model was fitted to evacuation rates at different oxygen levels and integrated in the traditional consumption model. The implementation of the reduced consumption rates for cod in the MSVPA resulted in changes in suitability coefficients. However, at the presently low predator stock size these stayed without visible effect on the estimates of predation mortality and stock size of cod, herring, and sprat. If successful management leads to higher cod stock sizes in future, the precision of prey population estimates in a multi-species context would largely be enhanced by the application of an oxygen sensitive consumption model. In an alternative approach, a recently developed, new multi-species model, which is including stochastic uncertainty (SMS) was applied. The model allows simulating different harvesting strategies. Results stressed the importance of including recruitment variability in biological-economic models: For example sprat stock size was strongly influenced only by variation of recruitment scenarios (1.000.000 tons vs. 200.000 tons) due to the pronounced species interaction (Fig. B1-1).

A number of important life history parameters of Baltic sprat and cod are directly affected by changes in temperature. We advanced our work on stage-based matrix models to examine the influence of temperature-induced match mismatch dynamics on various developmental stages of a cohort of the species in the Baltic. Preliminary results revealed that a moderate increase of present mean temperatures will have positive effects on all developmental stages of sprat and increase overall stock productivity while cod will be negatively effected.

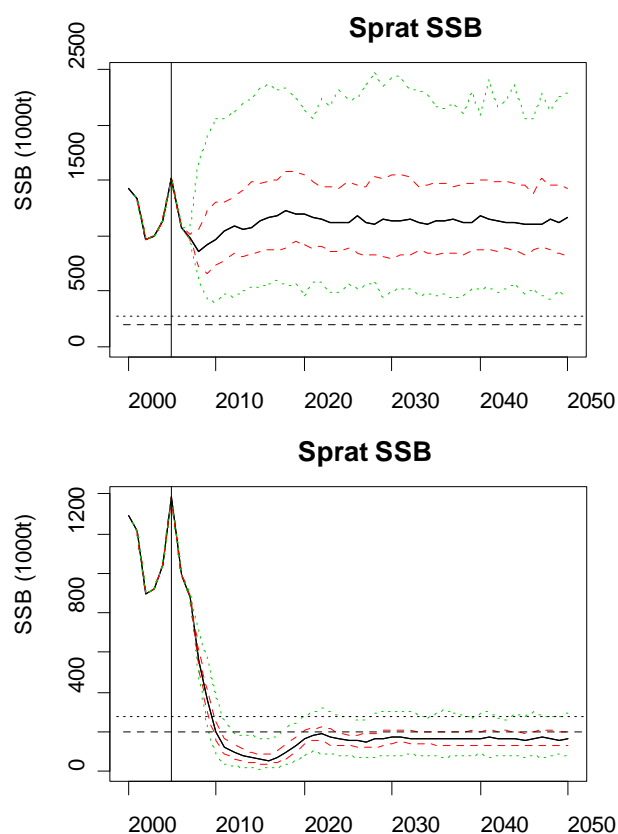


Figure CP0605-1. Projection of sprat spawning stock biomass 2000-2050. Harvesting strategy was held constant over time and between runs; only recruitment assumptions varied. Top: low cod recruitment phase; sprat recruitment as geometric mean 1987-2005; Bottom: high cod recruitment phase; sprat recruitment as geometric mean 1974-1986.

Economic Part

In the first phase of the project the economic part started with coupling profit maximization with a stage-based Lesley-Matrix as biological constraint. This approach has been enhanced in the present reporting period to address the question whether it is beneficial to harvest only old or both young and old cod. Thereby, several assumptions have been adopted. To keep the model tractable non-mature age classes are omitted and predation disregarded. The standard Schaefer harvest function is used. Depending on the chosen values for the harvest rates for the young and mature cod, numerical simulations showed convergence, oscillations and pulse fishing. The profit optimization for this model is carried out using inter alia the solver Knitro (Ziena Optimization Inc.) which provides three

state-of-the-art algorithms (Interior-Point Direct, Interior-Point-Conjugate Gradient, and Active Set Algorithms).

Cluster Project CP0608: DearX – XML Technology for Marine Data Exchange, Archiving and Retrieval

Lead Proponent: N. Luttenberger

Ocean Observatories face several common problems that are related to the fact that "raw" measurement data are meaningless when not enriched with contextual information. Marine data exchange, archiving and retrieval therefore requires solutions to the following problems:

- provision of continuous and complete documentation of the provenance of measured data
- unveiling of implicit knowledge that is hidden inside the processing chain
- declaration of the procedures for discarding raw data that are considered as irrelevant.

To find out which data formats are applicable for the Future Ocean research network, chains of data processing steps at several research groups have been analyzed. It turned out that data formats based on the Geography Markup Language (GML) are a good choice for marine measurement data because they offer adaptability, formal validation and self-describing data. Several international organizations such as ISO and the Open Geospatial Consortium (OGC) have been active in the field of XML grammars ("schemas") for geographic information and measurements. One of OGC's latest standards is "Observations and Measurements" (O&M), an XML schema to describe the process and the results of a measurement. Together with another

OGC standard, the Sensor Modeling Language (Sensor ML), they are a good basis for data in the Future Ocean research network.

A working demonstrator program has been created to illustrate the capabilities of an XML-based framework (O&M and SensorML) for marine data exchange, archiving and retrieval. Ongoing is the development of a real application for handling O&M documents.

Language binding can be used to generate software components based on formal data descriptions. A software generator has been developed that generates input routines based on O&M documents. In a test case this code has been used to simplify Matlab scripts for data processing in various ways: Cryptic input routines that used to be hard to understand became much easier to read because values are accessed by their names. Instead of dealing with unit-less numbers the units of measurement which are required by the algorithm are stated explicitly. The generated code will even perform conversion of units in the background if possible.

The goal of another test case was to reduce the man/machine interaction in measurement projects by using XML-based data formats for data and metadata. Manual steps in are error-prone and might contain media breaks (electronic files and paper). That makes these steps difficult to reprocess. Importing data and metadata directly from the measurement device eliminates the need of hand-written notes. The data is converted into standard data formats that can be easily processed using the language binding technology mentioned above.

The work has been done in collaboration with Prof. M. Visbeck's Physical Oceanography research

unit, Prof. U. Riebesell's Biological Oceanography research unit and Prof. D. Piepenburg's research group at the Institute for Polar Ecology. We are also involved in the Device Ontologies Working Group working on common vocabularies for oceanographic devices.

Results of the work has been published as a white paper at the Ocean Sensor 08 conference in Warnemünde: J. Zedlitz, J. Graybeal, N. Luttenberger: "Using XML-based formats for marine data"

Cluster Project CP0609: The Role of Light Fluctuations on Ocean Heating and Photosynthesis

Lead Proponents: A. Macke, M. Wahl, P. Croot, C. Eden & M. Zimmer

The solar radiation is responsible for ocean heating and enables photo-biological and photo-chemical processes in the ocean. Most of these processes respond in a nonlinear way on the solar radiation intensity. Consequently, physical and biogeochemical reactions on varying insolation differ from those with mean insolation of same intensity. The projects objective is to quantify these differences in model and experiments under realistic conditions.

The supply of radiation into the ocean, its intensity and penetration depth, depend on the electromagnetic wavelength and water properties. Underwater light fluctuations arise from cloud dynamics and temporal changes of the sea surface topography.

Since July 2007 PhD. candidate Martin Hieronymi (Macke group) works on radiative transfer modeling and underwater light measurement and

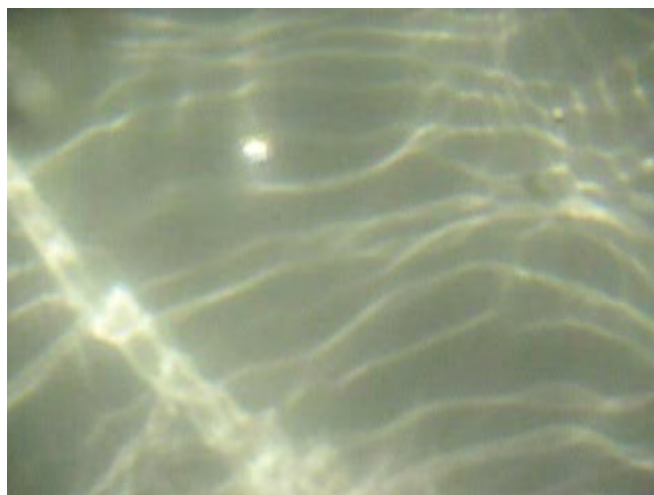


Figure CP0609-1. Underwater light regime due to waves.

data analysis. From this side, properties of light fluctuations (depending on water depth, sea state, ...) are determined and provided to the other groups. In order to investigate effects of erratic light on marine processes, motion pictures of a white board mirroring a realistic underwater light regime have been taken (example picture in Fig. CP0609-1). The real time animation shows very bright light fields caused by gravity waves and less bright light due to capillary wind waves. The temporal variation of the downwelling radiation for one example pixel is shown in Fig. CP0609-2. From time and frequency analysis, conclusions on light intensity, fluctuation rate, statistical characteristics and spectral split-up can be drawn. For example, in Fig. CP0609-2 the mean fluctuation period is about 0.3 seconds, thus the dominant wave is 20 cm in length.

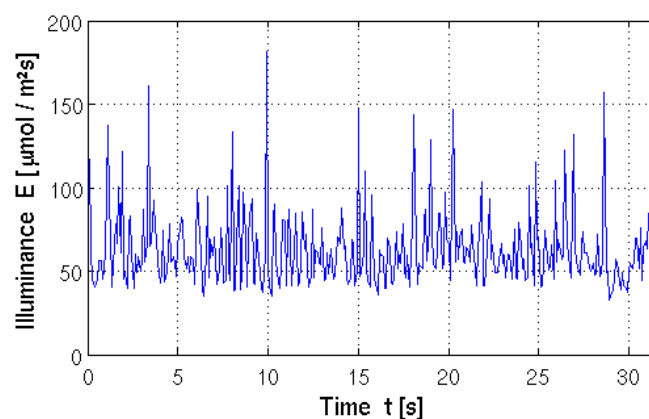


Figure CP0609-2. Time series of brightness of a motion-picture pixel.

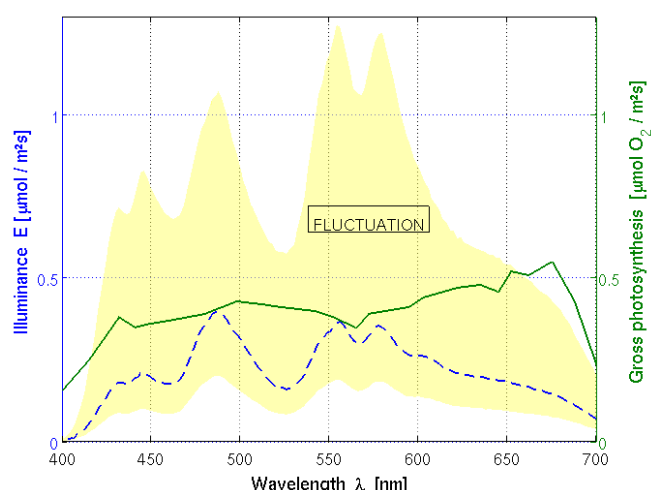


Figure CP0609-3. Spectral irradiance of the fluctuation movie (mean value of 60 $\mu\text{mol/ms}$ is blue dashed, yellow area is for fluctuation); green: photosynthetically active range of *Fucus* at 10 $\mu\text{mol/m/s}$ (according to Lüning & Dring, 1985).

The quantitative observation of subsurface light variation will be carried out along the Atlantic transects of the German research vessel Polarstern under various climatological, synoptical and aquatic conditions.

In the framework of a Diploma thesis, Katharina Grosser (Wahl group) investigates the role of light fluctuations on algae growth and feeding preferences of herbivores. By means of two beamers, macro algae *Fucus vesiculosus* were illuminated with varying light of the motion picture described above and with constant light with same average intensity (Fig. CP0609-4). Later herbivores

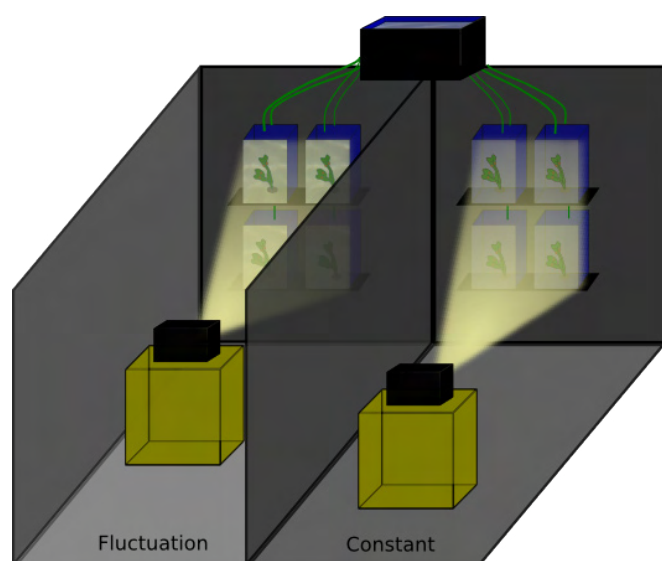


Figure CP0609-4. Experimental Setup for algae under different light regimes.

were added to the algae to induce their feeding defense.

Because of the low number of replicates, only tendencies can be detected, e. g. in the results of algae growth rates (so this needs further analysis). Nevertheless, there are significant differences in the feeding preferences of *Idotea baltica*, which can be proved by feeding assays and HPLC runs. The herbivores preferred algae pellets that had been subject to fluctuating light. Algae under fluctuating light produce a chemical component, causing a favouritism of them by *Idotea*. These components need to be identified in future works by means of mass spectrometry. C/N analysis showed that the C/N ratio of algae, which had been subjected to fluctuating light, is significantly higher than those of algae that were under constant light.

Cluster Project CP0610: Synergetic Effects of Temperature, pH and Salinity on the Metabolism of Benthic Organisms

Lead Proponents: D. Piepenburg

This project was strongly associated with cluster research topic A2 (effects of seafloor warming) by addressing the issue of how benthic organisms respond in terms of their metabolic performance to changes in environmental key factors (temperature, pH, salinity, and food availability). In an integrated approach, we investigated the sediment community oxygen consumption (SCOC) in small-scale field measurements in relation to ambient temperature, salinities as well as sediment properties used as proxies of food supply. For the oxygen measurements, we employed a device consisting of a combination of a CTD and a high-precision high-resolution fibre-optical oxygen sensitive sensor (optode)

mounted on a core. During in-situ deployment, the probe was pressed into the sediment and the oxygen depletion over time was measured in the overlying water to estimate the SCOC of the benthic fauna within the core. The intention to determine the oxygen consumption of selected macrobenthic organisms in laboratory experiments in relation to varying temperature and pH had to be postponed due to technical and logistical problems (these measurements are currently performed within cluster project CP07A54).

For the field study, a site in the Kiel Fjord near the "Seebadeanstalt Düsternbrook" at 3-4 m water depth was selected. During a setup phase until April 2007, the respiration measurement system, which had been used before in the Arctic deep sea, was modified for the deployment by scuba divers in shallow waters. The actual in-situ measurements started in May and finished in October 2007. Within this period, there were thirteen successful deployments in total, each lasting between 15 and 24 hrs. At other occasions, the probe did not deliver proper data, as it had obviously toppled over during deployment or because of reasons about which we can only speculate (possible leakage due to burrowing megabenthic in fauna). The amount of oxygen depletion over time, the length of incubation time and the spatial dimensions of the incubation chamber (volume: 1.801 l; area: 0.025 m²) were used to estimate SCOC rates per m² and day. In addition to measuring the decreasing oxygen concentration in the incubation core, the CTD component of the system also recorded ambient temperature and salinity. Moreover, after the deployments the sediment in the incubation chamber were analysed for sediment parameters (water and organic carbon content (TOC), chlorophyll a and phaeopigment concentration).

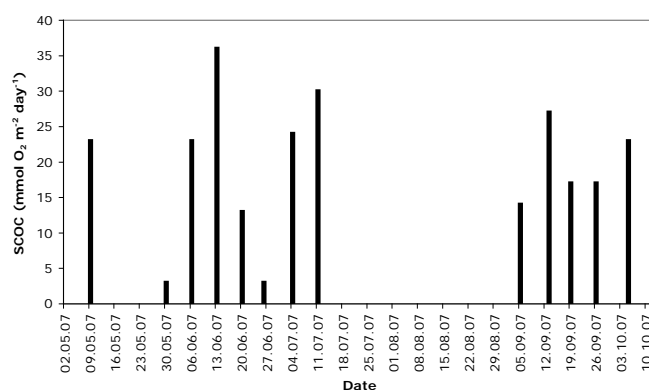


Figure CP0610-1. Sediment community oxygen consumption

Bio-mass and taxonomic composition of the sediment community in the incubation cores are to be determined yet.

The SCOC rates determined in the field study ranged widely over one order of magnitude between 3 mmol O₂ m⁻² day⁻¹ on June 25-26 and 36 mmol O₂ m⁻² day⁻¹ on June 12-13 (see Fig. CP0610-1). These values, being equivalent of carbon remineralisation rates of 30 and 370 mg C m⁻² day⁻¹ (assuming a respiratory quotient of 0.85), fall well into the range of 10-20 mmol O₂ m⁻² day⁻¹ that has been reported as common for coastal shelf sediments (Tengberg et al. 2004). However, we did not detect any clear seasonal pattern in the temporal distribution of SCOC values. Moreover, there were no significant correlations between SCOC and ambient water temperature (ranging between 10.5 °C in May and 18.1 °C in July) and salinities (11.4 psu in May to 16.7 psu in October) or sediment properties (TOC: 1.1-8.9%; Chl a: 2.8-18.9 µg cm⁻³; phaeopigments: 17.0-37.4 µg cm⁻³) in our data. Hence, any possible relationship between benthic community metabolism and environment (temperature, salinity, food supply) was masked by a high degree of randomness in the data, probably due to the small-scale patchiness in the distribution macro-benthic fauna and, hence, biomass in the incubation cores.

Cluster Project CP0611: Complex Barriers and Microbiota in the Ocean: Implications for Human Barrier Disorders

Lead Proponents: R. Schmitz-Streit, Rebekka Metzger

Summary of Scientific Results

First objective of this project was to examine the diversity of microbiota associated with different species of copepods in order to gain insights into interactions between the animals and their microbiota. These diversity analyses have been performed and are available (see report 06/07). However, decision has been made to use a different model organism as the first results have shown that the marine copepods used in this study were too small and the amount of epibiotic bacteria too less to get enough prokaryotic DNA for further studies using metagenomic and transcriptomic approaches.

The moon jellyfish (*Aurelia aurita*) and its different life stages (*sessile polyp*, mobile stages *ephyra* and *medusa*) was chosen as a new model organism. This animal shows almost a cosmopolitan distribution with temporarily very high abundances. Its life cycle involves metagenesis (alternating sexual and asexual reproduction) and epithelia is covered by mucus which consists of "qniyumucin" a glycoprotein that resembles one mucin found also in humans (Masuda et al., 2007). No previous work concerning this species and associated micro-organisms by other investigators is known by now. Thus, the microbiota of all three life stages of *A. aurita* was examined (see results). We started to closely cooperate with the group of Prof. Dr. T. Bosch, Zoological Institute, Department of Cell-and Developmental Biology, which are currently focussing on gener-

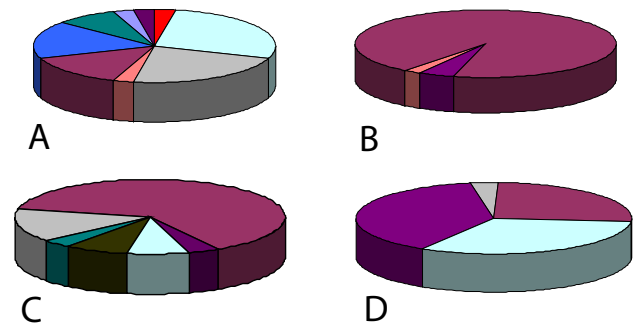


Figure CP0611-1. 16S-rRNA-analyses (examples) of ambient water (A), surface mucus of *A. aurita medusa* (B), whole *polyp* (C) and *Ephyrae* (D).

ating transgenic *A. aurita* (see also intermediate report by Thomas Bosch and Björn Fuchs). Further experiments with *Aurelia larvae*, strobilating polyps and later genetically engineered animals are currently outlined.

First Results

So far diversity analyses of all three examined life stages of *A. aurita* have been performed (Fig. CP0611-1, A-D). A higher bacterial diversity was found in ambient waters compared to animals indicating specific associated microbiota (ambient water, A; surface mucus of *medusae*, B, *ephyrae*, C, *polyps*, D). Additional analyses of different parts of *medusae* will be necessary for comparison with other life stages (whole animals of *ephyrae* and *polyps*). Furthermore differences in bacterial species composition between the three life stages with a lower diversity were found in surface mucus of adult *medusae* and whole *ephyrae* compared to *polyps* (Fig. CP0611-1, B-D).

Ongoing work

Whole DNA extraction of different tissues of the adult *medusae* and whole *polyps* (length approx. 2 – 5 mm) yields too high amounts of eukaryotic compared to the prokaryotic DNA and cannot be efficiently used for the construction of a prokaryotic metagenomic library. Therefore, we

are currently establishing a method to enrich the prokaryotic DNA by a combination of differential lysis and centrifugation. This method will also be used to purify prokaryotic RNA for construction of metagenomic cDNA libraries.

Additionally, culturable bacteria from homogenized animals (*polyps*, *medusae*) and surface swabbing of *medusae* (upper and lower surface) have been isolated and identified. These isolates are currently being tested for different properties, e. g. antimicrobial effects.

Perspectives

During the next few months prokaryotic metagenomic libraries will be constructed and using *A. aurita* as a model organism, it is expected to gain insights into how microbiota-host-interactions and barriers (innate immune system) evolved.

Cluster Project CP0612: Radiocarbon Dating of Fossil Biogenic Carbon as an Indicator of Age Differences in Surface and Subsurface Water Masses in the Past Ocean

Lead Proponents: R. Schneider, T. Blanz, , P. Grootes, Dr. N. Andersen, M.-J. Nadeau

This project aimed to test the use of differences in the radiocarbon age of different fossil organic (alkenones) and inorganic (calcitic skeletons of coccoliths and planktonic foraminifera) carbon in marine sediments as an indicator for changes in the dissolved carbon inventory of surface, subsurface and deep-water masses (or mixing of them) for the last 30.000 years. We intended to set up a routine method using preparatory gas chromatography and the SPLIT system (both purchased through Cluster start-up funding) for extraction of biomarker carbon and cocco-

lithophore calcite, respectively. The project started by February 1, 2007 with the Postdoc contract given to Dr. Enno Schefuß, who worked before at the Woods Hole Oceanographic Institution, MA, USA on a similar theme. As radio-carbon dating of individual organic compounds by AMS is laborious and cost-intensive, we used the first 6 months of the project to intensively test and optimise the system of preparatory capillary gas chromatography before starting the dating of real samples. The major purpose of this technical work was to ensure that routine dating of organic biomarkers can be performed without contamination of the samples by GC capillary column bleeding or incomplete recovery of specific compounds due to leakage of the GC and trapping system.

In order to minimize potential effects of column bleeding already beforehand, our system was equipped with a special high temperature column (XTI-5 from Restek), which is characterised by extreme low bleeding and a system was installed that permanently checks for leakages within the GC oven. Furthermore, we tested the trapping efficiency with mixtures of specific organic compounds with different chain-lengths (e.g., n-C18 to n-C32). By ensuring a leak-tight

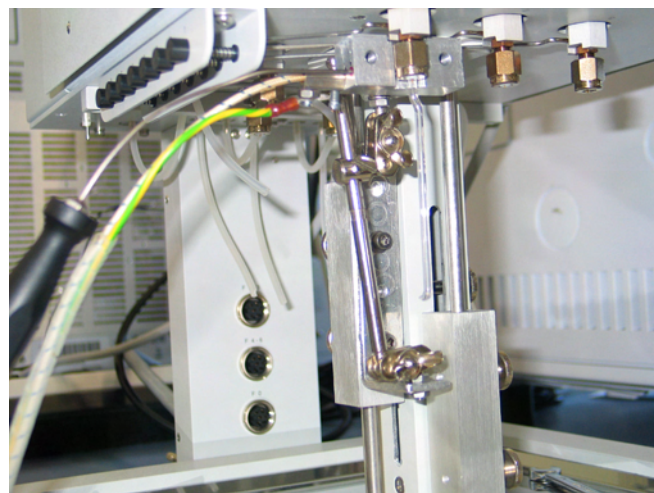


Figure CP0612-1. Improved trap system with heating device for the preparatory GC.

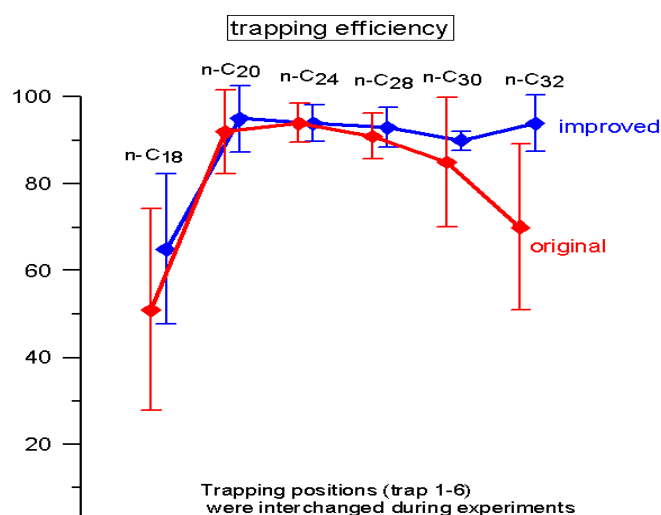


Figure CP0612-2. Trapping efficiency with respect to hydrocarbon chain length.

system, the trapping efficiency for all compounds can be above 90%, however often with outliers below 70% for compounds with different carbon-chain length. By running several test samples over several weeks we found that with standard length of the capillary and the original technical set up of the GC and trapping system, some material gets lost at the very end of the trapping capillary. This loss is due to the strong temperature gradient between the preparative fraction collector (PFC) oven at 320°C and the component trap at room temperature. To reduce this temperature gradient, we built an optional heating device (up to 350°C) for the metal nut at the connector next to the component trap. In addition, by modifying the length of the trapping capillary which transfers the substances to the component trap we could reach trapping efficiencies close to 100%. Even for less efficient trapping there is no memory effect, which means that no material from previous samples will be sampled in later samples.

After the successful technical improvement of the preparatory system, the hired post-doc Dr. Schefuß cancelled his contract after 8 months and left our department for private reasons. We sought for other experienced candidates to hire

but this was not successful because of the short contract time to offer. On the other hand, we were able to further enlarge our equipment by purchasing a GC-irm MS system through platform P2 cluster investments in 2007 and we changed our strategy by searching now for a post-doc candidate to work with both systems who will be paid by grant money from external third party funds. Hopefully this person then can be hired for longer and thus can proceed with the work intended originally also for this cluster proposal.

Cluster Project CP0614: „Mathematische Optimierung in der Meeresforschung“

Project period: 1/2007-6/2007

Lead Proponent: A. Srivastav

Theme and Personell

The theme of the project was the development of an optimization library for the application and integration in other projects of the excellence cluster. Funding was granted for 9 months (1 BAT IIa position), approximately 40000 €. Several persons worked in the project:

- Dipl. Math. Lasse Kliemann (01.01.07-30.06.07)
- Dipl. Math. Volkmar Sauerland (01.04.07-30.06.07)
- Dr. Soeren Werth (15.09.06-30.06.07)

Research Tasks and Goals

The project aimed for a solid foundation to bridge the gap between state-of-the-art mathematical optimization methods and the demands for mathematical optimization arising in marine science. Methods developed and/or used in discrete optimization have to be presented and

provided in an applicable manner for the research groups in the excellence cluster allowing a smooth integration in existing frameworks.

Results and Ongoing Work

There is a variety of freely available optimization software libraries (or at least freely available for academic use) for fundamental problems like linear, quadratic, or general nonlinear optimization. Their quality as well as their use is, however, not always clear even to experts.

The main achievement of the project is a manual in which several free software libraries are presented with discussions about their advantages and disadvantages based on our practical experience. We give several examples of their use that come from past and ongoing research, simplified where necessary for the sake of a concise presentation.

The manual and source code are open and will be accessible for the cluster of excellence. The example code is cleanly written and well-structured allowing it to be easily used in the way of a software library itself for the chosen example problems and related ones.

The manual presents and comments on 50 pages the following optimization libraries:

- CLP and GLPK linear programming optimizers using simplex and interior point methods. Different interfaces are described and discussed in terms of usability and memory-efficiency.
- CFSQP, a C library for feasible sequential quadratic programming.
- LANCELOT and IPOPT general nonlinear programming optimizers.

These solvers are especially difficult to use but have shown to be powerful in our applications. We therefore take a special effort to present their programming interfaces and give illustrations for their use. The manual is accompanied by the complete source code of all the examples in runnable form.

We also offer scripts to compile and install the libraries themselves from source on a recent Linux system. Other projects have already benefited from the manual, like the project on “Mathematical and Algorithmic Challenges in Modelling Biochemical Cycles”, which uses CFSQP. It also is planned that general nonlinear solvers will be used in the framework of parallel methods for biogeochemical (BGC) tracer simulation.

Future Work

The manual is already in use, but it also far from being exhaustive. Our future efforts will go into two directions. On the one hand, we will include a chapter describing technical details on the implementation of parallel genetic algorithms as they are currently developed and tested in the modelling of biochemical cycles. On the other hand, more optimization libraries shall be included, with a special focus on parallel implementations which seems to be a specific requirement for efficient computation within the cluster. Candidates are the OPT++ nonlinear optimizer and the OOPS parallel interior point solver.

Cluster Proposal CP0618: Beyond Mineral Resources - The International Legal Regime and Regulation of New Uses of the Deep Sea Bed

Lead Proponents: A. Zimmermann, T. Giegerich, U. Jenisch

After an initial survey of current literature in the field, research has focused on the Principle of Common Heritage and how it relates to novel uses of the Deep Seabed. So far it can be concluded that while the elaborate regime of UNCLOS is not applicable to non-mineral resources, the general principle of Common Heritage is. It is however far from certain what consequences for the exploitation of non-mineral resources that entails. These preliminary thoughts were presented at a Blue Hour event hosted by the Junior Research Group "The Law of the Sea and Marine Resources" on May 5th 2008. Furthermore the current research was presented in the form of a poster at the Cluster Retreat in Salzac on the 17th/18th of March 2008.

Another focus point has been the issue of access to the genetic resources of the deep seabed, which is proving to be the most complex and pressing theme of this work. In order to better understand the position of genetic resources in today's legal order the PhD student attended a conference on the CBD in Bremen in January of 2008. Analyzing the immense difficulties of the Access and Benefit Sharing (ABS) regime of the CBD will enable the student to better gauge the possible implications of a possible ABS regime for Deep Seabed Resources.

In order to clearly identify the area of the Deep Seabed beyond national jurisdiction, the PhD student analyzed the legal provisions establishing the outer limits of the continental shelf claimable

by coastal states. This work has cumulated in a paper on the legal regime of the Arctic Ocean written together with Prof. Dr. Proelß from the Junior Research Group "The Law of the Sea and Marine Resources" which has been submitted for publication with the Zeitschrift für ausländisches öffentliches Recht und Völkerrecht.

Currently the PhD student is involved in a project with Kirsten Ruckes, from the Institute for Economics in Kiel, on the correlation of legal structure and effective resource management. It is hoped that this project does not only yield valuable insights regarding a possible legal regime for the resources of the Deep Seabed but will also lead to the publication of a joint paper.

Additionally the PhD student has been deeply involved in the work of ISOS, planning one, and participating in two ISOS PhD retreats. This involvement has already led to the cooperation with Kirsten Ruckes and it is hoped that it will foster further inter-disciplinary cooperation in the future. Especially the issues of CO₂ sequestration as well as the exploitation of methane hydrates seem quite promising in this regard.

Cluster Project CP0619: Development of a Coupled Climate/Ocean Biogeochemistry Model

Lead Proponents: H. Dietze, A. Landolfi, A. Oschlies, M. Latif, C. Böning

Within Project A3 the Kiel Climate Model system has been augmented by a typical nutrient-phytoplankton-zooplankton-detritus (NPZD)-type biogeochemical model of nitrogen and carbon cycles. Results of this initial work showed substantial deficiencies with respect to observations. In particular, the model fails to reproduce nutrient and phytoplankton distributions in the

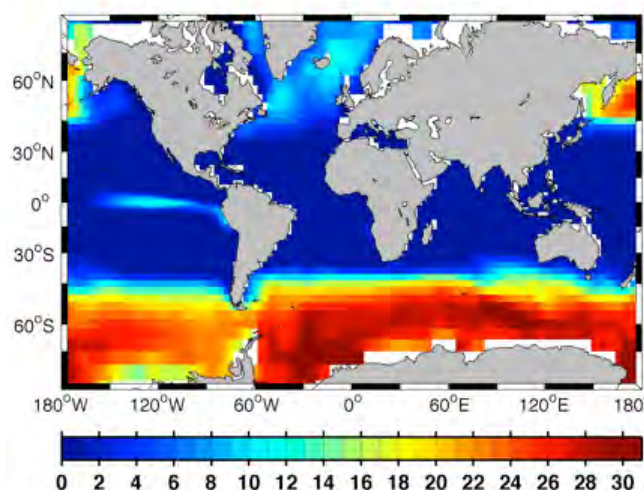


Figure CP0619-1. Modeled annual mean nitrate concentrations (mmol m^{-3}) with the modified grazing parameterization in the biogeochemical NPZD module.

eastern equatorial Pacific and in the Southern Ocean (often referred to, as HNLC regions). This flaw is common to simple ecosystem models and is persistent over a wide range of circulation models and is generally attributed to the limiting effect of iron deficiency (Fig. CP0619-1).

In order to investigate possible causes of the significant model-data misfits, a simple NPZD

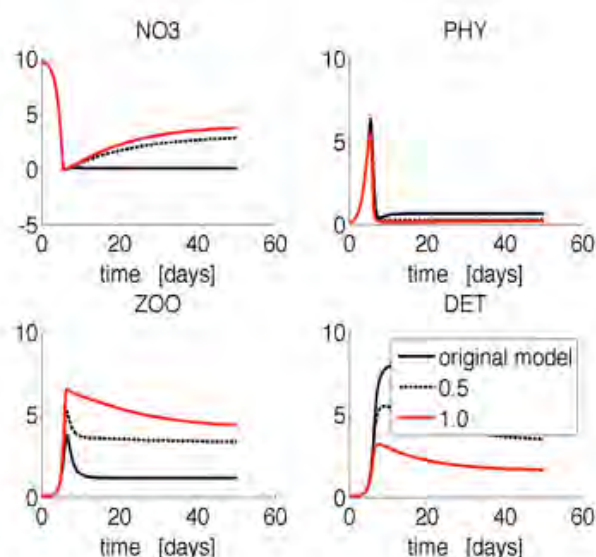


Figure CP0619-3. 0-D Sensitivity study: nitrate, phytoplankton, zooplankton and detritus time evolution in 3 grazing parameterizations experiments. In the original model (solid black lines) zooplankton does not feed on detritus. The red lines correspond to a simulation in which zooplankton feeds on both phytoplankton and detritus without any food preference. The dashed black lines refer to a model in which zooplankton prefers phytoplankton to detritus.

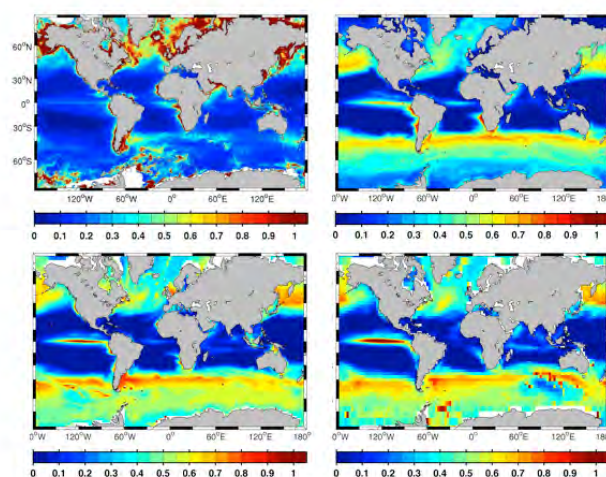


Figure CP0619-2. Top left panel: Annual mean distribution of chlorophyll a as estimated from the SeaWiFS satellite composite 2005 observations. Top right, bottom left and bottom right panels: Modeled annual mean phytoplankton concentration in the surface layer corresponding to the Kiel Climate Model (KCM), Modular Ocean Model 4 (MOM4) 1° , and MOM4 3° respectively. Units in all panels are mg Chl a m^{-3} .

type model was modified such that zooplankton does graze not only on phytoplankton but also on detritus. An additional model parameter now describes the food preference of zooplankton and can be tuned such that the representation of HNLC regions is improved while phytoplankton and macronutrient dynamics during blooms remain almost unchanged (Fig. CP0619-2).

The sensitivity of the biogeochemical module towards changes in the grazing parameterization has been further studied in a zero-dimensional study (Fig. CP0619-3). While this is only a single attempt to subjectively change the ecosystem model and its parameters, the large sensitivity of the simulated nutrient fields is viewed as promising in terms of ongoing attempts to develop model assessment criteria based on model-data misfit metrics. Such metrics will be required for successful applications of data assimilation methods, development of which is ongoing in Theme A3.

Appendix E: Reports from Proposals 2007

Cluster Proposal CP0702: Transgenic *Aurelia* Allow Functional Analysis of Genes Involved in Control of Tissue Homeostasis and Biological Barriers

Lead Proponent: T. Bosch

Goal: To dissect the molecular mechanisms controlling barrier function at the base of the animal tree in vivo, we proposed to develop an efficient method to generate transgenic jellyfish (*Aurelia aurita*) by embryo microinjection.

Progress report: Based on our success in stably transforming the freshwater *polyp Hydra* (Wittlieb et al., PNAS 2006), we are currently developing a system that allows generation of stable transgenic *Aurelia* lines. With the help of a Ph.D. student, Björn Fuchs (member of ISOS), we have generated a number of reporter (EGFP /mCherry)

expression constructs based on the *Aurelia aurita* β -actin, tubulin, histon and upiquitin genes (Fig. CP0702-1.A) for microinjection into *Aurelia* embryos at the 1 – 2 cell stage. Since sexually mature animals can be collected in the Baltic Sea only between June and September, we now just have started to collect embryos and planula larvae from oral arms of adult *Aurelia* (Fig. CP0702-1.B and C). Furthermore, with support from Eppendorf Inc. we have adapted the existing microinjection facility for *Aurelia* embryos. Embryos will be held by a micropipette using a CellTram Air pump (Eppendorf). Construct will be injected using a CellTram vario pump (Eppendorf).

Perspective: We expect within the next few months to successfully transform *Aurelia* embryos. Transgenic *Aurelia* will then be used to understand human barrier disorders by describing ancient mechanisms of host/microbial interactions and the resulting evolutionary selection processes or advantages, which have originally evolved in the marine environment.

Cluster Proposal CP0704: Carbon Acquisition in Coccolithophores: Molecular Basis and Adaptive Potential

Lead Proponent: R. Schulz-Friedrich

R. Schulz, N. Backasch (PhD), B. Forberich (PhD) and J. Appel (Institute of Botany) U. Riebesell, J. Barcelos e Ramos (PhD), A. Eisenhauer and K. Schulz (IFM-Geomar) M. Bleich and K. Suffrian (PhD) (Institute of Physiology) H. Kinkel (Institute of Geosciences)

The oceans presently absorb one third of anthropogenic CO₂ emissions, causing a gradual acidification of oceanic surface waters. While the magnitude of CO₂-induced ocean acidification

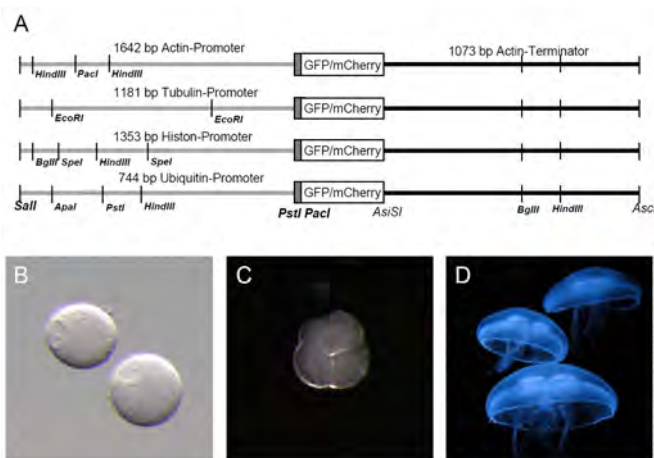


Figure CP0702-1. Towards generation of transgenic *Aurelia*. (A) The expression constructs used to generate transgenic *Aurelia*. (B) Unfertilized eggs collected from female *Aurelia* taken from the Förde. (C) 4-cell stage embryo. (D) Sexually mature *Aurelia* jellyfish (photo thanks to Sebastian Fraune).

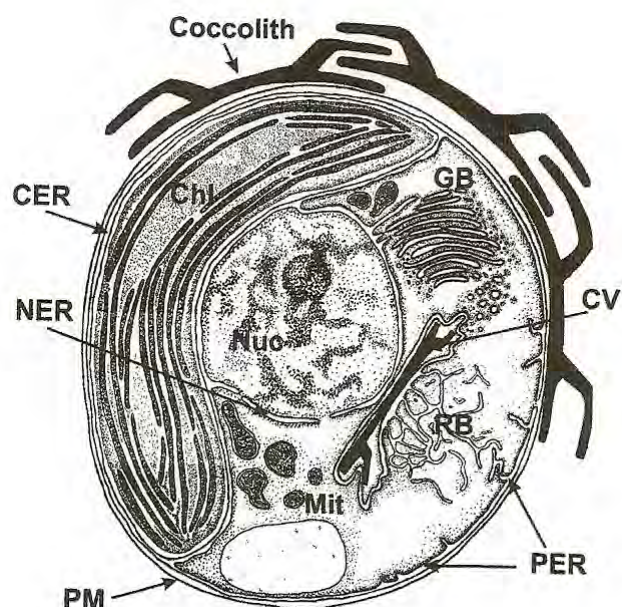


Figure CP0704-1. Schematic representation of a *coccolithophorid* cell. Nuc, nucleus; Mit, mitochondria; Chl, chloroplast; PM, plasma membrane; GB, Golgi apparatus; CV, coccolith forming vesicle; RB, reticular body; PER, peripheral endoplasmic reticulum; NER, nuclear endoplasmic reticulum; CER, chloroplast endoplasmic reticulum (Thierstein and Young 2004).

can be predicted with reasonable confidence, its impacts on marine organisms and their ecosystems are largely uncertain. Recent data show that particularly calcifying organisms can be adversely affected by ocean acidification. At the base of the marine food web, *coccolithophores* - an important group of calcifying phytoplankton - experience reduced calcification and increased malformations of their calcite platelets at elevated CO_2 . Like most phytoplankton, *coccolithophores* operate active ion transport systems to take up inorganic carbon for photosynthesis. This so-called carbon concentrating mechanism (CCM) also supplies, together with calcium ion transporters, the building blocks for calcite formation. The ability of *coccolithophores* to adapt to acidification and to maintain their competitive fitness in "The Future Ocean" will partly depend on the adaptive potential of their membrane transport systems to CO_2 -induced changes in seawater chemistry.

To address the question of adaptive cellular responses to ocean acidification we developed multidisciplinary collaborations across various topics of the Cluster of Excellence Future Ocean by combining expertise ranging from molecular and marine biology, cell physiology to isotope geochemistry and paleoceanography. The project establishes active cooperation between research groups associated with Themes A1 (Ocean acidification), A4 (Hydrological cycle during the Holocene), and B2 (Interactions between complex barriers and microbiota), which have not previously worked together. The project uses the excellent facilities at the central microscopy lab, the centre for biochemistry and molecular biology (Platform P3) and the Tracer Analysis Centre (Platform P2). These collaborations directly benefit the Junior Research Groups (JRG) in the respective topics and will allow them to quickly develop their research program and make use of the broad expertise available in the Cluster of Excellence Future Ocean.

1. Development of cell fractionation methods to isolate organelles and membranes

The uptake of calcium and carbon into the coccolith forming vesicles requires transporters in the plasma membrane, the endoplasmic reticulum, the Golgi apparatus and the vesicle itself (Fig. CP0704-1). These transporters are likely to be of different phylogenetic origin and to have different affinities and kinetic properties. Work is in progress to develop a reliable protocol for the fractionation of the relevant cellular compartments in the *coccolithophore* *Emiliania huxleyi*. Although the cultivation of axenic culture of *E. huxleyi* still makes difficulties, we succeeded in isolating first total membrane samples, from which the membrane-complexes were separated in a blue-native gels (Fig. CP0704-2.A,B).

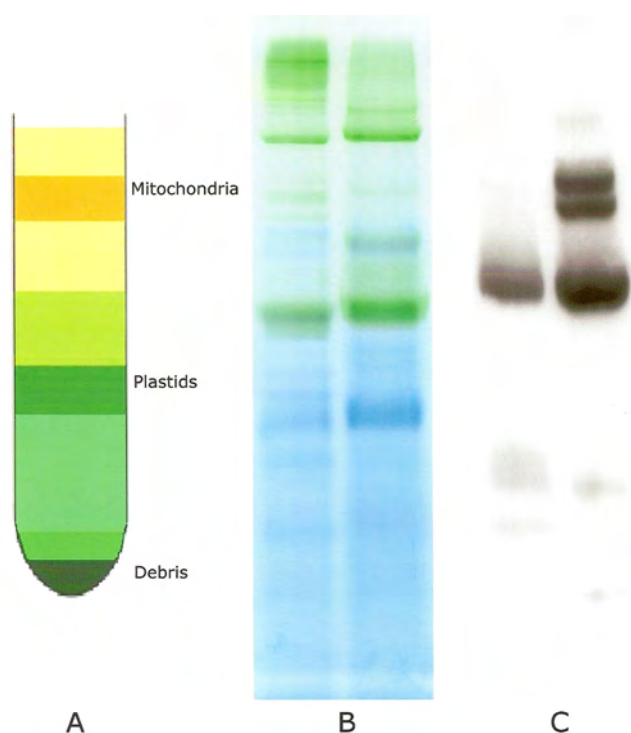


Figure CP0704-2. A: Isolated organelles after sucrose density gradient centrifugation of disrupted cells, grown with CO_2 between air level and 2%. B: Blue-native-gel of isolated plastidal membranes. C: Immunoblot with CCM-specific antibodies.

2. Proteomic analysis of isolated membranes for specific transporters

Genetic information on transporters in *coccolithophores* is presently scarce. The group of R. Schulz successfully use blue-native gels for the investigation of CCM components in cyanobacteria. We are working on the adaptation of this technique for the separation of membrane complexes in *coccolithophores*. First isolated total membrane samples were separated in blue-native gels (Fig. CP0704-2.B). In a following western blot with antibodies against one subunit of complex 1, a complex involved in carbon concentrating mechanism (CCM), we obtained first results (Fig. CP0704-2.C). Next will be the isolation of the organelles of *E. huxleyi* to get rid of bacterial contaminations. For a more precised localization of the membrane complexes application of different antibodies against complex 1 and other candidates for CCM will be performed.

Proteins and complexes in the gels will be analyzed by mass spectrometry to determine their exact composition. The currently ongoing *E. huxleyi* EST sequencing project will enable us to find the respective transcripts which will then

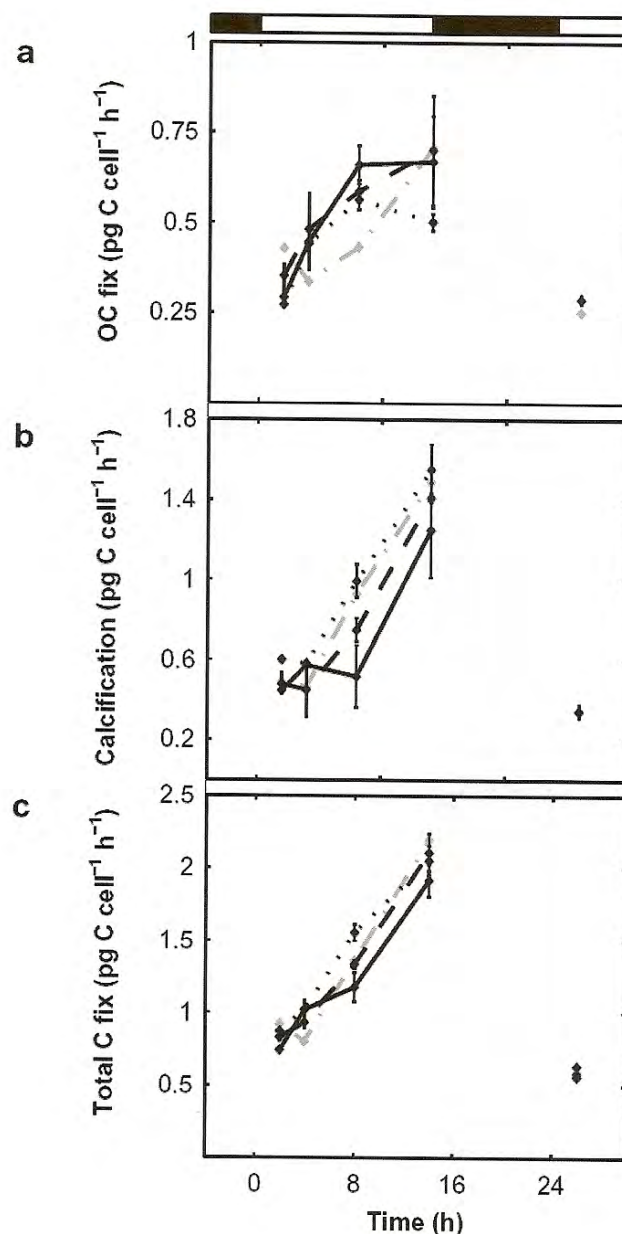


Figure CP0704-3. Carbon fixation rates of *Emiliana huxleyi* determined for each period of time between consecutive sampling points. (a) organic carbon fixation per cell per h, (b) calcification per cell per h and (c) total carbon fixation per cell per h. For each period of time the data point marks the end of the incubation. 190 μatm CO_2 (dash-dotted grey line), 420 μatm CO_2 (dotted black line), 800 μatm CO_2 (dashed black line), 1470 μatm CO_2 (solid black line). Each CO_2 level has duplicate measurements. Vertical error bars represent standard errors of means at each time point. The white /black bar on top represents the light/dark diel cycle. Vertical grey bars denotes the dark phase of the light/dark diel cycle.

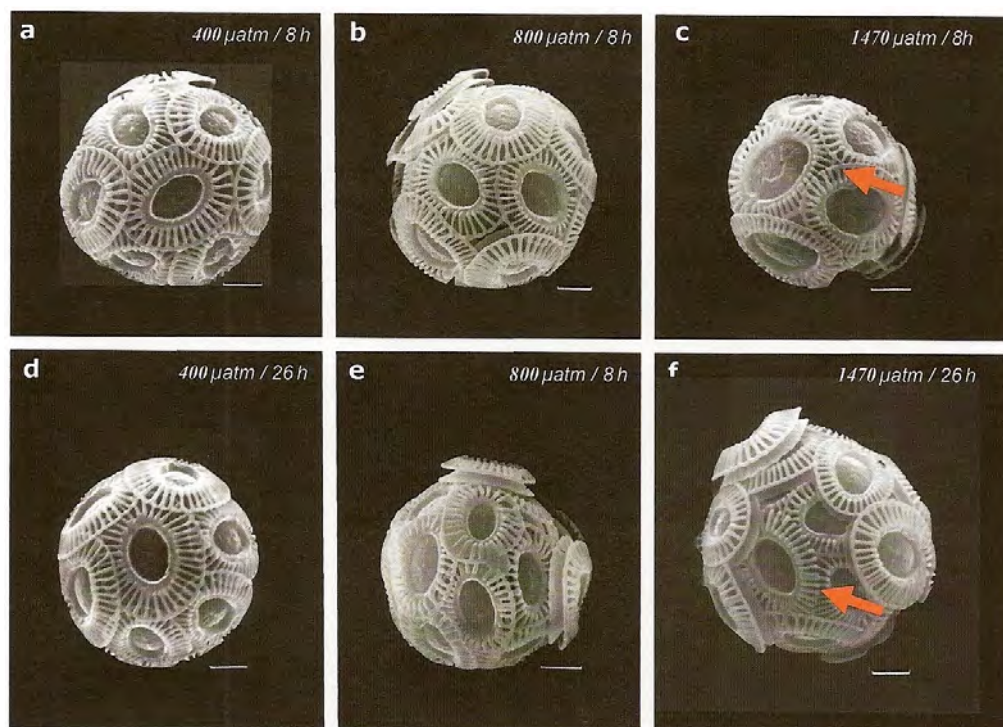


Figure CP0704-4. Scanning electron microscope pictures of *Emiliana huxleyi* under rising CO₂ concentrations. *Emiliana huxleyi* after 8 hrs of exposure to (a) 420 μatm, (b and e) 800 μatm and (c) 1470 μatm. *Emiliana huxleyi* after 26 hrs of exposure to (d) 420 μatm and (f) 1470 μatm. The photos chosen represent the general trend observed. Note the presence of under-calcified coccoliths under enhanced CO₂ conditions, especially visible in the connections between the elements forming the "outer ring" (distal shield elements) and in the enlargement of the central area. Scale bars correspond to 1 μm.

pave the way to powerful genetic methods.

3. Assessing carbon transport regulation in response to environmental changes

CCM regulation in *E. huxleyi* is investigated using membrane inlet mass spectrometry (MIMS) recently established in the lab of U. Riebesell. The affinities and kinetics of cellular carbon transport and calcification are on the way to be determined in cultures of different strains acclimated to a variety of growth conditions (pCO₂/pH, light, nutrients). Aliquots of the same cultures will be used for proteomic and isotope analyses.

In the meantime experiments were conducted to assess the short-term response of *Emiliana huxleyi* to rising CO₂ concentrations, determining the time necessary for the cells to reach a new physiological "equilibrium". We found that at

CO₂ levels from glacial (190 μatm) to those predicted for the year 2100 (750 μatm), calcification rates decreased and organic carbon fixation rates increased already 8 hrs after exposing the cultures to the changed CO₂ conditions (Fig. CP0704-3). The decrease in calcification could even be seen with scanning electron microscopy within 8 hrs. Cells under enhanced CO₂ levels showed incomplete or under-calcified coccoliths more frequently than at lower CO₂

(Fig. CP0704-4). Our results show that with the change in CO₂ concentration a new physiological "state" is established in a matter of hours, apparently independent of cellular division. Moreover, our short-term response (within 26 hrs) results are similar to previous studies with acclimated cultures under comparable conditions.

In another part of the project in the lab of M. Bleich *Coccolithophorids* are currently investigated for membrane transport properties and intracellular pH-regulation. Experiments provide data on membrane permeabilities for H⁺ and CO₂. Within this project we will further focus on carbon uptake and pH-regulatory mechanisms. Figs. 5 and 6 show changes in intracellular pH (pHi).

4. Analysis of the coccolith isotopic composition in relation to growth conditions

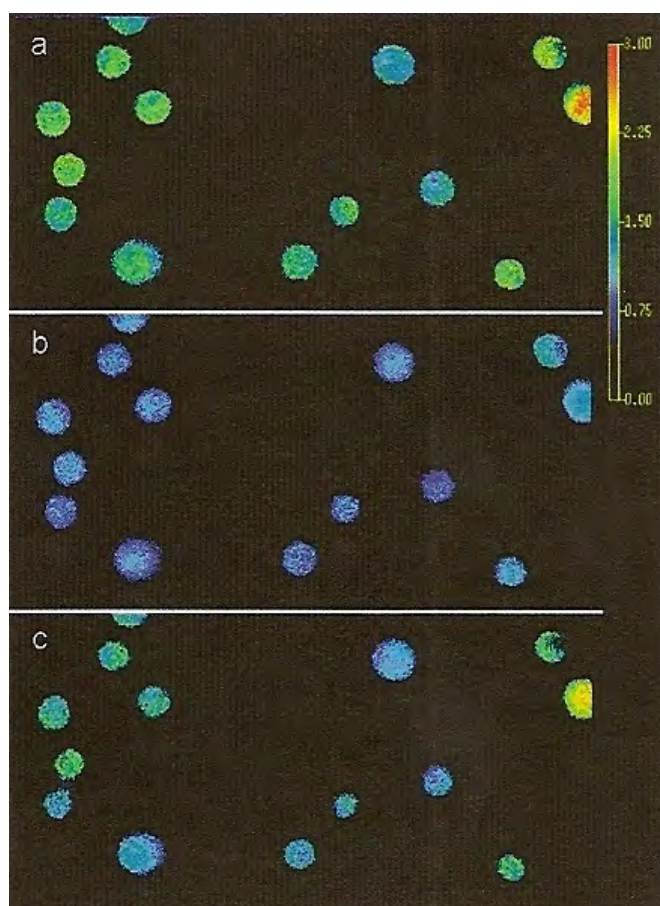


Figure CP0704-5. Ratio images of BCECF-loaded cells under control conditions (a), during a 5% CO₂-pulse (b), and under subsequent control conditions (c).

Coccolith carbon, oxygen, and calcium isotopic compositions ($\delta^{13}\text{C}$, $\delta^{18}\text{O}$, $\delta^{44}\text{Ca}$) will be measured to identify processes involved in the corresponding isotope fractionations and to further improve the calibration of these paleo-proxies.

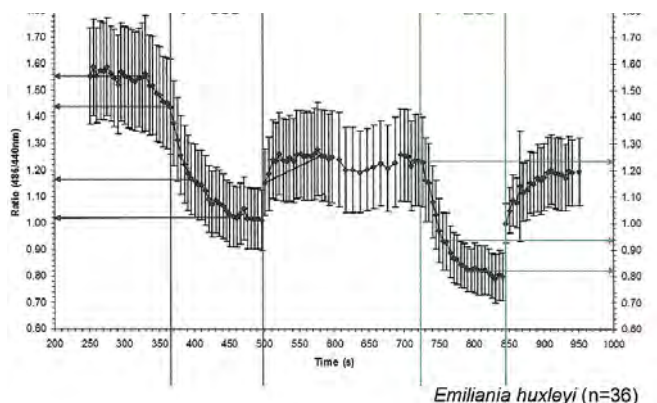


Figure CP0704-6. A typical experiment, showing the fluorescence ratio as a measure of pH_i. Application of seawater with a pH of 6.0 at 0,038% (acid load) and 5% CO₂ (aeration) concentrations, respectively, for approx. 120 seconds. (τ = time constant).

Cluster Proposal CP0706: Complex Barriers: the Biotic Control of Marine Biofilms on Algal Surfaces

Lead Proponents: M. Wahl R. Schmitz-Streit, F. Symanowski, D. Meske, T. Lachnit, M. Fischer, G. Friedrichs

This project had three aims:

- I. Characterise the epibacterial community on macroalgae
- II. Investigation of the chemical interaction between the alga and epibacteria
- III. Monitor the microfouling on artificial and living surfaces.

I). Substantial progress has been made in all three aims. As model host organism we have chosen the brown alga *Fucus vesiculosus* (Fv). Our first results using DGGE analysis indicated that several macroalgal species carry specific biofilms regardless of the habitat in the North or Baltic Sea where they were collected. This was confirmed by another replicated DGGE analysis followed by a 16S-rRNA analysis of the epibacterial communities on the invasive red alga *Gracilaria vermiculophylla*, the green alga *Ulva compressa* and the brown alga *Fucus vesiculosus* where the similarity between biofilms never exceeded 60% between the three host species (Fig. CP0706-1). In a second approach we isolated and sequenced culturable bacteria from the surface of Fv and from two co-occurring species, the red alga *Polysiphonia stricta* (Ps) and the kelp *Fucus serratus* (Fs) as well as from sediment samples. The genus *Pseudoalteromonas* occurred on all substrata, however, the only shared strain was BSw20057 which was found on Ps and Fs. All other strains were restricted to one host species (or sediment), i.e. the epibacterial communities differed to almost 100%.

These findings confirmed our original impression that epibiotic biofilms are host specific. Since all these epibacteria presumably recruit from the same pelagic colonizer pool, the bacteria absent from a given host alga but present on another algal species or on inert substratum must be repelled by metabolites either from the host alga or from other epibacteria.

II) Relevant host metabolites must be localized at the thallus surface. In order to extract specifically surface-bound metabolites, we optimized our surface-extraction method. To this end, algae were dipped in a hexane: methanol mixture (1:1) for various duration, and the accumulation of sugars and amino acids indicative of cell rupture was monitored by GCMS. It turned out, that the epithelium cells were not extracted if the dipping did not exceed 10 sec. Surface algal extracts (< 10 sec) were separated into polar water soluble and apolar substances. The latter were embedded into a phytigel matrix and polar substances were pumped gradually through the phytigel matrix, which was perforated by pinholes. At the phytigel matrix surface a chemical environment similar to the one at the thallus surface was expected. This device was exposed in situ to natural micro-fouling. A role of algal metabolites in the structuring of the biofilm was indicated by a higher

similarity between the phytigel community and Fucus biofilm than between the former and biofilm on inert substratum exposed in parallel. In a parallel study, we could show that exsudates of bacteria associated with algal surfaces had the potential to inhibit strains isolated from other algal species or from the sediment.

III) The development of a technology to optically monitor the settlement of bacteria at a very small scale and in real time by fibre glass fluorescence measurement is under way.

Concluding, we could confirm that macroalgae bear specific biofilms and that the establishment of these is controlled by metabolites of the host algae and associated bacterial strains.

Cluster Proposal CP0709: Marine Steroid Pharmaceuticals to Control Human Diseases

Lead Proponent: E. Maser

Institute of Toxicology and Pharmacology for Natural Scientists, University Medical School Schleswig-Holstein, Brunswiker Str. 10, 24105 Kiel, E-mail: maser@toxi.uni-kiel.de, <http://www.uni-kiel.de/toxikologie>

Summary

Steroids are evolutionary ancient molecules and play multifunctional regulatory roles in physiological processes like mineral, lipid or glucose homoeostasis. Important diseases including diabetes type 2, obesity, hypertension, osteoporosis etc. are linked to a malfunction of the steroid hormone system. Although a variety of procaryotes respond to steroids, almost nothing is known about the molecular basis of steroid signalling in bacteria. In this project, we want

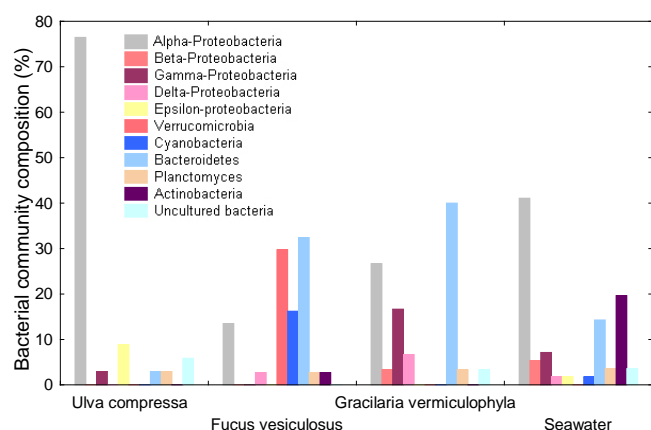


Figure CP0706-1. Microbial diversity determined by DGGE and 16S-rRNA analysis of ambient water and surfaces of different algae.

to infer how marine bacteria have evolved the steroid system to defend their ecological niche and which mechanisms they use to expand their capacity, diversity and adaptability to respond to steroids. The knowledge will be transferred to the development of new drug candidates for the treatment of important steroid-dependent diseases in human medicine.

Testosterone inducible regulator (TeiR) is a kinase which drives steroid sensing and metabolism in *C. testosteroni*

We use steroid-inducible 3 α -hydroxysteroid dehydrogenase/carbonyl reductase (3 α -HSD/CR) as a reporter system to study steroid signalling in *Comamonas testosteroni*. In previous investigations, we have cloned the 3 α -HSD/CR encoding gene, *hsdA*, and have determined the three-dimensional structure and function of the 3 α -HSD/CR protein. In addition, we have identified two negative regulator genes (*repA* and *repB*) in the vicinity of *hsdA*, the protein products of which repress *hsdA* expression on the level of transcription and translation, respectively. Recently, a positive regulator of *hsdA* expression, TeiR (testosterone inducible regulator), was found by transposon mutagenesis, but the mode of its action remained obscure. In the present work, we produced a TeiR-GFP fusion protein and showed that TeiR is a membrane protein with asymmetrical localization at one of the cell poles of *C. testosteroni*. Knock-out mutants of the *teiR* gene revealed that TeiR provides swimming and twitching motility of *C. testosteroni* to the steroid substrate source. TeiR also mediated an induced expression of 3 α -HSD/CR which was paralleled by an enhanced catabolism of testosterone. We also found that TeiR binds to a variety of different steroids other than testosterone. Biochemical analysis with several deletion mutants of the *teiR*

gene revealed TeiR to consist of three different functional domains, an N-terminal domain important for membrane association, a central steroid binding site and a C-terminus mediating TeiR function. Finally, we could demonstrate that TeiR works as a kinase in the steroid signaling chain in *C. testosteroni*. Overall, we provide evidence that TeiR mediates steroid sensing and metabolism in *C. testosteroni* via its steroid binding and kinase activity.

Isolation of a steroid degrading bacterial strain from the Baltic Sea at Kiel Germany

In this work we isolated several bacterial strains from the Baltic Sea at Kiel, Germany, which degrade steroids and which are able to use steroids as carbon source. Two of them, strain H5 and S19, were characterized as being gram negative. They could be best grown in SIN medium supplemented with 1,6–4,1% NaCl. More than 80% of cholesterol was digested when these strains were grown in SIN medium with 0,05 mM cholesterol. Western blots revealed that these salt water strains express a 3 α -HSD/CR orthologous enzyme. Interestingly, 3 α -HSD/CR expression in strains H5 and S19 increased after induction with 0,3 mM testosterone, 0,3 mM estrogen or 0.05 mM cholesterol. Isolation of the 3 α -HSD/CR orthologous gene, as well as studies on its regulation and the generation of homologous *hsdA* knock-out strains of S19 are currently in progress. In addition, the exact characterization and systematic classification of this marine steroid degrading bacterial strain is envisaged.

Cluster Proposal CP0710: VARAN -Variations of Trace Element Fluxes induced by Ocean Acidification at Ca^{2+} - Channels/ Ca^{2+} -ATPases

Lead Proponent: A. Eisenhauer

Hired Personal: I. Taubner, hired in December 2007, currently at Hebrew University of Jerusalem, Israel

In this cluster project we examine the reaction of scleractinian reef building corals on rising pCO_2 and decreasing pH. For this purpose Dr. Taubner is currently culturing hard and soft corals under controlled laboratory conditions at the Hebrew university of Jerusalem, Israel. In the laboratory we simulate decreasing pH's from 8,4 down to 7,8 as well as rising seawater temperatures from about 20 to 35°C. Furthermore, changes of the carbonate chemistry and salinity are also simulated. This study is a joint collaborative effort of German and Israeli scientists. After finishing the culturing experiments we will determine trace metal (Sr/Ca, Mg/Ca, etc.) and isotope partitioning rates (e.g. $\Delta 44/40\text{Ca}$, $\Delta 88/86\text{Sr}$) and fractionation factors on the cultured sample material together with their growth and precipitation rates. These data will then help to better constrain models on biomineralisation and in

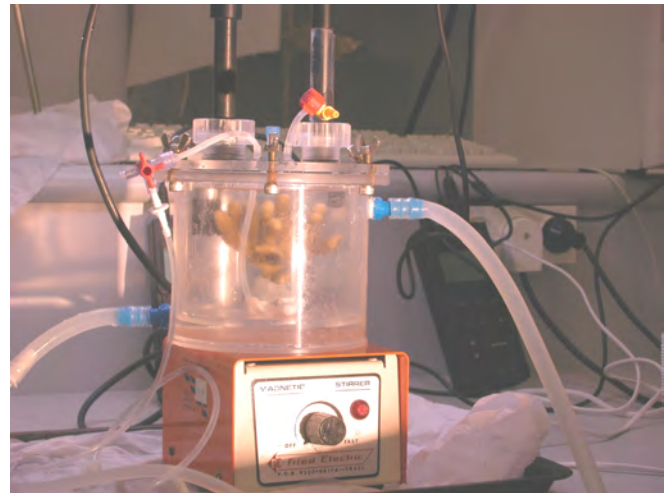


Figure CP0710-2. Metabolic Chamber to perform culturing experiments under controlled laboratory conditions for single corals (Hebrew University Jerusalem, Israel) (courtesy Prof. J. Erez, HUJI).

particular on our understanding of trace element transport from the seawater via the cytosol to the site of calcification.

Cluster Proposal CP0713: A New Computational Framework to Efficiently Integrate Biogeochemical Models from Seasonal to Multi-millennial Time Scales

Lead Proponents: A. Oschlies, M. Latif, R. Schneider, A. Srivastav, in collaboration with I. Kriest, S. Khatiwala

Objectives

To prepare the ground for future paleoceanographic applications of the Kiel Climate Model, the work proposed here had two aims: (1) implement and test the "Transport Matrix Method" (TMM) by Khatiwala et al. (2005), (2) use the new method to develop and identify a description of the sedimentation and remineralisation of particulate organic matter (POM) that, for our best estimate of the present ocean circulation, generates nutrient and oxygen distributions consistent with observations.

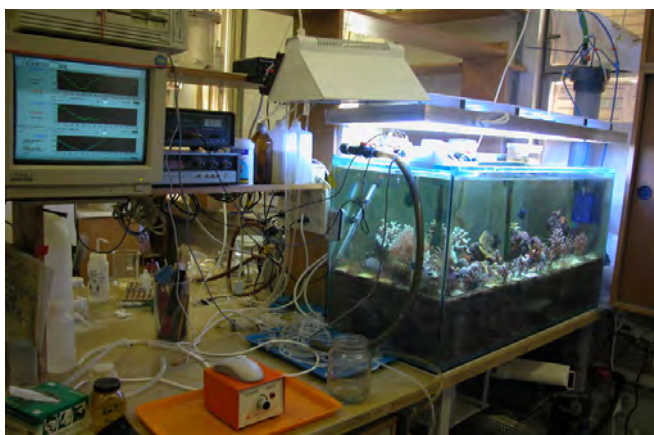


Figure CP0710-1. Closed system aquarium which allows the simulation of changing environmental conditions (temperature, salinity, etc.).

Progress towards objectives

During a visit of Dr. Samar Khatiwala to Kiel (May-June 2007) we have set up his method on the Linux cluster at the Computing Centre, Kiel University. The transition of the framework (TMM) to the newly installed nodes (AMD Barcelona connected by DDD Infiniband) has been accomplished.

The TMM has been coupled to several biogeochemical modules, which simulate ocean biogeochemical processes in a hierarchy of increasing complexity, in conjunction with different parametrisations for export and sedimentation on organic matter (e.g., Kriest and Oschlies, 2007, 2008). Data sets for model assessment (PO4, O2) have been retrieved and prepared for fast and efficient evaluation of different misfit functions. Several (~20) model scenarios of the TMM (based on 2.8 X 2.8 transport matrices) have been simulated over a period on 3000 years, and compared to observations. Analysis of the model-data misfit with respect to different metrics is underway, as well as the analysis of the effect of different physics (matrices).

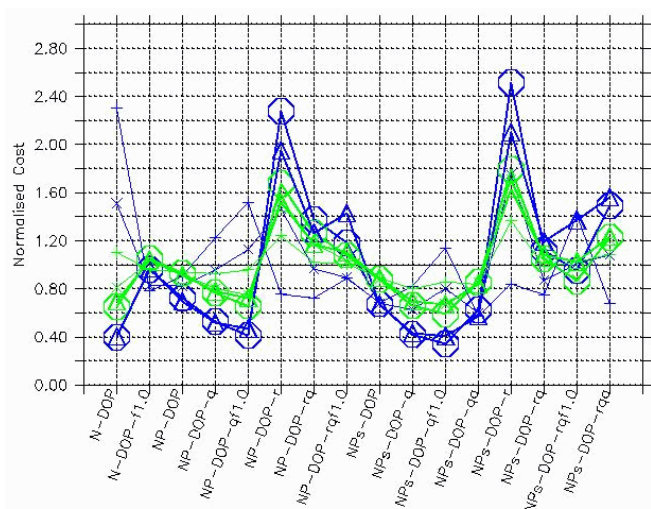


Figure CP0713-1. Global mean model-data misfit (normalized, different lines and symbol denote different metrics and data sets) of various biogeochemical models. "N-DOP": simple nutrient-DOP model. NPs-DOP-*: nutrient-DOP-phytoplankton model with size dependent phytoplankton physiology (Kriest and Oschlies, 2007).

Some results

First results of the system suggest a quite good performance even of a simple (N-DOP) model of ocean biogeochemistry (Fig. CP0713-1). More complex descriptions of autotrophic processes (e.g., Nps-DOP-*) show an equally good performance, with respect to many misfit functions. In addition, these models seem perform slightly better w.r.t. to observed spatial and temporal variability.

Cluster Proposal CP0717: Complex Barriers and Microbiota in the Ocean: Development of Genetic Tools for *Prochlorococcus* to Study Host Microbe Interactions

Lead Proponents: A. Schilhabel, C. Ehlers, J. Thomsen, R. Schmitz-Streit

Scientific position: A. Schilhabel (half time PostDoc, engagement 01/2008)

Goal

The project addresses the questions for the role of β -N-methylamino-alanine (BMAA) in *Prochlorococcus marinus* and for the ecological benefits for the marine cyanobacterium and its potential symbiotic partners from production of this toxic compound. Therefore the biosynthetic pathway for this amino acid, which is still unknown, has to be elucidated and genetic tools have to be developed.

Scientific results

We aim for a combination of biochemical and molecular biological approaches to identify genes and enzymes involved in the biosynthesis of BMAA. In order to determine the production of BMAA by the cyanobacterial strains (i) enough biomass of

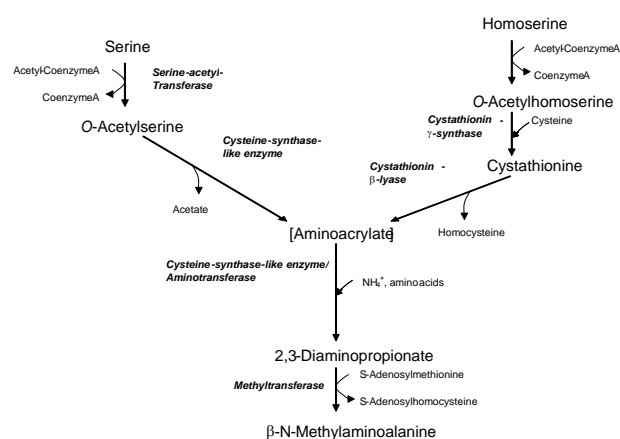


Figure CP0717-1. Possible reaction scheme for BMAA biosynthesis from serine or homoserine as precursor and candidate genes from *Prochlorococcus marinus* MIT9313 (PMT).

Prochlorococcus marinus had to be produced by up-scaling the volume (up to 0.5 l) of the slow growing (14-21 days) *Prochlorococcus*-batch cultures, and (ii) the analytical HPLC procedure for the detection of BMAA [1, 2] had to be set up and evaluated. All *Prochlorococcus* strains tested, *P. marinus* Med4, *P. marinus* MIT9313, and *P. marinus* SS120, produced detectable amounts of BMAA during cultivation. Since samples for BMAA analysis are produced by hydrolysis of the cellular protein, mass spectrometry (MS) or HPLC-MS will also be used to verify the identity of BMAA in these very complex samples.

The pathway for BMAA synthesis is not known; however, a report on an EST-sequence project of the seed plant *Cycas rumphii* hypothesizes a cystein-synthase like enzyme and a cocomitantly acting methyltransferase as catalysts in BMAA biosynthesis from O-acetyl-serine or phosphatidylserine as precursor [3]. Another possible precursor of BMAA is O-acetyl-homoserine, whereas 2,3-diamino-propionate (DAP) could be the common intermediate which is then methylated to BMAA (Fig. CP0717-1). Based on sequence comparison using among others the corresponding gene sequences from *Cycas*

rumphii [3,4] genes possibly involved in BMAA biosynthesis in various *P. marinus* strains were identified. The respective candidate genes of *P. marinus* MIT9313 (Fig. CP0717-1) are currently cloned into an *Escherichia coli* expression vector.

As we are still in progress of developing genetic tools for *Prochlorococcus* we are also testing other cyanobacterial strains, which are more accessible to genetic manipulation like e.g. *Synechocystis* spec. or *Synechococcus* spec., for the production of BMAA. Here, a screening of mutants defective in BMAA production from alternative cyanobacteria may speed up the identification of the respective genes in *Prochlorococcus* strains.

Ongoing work and perspectives

Methods for the biochemical detection of the respective enzyme activities from *P. marinus* cell extracts, which can either be used for detection of enzymatic activities of the recombinant proteins as well as for the screening of cyanobacterial mutants have been designed and are currently under evaluation.

In order to adapt the method of liposome-mediated transformation for *Prochlorococcus* we are currently examining and optimizing the survival rate of *Prochlorococcus* after different treatments to enable the cells for uptake of DNA. Furthermore we are testing different plating techniques (i) to improve culture quality by getting the *Prochlorococcus* strains axenic, and (ii) to facilitate selection of potential mutants in future.

Cluster Proposal CP0718: Economic Valuation of the Ocean's Role in the Carbon Cycle and Consequences for Abatement and Mitigation Strategies

Lead Proponents: G. Klepper, A. Oschlies, T. Requate, U. Riebesell, K. Wallmann

Goal

The cluster proposal seeks to improve economy-climate modelling with respect to the role of the oceans. The idea is to start with rather simple, stylized models that will give some general insights into the question of how accounting for the oceans with their changing carbon pumps will affect optimal mitigation strategies and whether the exploitation of methane hydrates might serve as a substitute for CO₂ intensive coal. The aim is to derive analytical results as well as to parameterize a model for numerical simulations. The general approach will be to set up a dynamic optimal control model that includes the most relevant aspects of the ocean in the global carbon cycle.

Progress

We have developed a microeconomic partial analysis modelling framework to investigate the optimal anthropogenic intervention into the global carbon cycle. In the first version we replaced the proportional decay assumption in the existing economic models by a simple two-box model in order to incorporate the non-renewable features of the global carbon cycle. The upper box contains the carbon stocks in the atmosphere and the upper ocean, the lower box contains the carbon stock in the deep ocean. The anthropogenic intervention enters into the model as the amount of CO₂ emitted into the atmosphere and

the amount of CO₂ injected into the deep ocean for purpose of sequestration. In this first version we excluded the endowment of fossil reserves, because we argued that the limiting factor for the optimization problem is rather the accumulation of carbon in the atmosphere than the endowment of fossil reserves. The analytical results of the first version show that sequestration might either appear as a temporary option when sequestration costs are high or as the long-run option allowing extended use of fossil reserves. The working title of the first version is "Optimal Global Carbon Management with Ocean Sequestration". In the second version we included the endowment of fossil reserves. This inclusion does not substantially change the steady state results, however, it changes clearly the dynamics of the optimal intervention. This version runs under the working title "Ocean Sequestration and the Oceanic Carbon Storage Index". In the following versions we want to consider feedback mechanisms and carbon leakage. We want to incorporate feedback mechanism by replacing the exchange parameters between the different boxes by functions which depend on the carbon stocks. We want to incorporate the carbon leakage by including an additional stock variable which describes the amount of sequestered carbon. The carbon stock leaks to other carbon reservoir, whereby the leakage is influenced by an additional control variable. In the investigation of the two extensions we expect that numerical simulations will become the dominant aspect for the solution procedure.

Timetable

September 27th, 2007 - first group meeting
February, 19th, 2008 - Presentation of work in progress under the title "Global Carbon Management with Endogenous Ocean" at

the AURÖ in Regensburg by Wilfried Rickels planned for June 2008 - Manuscript submission of "Optimal Global Carbon Management with Ocean Sequestration" planned for June 2008 - Presentation of work in progress under the title "Ocean Sequestration and the Oceanic Carbon Storage Index" at the SURED in Ascona by Thomas Lontzek

Cluster Proposal CP0721: Parameterization of Near Surface Vertical Mixing Processes by Multiscale Methods

Lead Proponents: M. Braack, H. Dietze, C. Eden, U. Löptien

Support by the Excellence Cluster: Phd student Madlen Kimmritz (0.5 TVL 13)

Goals

We aim to improve the parameterization of near surface vertical mixing processes by applying a 3-D non-hydrostatic Large-Eddy Simulation (LES) model to the surface ocean to explicitly resolve spatial scales ranging from 500 m down to 1 m. The results will be compared with different state-of-the-art parameterizations of vertical mixing as used in the existing global ocean circulation models. The intention is to optimize parameters associated with the parameterizations of vertical mixing and, subsequently, to examine the sensitivity of modeled carbon uptake (as modeled with an ecosystem coupled to a global ocean circulation model) on the optimized parameterizations.

Work program 09/2007 to 03/2008

During the first months of this project the global ocean model used in the FLAME model was studied as well as the finite element method for the

discretization of the LES model. Special emphasis was taken on the difference between the hydrostatic approximation and the full Navier-Stokes equations. In order to compare a global hydrostatic model with a local non-hydrostatic LES model a common platform is necessary where the algorithmic approach can be easily studied and the first parameter studies can be carried out. Such a platform has been developed in this project by implementing a hydrostatic model in an existing finite element code (Gascoigne3D) which will be used later for the local LES model. Due to the character of the hydrostatic model, the equations for the pressure and the velocities are solved sequentially. The pressure equation is solved on the surface while the velocities are solved in the 3D domain. Hence, the numerical solver is completely different to a monolithic solver of the 3D Navier-Stokes equations. However, this step is finished and even implemented and tested on a parallel computer (PC cluster).

For a first validation a standard driven-cavity problem at Reynolds number $Re=1000$ was chosen, see Fig. CP0721-1. Obviously, a large difference in the solutions of hydrostatic model and the Navier-Stokes model can be observed. This difference becomes smaller, when the domain becomes anisotropic. This is the justification why the hydrostatic approximation is widely used for global ocean models. For local (isotropic or moderate anisotropic) sub-models,

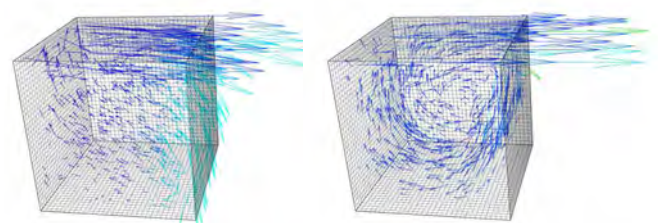


Figure CP0721-1. Flow field of a driven cavity problem with hydrostatic approximation (left) and with the full 3D Navier-Stokes equations (right) at Reynolds number $Re = 1000$.

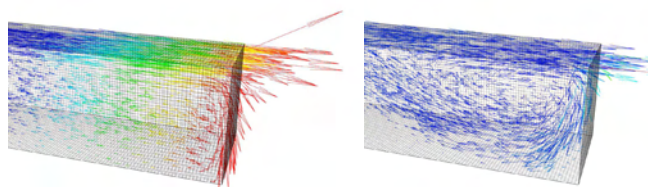


Figure CP0721-2. Flow field in an anisotropic domain (1:1:30) with enforced subduction zone due to external boundaries with hydrostatic approximation (left) and with the full 3D Navier-Stokes equations (right). The color represents the hydrodynamic pressure field

this is obviously not any more acceptable. That is why we need in this project the full 3D Navier-Stokes equations.

Furthermore, it is observed that even on anisotropic domains the hydrostatic approximation describes the flow inexactly when the flow field is forced to subduct due to external boundaries (coast). The difference in the flow field is clearly visible in Fig. CP0721-2 where such a situation is simulated. Moreover, close to the region where the fluid subducts the hydrostatic approximation shows some spurious modes of velocities pointing upwards. This is a minor effect but not present in the 3D Navier-Stokes model.

Outlook

The next step consists in a more quantitative comparison of the hydrostatic approximation and the full Navier-Stokes equations. Afterwards, the Navier-Stokes equations discretized with stabilized finite elements on a fine mesh will be used as a LES model on sub-domains of a larger domain (with a coarser mesh). Statistical data on velocity fluctuations will be assembled and analyzed. This information will enter as a closure model for the global system on coarser mesh sizes. This procedure has to be done for a sample of characteristic ocean situations including temperature and salinity fluctuations.

Cluster Proposal CP0722: Building up the Capacity for $\delta^{34}\text{S}$ Measurements from Organic Samples by Continuous Flow Isotope Mass Spectrometry

Lead Proponents: U. Sommer, F. Sommer, T. Hansen

Motivation

Currently, the simultaneous measurement of carbon (C), nitrogen (N) and sulphur (S) stable isotopes is hampered by the high sample mass required, which leads to an overloading of the system. With this proposal we planned to expand the capacity of our present EA-IRMS-set-up, in which C and N stable isotopes are routinely measured, in order to include simultaneous measurements of S stable isotopes of organic samples. The relevance of establishing the use of ^{34}S as an additional tracer in food web studies (besides ^{15}N and ^{13}C) is the prospect of overcoming difficulties resulting from physiological variability in N isotope fractionation or similarity in organism $\delta^{13}\text{C}$ signals.

State of technology

By successfully decreasing the requested sample mass, we are in the position of fulfilling the pre-requisite to avoid overloading. A simultaneous measurement of $\delta^{13}\text{C}$, $\delta^{15}\text{N}$ and $\delta^{34}\text{S}$ abundances in samples with low organic content has been carried out successfully. A sample run provided excellent peak separation of nitrogen, carbon dioxide and the additional separation of sulphur dioxide during analysis by a cryogenic trap procedure.

The determination range was calculated to 2-8 μg nitrogen; 10-80 μg carbon and 0,2-1 μg sulphur.

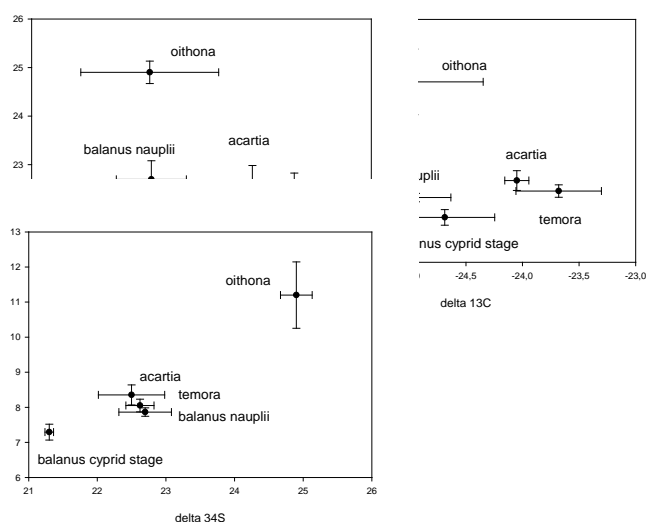


Figure CP0722-1. An application example with zooplankton from Kiel Fjord.

The precision for stable isotope measurements of an internal lab standard (hay powder) provided a standard deviation of ± 0.35 ‰ for ^{15}N , < 0.2 ‰ for $\delta^{13}\text{C}$ and ± 0.45 ‰ for $\delta^{34}\text{S}$ versus international standards (S1-IAEA, NBS123, NBS127).

Cluster Proposal CP0724: 3-D Simulation of Thermohaline Convection in the Ocean's Crust with Adaptive Finite Elements

Lead Proponent: M. Braack

Project started in 2008.

Cluster Proposal CP0725: Changing Habitats of Calcareous Plankton in the Greenhouse World

Lead Proponents: J. Schönfeld, A. Harbers

Species richness and ecological niches for planktonic organisms in the surface ocean are threatened by the increasing influence of rising CO_2 levels and climate change. The impacts on marine ecosystems are just emerging. It is still unclear how the response of calcareous planktonic organisms will be. We focus on planktonic foraminifera in the tropical to northeastern part of the Atlantic Ocean.

First results are available from the Porcupine Seabight off southern Ireland. Recently living planktonic foraminifera were collected with a sediment trap and subfossil assemblages from surface sediments in the northeastern Atlantic were studied to assess the recent variations of faunal assemblages. Another focus was on CaCO_3 flux and dependency of planktonic foraminifera to surface ocean temperature and chlorophyll concentrations. The sediment trap operated from April to August 2004 and covers the spring bloom and early summer conditions with sampling intervals of 8 days. Eight different foraminiferal species were recorded in the sediment trap. *Globorotalia scitula*, *Globorotalia hirsuta*, *Turborotalita quinqueloba* and *Globigerinita glutinata* appeared predominately in spring, while *Neogloboquadrina pachyderma*, *Globigerina bulloides* and *Globorotalia inflata* were abundant in spring and summer. A comparison with an earlier study from the OMEX programme revealed that in 2004, the highest flux of foraminiferal tests occurred in June, while in 1994, the highest number of tests accumulated in late July. The faunal composition is similar to subfossil assemblages from surface sediments, but the species proportions are different. A relationship between chlorophyll concentrations and weight of deposited planktonic foraminifera was recognized. A similar relationship between surface ocean temperature and the number of deposited foraminifera and pteropods was also recognized. The weight of deposited foraminifera increased about 30 days after the chlorophyll maxima. This is mainly effected by the subtropical to tropical *G. hirsuta*, which was frequent in 2004 and rare in surface sediment samples. Surprisingly, only 0.87 % of the total carbonate flux is contributed by planktonic foraminifera, which is one order of magnitude lower as in earlier studies. The three-

ranked species, *G. hirsuta*, *N. pachyderma* and *G. bulloides* contribute 86 % to the foraminiferal carbonate flux at this site.

We extended our investigations to the equatorial Atlantic and participated in a R/V Atalante cruise in January 2008. Surface waters were sampled on transit between South America and Africa by using an Apstein net and the ship's pump. The samples are currently analyzed, and the results will be compared with earlier investigations in the tropical Atlantic in order to constrain the change in planktonic communities and oceanographic conditions during the last decades. To supplement these results, we plan a research visit on the Cap Verde Islands.

Cluster Proposal CP0726: Improved Methods for Nitrogen Isotope Studies with Specific Application at the Tropical Eastern North Atlantic Time-Series Observatory, Cape Verde

Lead Proponents: D. Wallace, R. Schneider, J. LaRoche, P. Croot, H. Bange

Background

The stable nitrogen isotope ratio of nitrate ($\delta^{15}\text{N-NO}_3^-$) provides a powerful tool to investigate nitrate sources, sinks and transformations in the marine nitrogen cycle.

Goal

Extension and application of a sensitive method for the determination of low-levels of dissolved inorganic nitrate and its stable isotope composition (relevant to ExCl A1, A2, A3, A6). The project will extend Cluster-relevant measurements that can be supported by Platform P2. The method will be applied to a study of nitrogen cycling to be conducted at the TENATSO Ocean

Observatory at Cape Verde (Platform P1).

Progress

This project forms the basis for the PhD project of Evgeniya (Zhenya) Ryabenko. Since starting in Kiel in May, 2007, Zhenya has:

- Established and tested a modified version of the chemical reduction method (McIlvin and Altabet, 2005) for $\delta^{15}\text{N-NO}_3^-$ analysis of seawater samples. With the method we are obtaining excellent precision on replicate measurements.
- Identified a previously unrecognized effect of salt concentration on the critical 1st reduction step ($\text{NO}_3^- \rightarrow \text{NO}_2^-$) of the method. Laboratory testing showed that adding 5M NaCl during this reduction step can significantly improve reliability of the method.
- Participated in a cruise of L'Atalante to the TENATSO Ocean Observatory and the Mauritanian Upwelling region in Spring 2008 (ATALATE 08/3). Samples were collected for subsequent $\delta^{15}\text{N-NO}_3^-$ analysis (see Fig. CP0726-1).
- Visited the laboratory of Professor Mark Altabet at the University of Massachusetts, Dartmouth, USA. There she compared the methods used at IFM-GEOMAR with those used at the Altabet laboratory. A subset of samples from the L'Atalante cruise was measured for comparison with our measurements at IFM-GEOMAR. Further testing of the salt effect on the method was performed. This effect was previously unknown to Professor Altabet: a collaborative paper on this improvement to the original method is

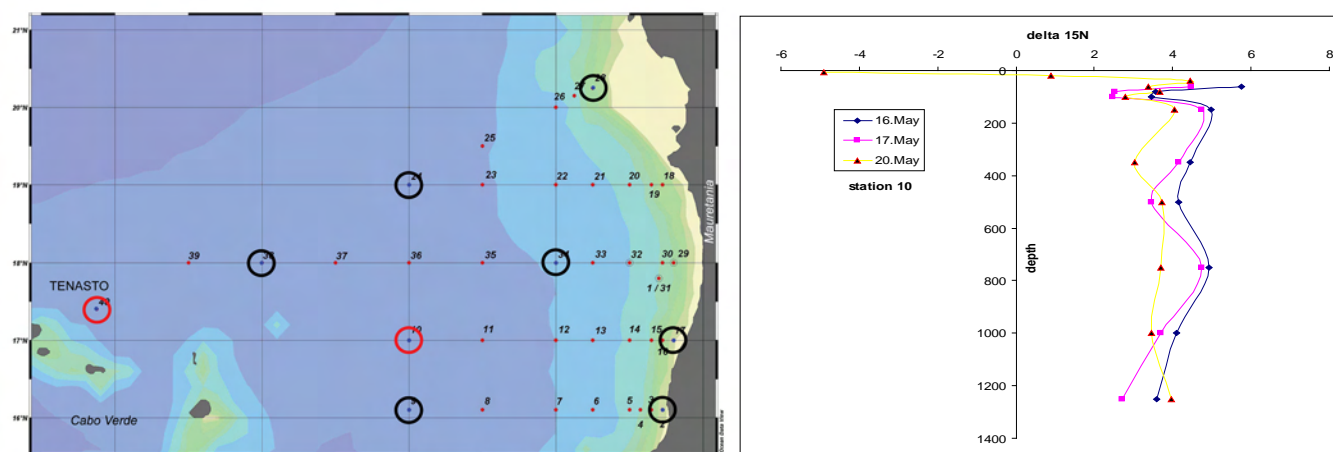


Figure CP0726-1. (a) Stations (circled) where vertical profiles were collected for $\delta^{15}\text{N}\text{-NO}_3$ analysis during the ATALANTE cruise. The westernmost station is the TENASTO station near Cape Verde. The coastline is the Mauritanian coast. Samples from red circled stations (TENASTO and station 10) were measured in University of Massachusetts, Dartmouth, USA. (b) Vertical profile of $\delta^{15}\text{N}\text{-NO}_3$ from station 10 of the ATALANTE cruise. Note: these are preliminary data as measured with different sample pretreatments in the Altabet laboratory and are still subject to final calibration adjustments and quality control.

in preparation (with Zhenya as lead author) and will be completed during a visit of Prof. Altabet to Kiel in September, 2008.

Plans

Additional experiments to demonstrate the salt effect are being conducted while the GC-IRMS system used for ^{15}N analysis is being moved to a new laboratory. An extensive set of inorganic N-species (NO_3^- , NO_2^- , N_2O , NH_2OH , NH_4^+) will be followed during reduction time-course experiments at different salt concentrations. Following this, the remainder of the ATALANTE samples will be measured. Zhenya will receive additional samples from the TENASTO station through the remainder of 2008 and into 2009. She will participate in a cruise of the Meteor to the Upwelling System off Peru (SFB 754) in early 2009. The Peru upwelling samples will be analyzed jointly with Professor Altabet and will allow Zhenya to make the 1st comparison of $^{15}\text{NO}_3^-$ in Atlantic (mildly reducing) and Pacific (strongly reducing) oxygen minimum zones (second paper in her dissertation).

Cluster Proposal CP0727: Deciphering Transcriptomal Responses to Environmental Stimuli in Simple Aquatic Model Organisms by Massive Parallel Sequencing Technology

Lead Proponents: P. Rosenstiel, T. Bosch, J. LaRoche, R. Schmitz-Streit, R. Schulz-Friedrich, J. Appel, J. Imhoff, U. Kunzendorf, E. Maser, S. Ott, S. Schreiber

Summary of Scientific Results

The major aim of the proposal is to employ massively parallel sequencing as a novel technological asset within the cluster to understand transcriptomal signature patterns of marine model and non-model organisms. Two different technologies (454/Roche and SOLiD/Applied Biosystems) are available at the Centre of Molecular Biosciences (ZMB). The proponents are currently developing protocols to apply both approaches in the context of transcriptomal profiling and de novo genome sequencing. Chosen examples are two distinct environmental stressors relevant for human barrier disorders using simple aquatic model organisms: (i) the cellular program

elicited by purified bacterial cell wall components (i.e. lipopolysaccharide and peptidoglycan) in the basal metazoan organisms *Hydra* and *Aurelia aurita*, where first inventories of the innate immune system have been described (Genome Biology, 2007 and PLOS Biology in revision) and (ii) adaptation mechanisms to iron limitation in different phytoplankton species. Within the framework of the latter subproject, a genome sequencing project for *Thalassiosira oceanica* has been initiated. *T. oceanica* is highly tolerant to iron limitation in contrast to two other diatoms for which genome sequences are available (PNAS, in press). The combined cDNA/genome sequencing project approach will allow the detailed functional analysis of the different physiological responses and will allow an exact annotation of gene models and interspecies structural genetic variation.

First Results

So far, sequencing libraries for *Hydra vulgaris* (substrain AEP) (cDNA) and *Thalassiosira* (genomic DNA) have been constructed and 5 runs (2 for *Hydra* and 3 for *Thalassiosira*) were completed. For *Thalassiosira* 1122657 reads with a total 292.63 Mb were aligned into physical contigs. From these first runs, a high representation of mitochondrial sequences was observed, where a near complete sequence (1 gap) was achieved.

In *Hydra vulgaris*, 422699 reads resulted in 118.97 Mb of EST data. *H. vulgaris* was chosen as there is limited EST information available, although it represents the only strain which allows the generation of transgenic animals. Most of the known major gene families are already represented in the dataset.

On-going work

Currently, libraries from stimulated conditions (e.g. LPS and flagellin) are prepared for *Hydra*. Together, with the metagenomic project (R. Schmitz-Streit), we are collecting material for the first *Aurelia* cDNA run. Special methods for the purification of nuclear genomic DNA of *Thalassiosira* have been established. A clonal isolate has been grown and material is prepared for the completion of the genome sequencing project. From the same isolate, algae have been subjected to various trophic stressors (e.g. iron limitation) in order to delineate the transcriptomal response patterns via sequencing. The approach will be performed on a single slide with a pool of mixed libraries from different conditions, that will be deconvoluted using unique molecular ID tags (barcoding).

Perspectives

Approximately five additional runs will be needed to finish the exploratory phase of both subprojects. It is expected that the comprehensive transcriptomal inventories will foster functional follow-up projects in order to understand the individual components of the transcriptomal signature patterns.

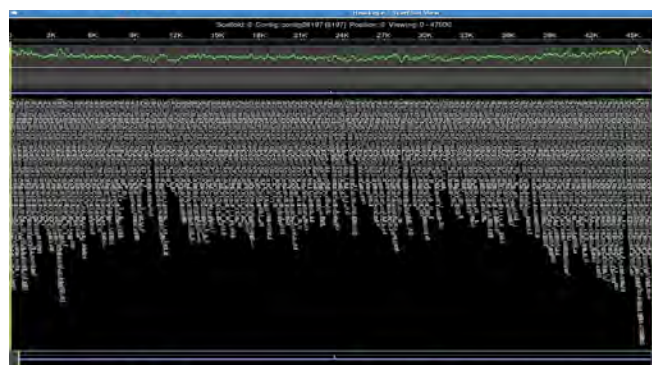


Figure CP0727-1. Deep-sequencing contig of *Thalassiosira* mitochondrial genome (example) each horizontal white line represents an individual sequence.

Cluster Proposal CP0730 : Modelling Chemosensor-Aided Foraging in Zooplankton

Lead Proponents: A. Oschlies, M. Pahlow, and F. Prowe

Theory development

We began by deriving basic equations of chemosensor-aided foraging (CAF) and comparing their behaviour with that of previous models. CAF is based on the assumption that zooplankton can detect the location of their prey by means of sensing trails of chemicals released by prey organisms. With CAF, ingestion (I) is a function of swimming velocity (v), prey biomass concentration (B), and prey size (M): $I = vBbM^{1-b}$, where the exponent b depends on the length of the chemical trails (L) relative to the average distance (d) between prey organisms, which depends on prey density and ambient turbulence: if $L \geq d$ then $b = 1/3$ and $b = 1$ for $L \ll d$. Simple filter feeding (FF) ($b = 1$), which is the basic assumption behind most previous zooplankton feeding models, is thus an extreme case of the CAF model when chemical trails are destroyed by turbulence or cannot be sensed by the predators.

The CAF model displays much higher ingestion rates at low prey density (as long as not $L \ll d$) than FF models, but FF is more efficient at high prey density. Hence, an efficient strategy would switch from CAF to FF as prey density increases. Further examination of CAF model behaviour revealed that CAF is more advantageous for small predators and large prey, and that the switch from CAF to filter feeding should occur at lower prey densities for larger predators and smaller prey. An apparent feeding threshold and size dependence of zooplankton feeding follow naturally from the CAF model.

Literature review

Reviewing of the literature was begun in parallel with theory development and is ongoing. Published observations of ingestion as a function of prey density shows that ingestion often increases at high prey concentrations after an initial plateauing of the response (usually interpreted as saturation), which is suggestive of the switching from CAF to filter feeding described above. Microzooplankton appear to change swimming behaviour from helical paths required for CAF to straight lines characteristic of FF as prey density increases (Bartumeus et al., 2003). We found the CAF model far superior to the FF model when trying to fit data from Hansen & Ockelmann (1991) for the feeding behaviour of *opisthobranch* larvae.

Feeding experiments generally show a preference for larger prey, which follows immediately for the CAF model. By contrast, ingestion is only a function of prey concentration (B) in FF models, such that size preference requires additional assumptions. The higher efficiency for preying on larger prey indicates an advantage for larger predators able to cope with larger prey, which might compensate for the generally negative relationship between size and activity, and hence could lead the way to explaining the development of larger organisms.

Outlook

The next steps in theory development include attempting to quantify the effects of turbulence using Kolmogorov theory and to derive predictions about the size structure of (zoo)plankton communities. We will test CAF theory with the help of additional experimental datasets to be found in the literature as well as recent

mesocosm data. It is also planned to integrate a CAF model with a plankton model to be able to compare model predictions, including effects of CAF theory on other plankton compartments, with mesocosm and field data.

Funded Proposals from Proposal Round 2007/2

CP07A32 Koch, Devey, Kuhn, Rüpke: 3D-Modeling of Seafloor Structures from ROV-based Video Data

CP07A34 Oschlies, Riebesell, Braack, Koeve, Kähler: Carbon and nitrogen cycle dynamics: integrated analysis of open ocean observations and mesocosm experiments

CP07A37 Luttenberger, Visbeck, Piepenburg, Riebesell, Karstensen, Krahmann: An XML-based workbench for marine and biological data collection projects (XDataCollection)

CP07A39 Oschlies, Wallmann, Schneider: Neural-network based coupling of benthic and pelagic components of biogeochemical ocean circulation models

CP07A43 LaRoche, Devey, Schmitz-Streit, Proelß: Exploring the genetic resources of deep sea extremophiles: Searching for high performance novel enzymes

CP07A45 Dullo, Riebesell, Eisenhauer, Piepenburg, Melzner, Form, Rüggeberg, Waller: Biogeochemical studies on the effects of ocean acidification on the cold-water coral *Lophelia pertusa* (Scleractinia)

CP07A46 Weinberger, Kruse, Hanel, Riebesell: A transcript profiling tool to investigate synergistic effects of non-biotic and biotic changes in a model macroalga

CP07A47 Karstensen, Körtzinger, Luttenberger, Brandt, Visbeck, Krahmann: Glider Swarm Pilot Project

CP07A51 Requate, Froese, Proelß: Alternative Scenarios for European Fisheries Management

CP07A52 Wahl, Melzner, Eisenhauer, Riebesell: The neglected bottleneck: Early life stage ecology in times of global change.

CP07A53 Weinrebe: Iceflow activity revealed from submarine morphology - mapping glacial-morphological manifestations of a retreating ice-front

CP07A54 Piepenburg, Spindler, Wernerm, Riebesell, Melzner, Form, Luttenberger: Ecophysiological consequences of ocean warming and acidification: Metabolic response of the cold-water coral *Lophelia pertusa* (Scleractinia) to variations in ambient temperature and pH

CP07A58 Friedrichs, Andersen, Körtzinger, Oschlies, Temps, Wallace: The Potential for Field Measurement of Surface Water $p\text{CO}_2$ and $\delta^{13}\text{CO}_2$ on Volunteer Observing Ships using Cavity-Ringdown Spectroscopy

CP07A65 Melzner, Rosenstiel, Bleich, Riebesell, Clemmesen, Piepenburg: Gene expression patterns in sea urchin embryos: Establishing a model system for biological and marine medical research in the context of global change

Appendix F: References

IMPORTANT NOTE:

This Reference Section **must not** be taken as a measure on the activity of a research group. The reference lists submitted with the reports were very divers. Some groups submitted cited references for their reports only, some submitted complete publication lists which may or may not be direct results form any cluster project. Any reader should consider and treat this list for reference only.

The Editor.

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Key Components and Urgent Needs of the Global Species Information System. Presentation at the first GSIS workshop, 10-11 December 2007, Kiel, Germany

Creating a Marine Atlas with Maps for All Species of the Oceans. Presentation at the 2007 Pew Fellows meeting, 3 December 2007, Morro Bay, CA, USA.

Fisch kaputt: Ursachen und Lösungen für die weltweite Überfischung. Public lecture at the Night of the Profs, 23 November 2007, Christian Albrecht University, Kiel, Germany

Biologie und Fischerei von Dorsch, Hering, Sprotte und Scholle

in der Ostsee. Einführungsvortrag zur Podiumsdiskussion, Wirtschaftsrat der CDU Schleswig-Holstein, 24 September 2007, Kiel, Germany.

Goodbye K, Welcome M: The Interrelationship between Life Span, Growth and Reproduction. Plenary Keynote at the XXII European Congress of Ichthyology, 10 September 2007, Cavtat, Dubrovnik, Croatia.

New Initiatives towards a Global Species Information System. Invited presentation at the XXII European Congress of Ichthyology, 9 September 2007, Cavtat, Dubrovnik, Croatia.

FishBase: Global Databank and Tool. Invited presentation at the Conference on Research in Aquatic Science Disciplines, 9 June 2007, Neu Wulmstorf, Germany.

FishBase: Lessons Learned. Invited presentation at The One Million Species Catalogue of Life Symposium, 29 March 2007, Reading, UK.

The Research in FishBase. Invited presentation at the Chinese Academy of Fisheries Science (CAFS), 27 February 2007, Beijing, China.

Life-history Strategies of Fishes. Invited presentation, Seminar Series of the Marine Science Institute, University of the Philippines, 22 February 2007, Quezon City, Philippines.

Recent Trends in Global Fisheries. Invited presentation. SEARCA Seminar Series, 13 February 2007, Los Baños, Laguna, Philippines.

Life-history Strategies of Elasmobranchs. Key note given at the 10th Science Conference of the European Elasmobranch Association, 11-12th November 2006, Hamburg, Germany.

Überfischung: ein weltweites Problem. Presentation at the press conference given by Verbraucherzentrale Hamburg at the occasion of the launch of the Fish-O-Meter, a ruler to identify immature fishes. 31 May 2006, Hamburg, Germany.

Lessons learned in the development of FishBase. Invited presentation at the meeting of the International Committee of the Ocean Biogeographic Information System (OBIS), 22 May 2006, Los Baños, Laguna Philippines.

The Science in FishBase: Putting a Huge Database to Work. Invited presentation given at the Symposium Thinking Big: A Global Look at Fisheries Science. 2nd May 2006, Fisheries Centre, UBC, Vancouver, Canada.

The Knowledge Society in Aquatic Biodiversity: Fishes of the World in the Computer. Invited presentation at the 2006 Annual Meeting of the American Association for the Advancement of Science (AAAS), 17 February 2006, St. Louis, Missouri, USA.

Web-based publications:

FishBase: Key data for 30,000 species of fishes. Froese, R. and D. Pauly, Editors, 2006-2007. www.fishbase.org

INCOFISH: Integrated coastal zone management with special focus on fisheries. Froese, R., Coordinator, 2006-2007. www.incofish.org

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Appendix G: Other Activities

IMPORTANT NOTE:

This Section **must not** be taken as a measure on the activity of a research group. The activities submitted with the reports were very divers. Some groups submitted complete lecture lists with their reports, some skipped these. Any reader should consider and treat this list for reference only.

The Editor.

Activities from Research Topic A7

ISOS-Lecture:

- Eric Naevdal, Threshold Effects in the Economic Management of Climate Change, Nov 7th, 2007
- Michael Hübler, Health Costs of Climate Change, Nov 14th, 2007
- Katrin Rehdanz, Economic Impact of Different Water Resource Policies, Dec 5th, 2007

Staff-Seminar (IfW):

- Daiju Narita, Carbon Dioxide Capture and Storage (CCS) and Climate Change Mitigation: A Resource-Economic Perspective, Feb 11th, 2008
- Bob van der Zwaan, The Economics of Geological CO₂ Leakage, March 4th, 2008

Other Talks:

Wilfried Rickels, Global Carbon Management with Endogenous Ocean Uptake and Sequestration, Feb 19th, 2008, AURÖ, Regensburg

Cluster-Activities

The IfW has established in 2006 the „Theme A Seminar Series“ (TASS) which aims at the promotion of interdisciplinary interaction in the research area. Several presentations have informed the members of Theme A about the approaches, models, research interests and activities of the partners.

22. August 2006

- Gernot Klepper: Ökonomische Modellierung: Vermeidung von und Adaption an Klimawandel
- Carsten Eden: Ozean Zirkulationsmodelle

12. September 2006

- Klaus Wallmann: Ozean Sequestrierung und Hydrat Abbau
- Anand Srivastav: Stochastische Variation von Einflussparametern

21. November 2006

- Reinhold Schneider: Die numerische Behandlung partieller Differentialgleichungen mit unsicheren Koeffizienten
- Ulf Riebesell und Markus Bleich: O₂-Induced Ocean Acidification: Biological Responses and Adaptations

27. Februar 2007

- Bernd Hartke: Von theoretischen Molekülsimulationen zum Future Ocean
- Andreas Oschlies: Datenassimilation zur Optimierung mariner Oekosystemmodelle

18. December 2007

- Thomas Slawig: Parameter Estimation Techniques for Ocean and Biogeochemical Models
- Katrin Rehdanz: Valuing the Ocean

At the moment there are no further TASS-

Seminars planned because the new Junior-Professors are already to some point overloaded with appointments and additionally there will be a dedicated lecture series in which the new Junior-Professors present their research groups. However, the possibility to use the TASS-Forum to present cluster-relevant research and discuss new research topics in the cluster is still present.

International Activities

We developed a contact to the natural resource group at the University of Bergen, Sigve Tjøtta and Odd Godal. A meeting for July 2008 is arranged.

Activities from the Integrated School of Ocean Sciences (ISOS)

ISOS Lectures

- Dr. Carol Turley, Plymouth Marine Laboratory, Plymouth, U.K., "Ocean Acidification: the Other CO₂ Problem"
- Prof. Dr. Jörn Piel, Kekulé-Institut für Organische Chemie und Biochemie, Universität Bonn, „Medizin aus dem Meer - Antitumor Polyketidwege symbiotischer Bakterien"
- Prof. Dr. Peter Lemke, Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung, Bremerhaven, „Verlieren wir das Eis der Erde?"
- 31.10.07, "Integrated Basin Modeling"
Prof. Dr. Lars Rüpke, IfM-Geomar (JRG B3)
- 07.11.07, "Threshold Effects in the Economic Management of Climate Change"
Prof. Dr. Eric Naevdal, Department of Economics, University of Oslo, Norway
- 14.11.07, "Health Costs of Climate Change"
Michael Hübler, Prof. Dr. Gernot Klepper, Institut für Weltwirtschaft
- 21.11.07, "Data Mining and Statistics"
Prof. Dr. Oleg Selesnjev, Dept. of Mathematical Statistics, Umeå University, Sweden
- 28.11.07, "Legal Regime of the Arctic"
Prof. Dr. Alexander Proelß, Walter-Schücking-Institut für Internationales Recht (JRG B6)
- 05.12.07
"Economic Impacts of Different Water Resource Policies"
Prof. Dr. Katrin Rehdanz, Institut für Weltwirtschaft (JRG A7)
- 12.12.07, "Human Chronic Inflammatory Diseases - What can we learn from Marine Animals?"
Prof. Dr. Phillip Rosenstiel, Institut für Klinische Molekularbiologie, UKSH (JRG B2)
- 19.12.07, "Estimating the Effects of Future Ocean Acidification on Marine Animal Performance"
Prof. Dr. Frank Melzner, IfM-Geomar (JRG A1)
- 09.01.08, "Economic Models of Fisheries"
Prof. Dr. Till Requate, Institut für Volkswirtschaftslehre, Innovations-, Wettbewerbs- und Neue Institutionenökonomik
- 16.01.08, "Modern Laser Techniques for Ocean Surface Research"
Prof. Dr. Gernot Friedrichs, Institut für Physikalische Chemie (JRG A6)
- 23.01.08, "What do we need to know about Mathematical Modeling and Simulation?"
Prof. Dr. Thomas Slawig, Institut für Informatik (JRG A3)
- 30.01.08, "Coupled Climate Carbon Cycle Models: how good are they?"
Prof. Dr. Birgit Schneider, Institut für Geowissenschaften (JRG A4)
- 06.02.08, "Complexity of Computation – an Introduction"
Prof. Dr. Anand Srivastav, Institut für Informatik,

Diskrete Optimierung

- 13.02.08, "Das Deutsche Klima Konsortium (DKK) eine neue Plattform der Klimaforschung an der Schnittstelle von Gesellschaft – Wirtschaft – Umwelt"

Prof. Dr. Martin Visbeck, IfM-GEOMAR

PhD Retreat

Dec. 7/8, 2007, 13 PhDs participated

Theme chosen: „Maritime Consultancy“

Guest: Dr. Levent Piker, Managing and Founding Director of Coastal Research Management, Kiel.

Planned ISOS Courses and Events through Summer Semester 2008

Specific Courses

- Neue Meeresnutzungen
Prof. Alexander Proelß (2 days)
- Mass Spectrometry
Prof. Gernot Friedrichs e.a. (4 days)
- Introduction to the economics of natural resource management
Daiju Narita (2 days)
- Oceanographic Data Bases
Prof. Birgit Schneider (2 days)
- Novel approaches in molecular biology/ lab rotation
Prof. Ruth Schmitz-Streit et al. (2 days)

Soft Skills Courses

- Scientific Presentation
Prof. Lars Rüpke (biweekly)
- How to write a scientific paper
Prof. Tina Treude (biweekly)
- Time management
Janus Consultants, Hannover (1 day)
- Grant writing for scientists
Pro Scientia GmbH, Lübeck (1 day)

other events

- Visit at Coastal Research Management, Kiel-Holtenau
(for ISOS PhDs)
- Presentation of research platforms of the cluster
4 afternoons
- 2nd ISOS PhD Retreat
topic: scientific communication (2 days in May)

e-Learning: portals, courses, and projects

e-Learning Portals

The Future Ocean – This e-learning portal offers master level courses (up to complete master study programmes) from different disciplines in ocean sciences. It is planned for Summer 2008 to divide this portal into several discipline specific and interoperable portals.

ISOS PhD Courses – This e-learning portal supports courses organized by ISOS for PhD candidates, ranging from specific courses of cross-disciplinary interest from the core oceanographic disciplines to soft skill courses for career planning.

Available courses

Introduction to Physical Oceanography
Introduction to Chemical Oceanography
Introduction to Biological Oceanography
Practical Courses in Biological Oceanography
Applied Biostatistics
Fish Systematic, Biology and Evolution
Current Topics in Marine Biogeochemistry
Current Topics in Marine Ecology
Marine Animal Physiology
Marine Chemistry (plus Exercises)
Atmosphärenchemie

Mass Spectrometry and Optical Spectroscopy (P)

Climate Relevant Trace Gasses in the Ocean

Algorithmic Differentiation

Numerical Parameter Estimation in Climate Models

Practical Course in Programming

Internationales Umweltrecht

Doing Science

Academic Presentation - Hard Skills and Soft Skills

Consulting and Training

Online Tutorial for Teaching and Learning with Nickels – a quick desktop reference, covering four chapters and 42 topics.

Introduction to Nickels - a training seminar periodically held at several institutions at CAU

Individual Consulting – open for all cluster members, individually dated.

Projects

Applied Biostatistics - For each of the 12 parts of this course (lecture and exercise), extensive interactive assignments have been developed for students to test their acquired knowledge. Exercises are based on multiple choice, order and assignment tasks and include automatic feedback functions.

Biogeochemistry - Scripts for the 5 day practical course 'Biogeochemistry' has been enriched with different interactive components, like assignments, maps, visual guidelines for experimental setups as well as interactive software and a master spreadsheet. Additionally, the Nickels glossary will get about 70 new entries.

Mass Spectrometry and Optical Spectroscopy -

For this ISOS PhD course, materials and assignments have been created and arranged in Nickels for a blended learning scenario (self-study, seminar, practical). Additionally, collaborative components will be applied.

Practical Course in Computer Programming - This course will be based on a framework for participative and collaborative components in Nickels. Students will be enabled to write e-content in groups and to upload and share Java applets as exercises results.

Cooperation

Nickels development cooperation together with the medicine e-learning group at CAU and the Nickels developer in Dresden.

Networking

CAU e-Learning Group - regular meeting of CAU members interested in a broader e-learning conception for CAU, consisting of representatives from central institutions at CAU as well as content-related representatives from several faculties. These meetings have been initiated by ISOS e-learning coordination.

Public Outreach Appendix

1. General Activities with high public awareness to the Cluster

| Title | date |
|--|-----------|
| „365 Orte im Land der Ideen“ – Auszeichnung für die Ausstellung Ozean der Zukunft Award Ceremony | 24.6.2007 |
| Erster Einsatz OTIS (Ocean Tracer Injection System), Ostsee | 9 / 2007 |
| Public Event: Streitgespräch: „Klimawandel - Hysterie oder Katastrophe“ | 6.11.2007 |

2. Press Resonance to the Cluster (Ozean der Zukunft)

| media (june to December 2007) | numbers |
|------------------------------------|---------|
| Science magazines | 4 |
| Press, national (Printed Articles) | 13 |
| Press, local (Printed Articles) | 50 |
| Internet articles | 143 |
| Radio | 4 |
| Television | 3 |

3. Press Monitoring Service (selection) / Start: 15.6.2007

| title | tv/radio/press/www | date |
|--|---|------------|
| Ein Tauchgang auf Schatzsuche | Financial Times (national press) | 20.06.2007 |
| Wir sind Klimakiller | Rheinische Post (national press) | 23.06.2007 |
| Kieler Wissenschaftspreis Verleihung | shz (regional press) | 24.06.2007 |
| Ozean der Zukunft im Land der Ideen | Kieler Nachrichten (regional press) | 25.06.2007 |
| Das blaue Wunder | Funkuhr (national press) | 22.06.2007 |
| Campus in Kürze | Stuttgarter Zeitung (national press) | 22.06.2007 |
| Schüler Forschen an der Schwentine | Stadtwerke Kiel Magazin (regional press) | 05.07.2007 |
| Die Energie des Meeres | Wirtschaftsland SH (regional press) | 01.07.2007 |
| Ozean der Zukunft | Merian (national magazine) | 01.07.2007 |
| Neuer Hot-spot | Wirtschaftswöche (national press) | 02.07.2007 |
| Ozean der Zukunft platziert sich | Kieler Nachrichten (regional press) | 04.07.2007 |
| Große Publikumsresonanz bei Ausstellung | Kieler Nachrichten (regional press) | 10.07.2007 |
| Der Meeresboden - CO ₂ -Depot der Zukunft? | Kieler Nachrichten (regional press) | 11.07.2007 |
| Der neue Kampfgeist auf dem Campus | FAZ (national press) | 15.07.2007 |
| Optimierte Klimaprognosen durch genaue Analyse der Vergangenheit | ldw-online (website) | 18.07.2007 |
| Hochtechnologie für Klimaforschung | Kieler Nachrichten (regional press) | 19.07.2007 |
| Ein Cluster wirkt sich auf die gesamte Uni aus. | Kieler Nachrichten (regional press) | 02.08.2007 |
| Maritime Koordinatorin der Bundesregierung besucht SH | shz (regional press) | 27.08.2007 |
| Klimawandel und der Ozean | umweltschutz-news (national press) | 04.09.2007 |

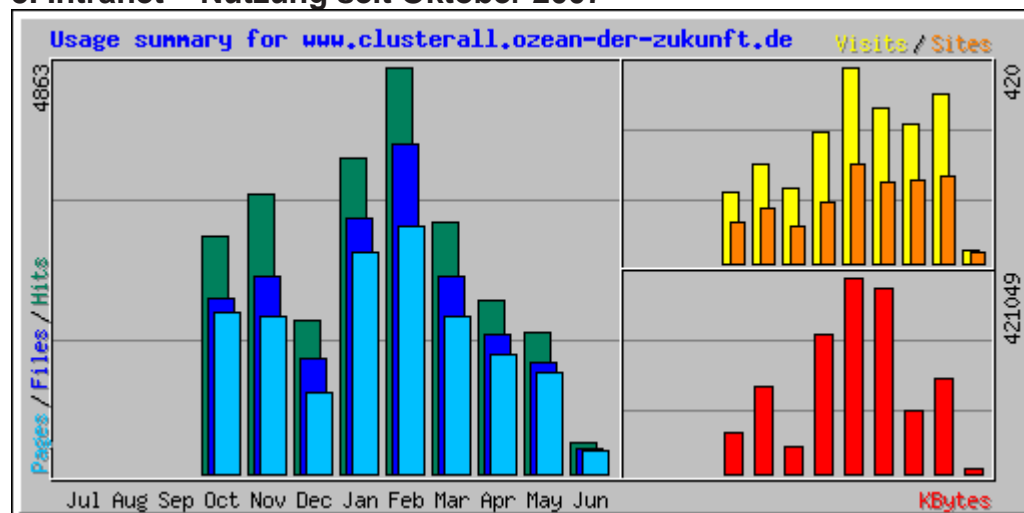
| | | |
|--|---|------------|
| Packeis der Arktis hat bereits im August den niedrigsten Stand seit Menschengedenken | extremnews.com (website) | 04.09.2007 |
| Alarmstufe rot für Ozeane | springer.com (website) | 05.09.2007 |
| Wo Formeln und Formulare zusammentreffen Neues Clusterbüro für den Ozean der Zukunft | Kieler Nachrichten (regional press) | 13.09.2007 |
| Ausstellung "Ozean der Zukunft" | juraforum.de (website) | 19.09.2007 |
| Der Kieler Exzellenzcluster "Ozean der Zukunft" stellt aus | pressrelations.de (website) | 20.09.2007 |
| Ozean der Zukunft auf Wanderschaft | Kieler Nachrichten (regional press) | 27.09.2007 |
| Einladung zur Eröffnung der Ausstellung "Ozean der Zukunft" mit einer Lesung von Frank Schätzing in der Vertretung des Landes Schleswig-Holstein beim Bund | schleswig-holstein.de (website) | 05.10.2007 |
| Dem Weg des Wassers auf der Spur | Kieler Nachrichten (regional press) | 09.10.2007 |
| Die Schleswig-Holsteinische Landesvertretung in Berlin zeigt die Ausstellung "Ozean der Zukunft" aus Kiel | openPR.de (website) | 10.10.2007 |
| Kieler Forschungsschiff "Alkor" nimmt Schüler auf | Lehrer-Online (website) | 10.10.2007 |
| Vorfriede auf eine besondere Forschungsfahrt | Kieler Nachrichten (regional press) | 15.10.2007 |
| Eine neue Allianz für die Klimaforschung | springer.com (website) | 17.10.2007 |
| Das Ziel: viele Studenten nach Kiel holen | Welt am Sonntag (national press) | 21.10.2007 |
| Kiel auf dem Weg zur Elite-Universität | Schleswig-Holstein am Sonntag (regional press) | 21.10.2007 |
| Positive Jahresbilanz des Exzellenzclusters "Ozean der Zukunft" | juraforum.de (website) | 22.10.2007 |
| Millionenförderung für Hochschulen - Forscher ziehen positive Bilanz | Hamburger Abendblatt (national press) | 22.10.2007 |
| „Wie richtige Forscher gefühlt“ | Kieler Nachrichten (regional press) | 23.10.2007 |
| Konträre Standpunkte zum Klimawandel | Kieler Nachrichten (regional press) | 08.11.2007 |
| Forscher streiten über Erderwärmung | Welt online www.welt.de (website) | |
| Das Meer lockt sie an | Kieler Nachrichten (regional press) | 17.11.2007 |
| Professor Dr. Martin Visbeck neuer Sprecher des Exzellenzclusters "Ozean der Zukunft" | idw-online.de (website) | 22.11.2007 |
| Visbeck neuer Cluster-Sprecher | Kieler Nachrichten (regional press) | 23.11.2007 |
| Schwimmendes Klassenzimmer | DER SPIEGEL (national press) | 03.12.2007 |
| Der Nordpol gehört niemandem | shz.de (website) | 05.12.2007 |
| Kieler Forscher fordert ein Klimaservicenetz | Kieler Nachrichten (regional press) | 10.12.2007 |

4. Expert-Database – Visits and Requests June to December

| Jahr | Monat | Besucher | Abfragen |
|------|-----------|----------|----------|
| 2007 | Juni | 1.171 | 18.904 |
| 2007 | Juli | 1.361 | 20.305 |
| 2007 | August | 1.219 | 27.674 |
| 2007 | September | 688 | 16.957 |
| 2007 | Oktober | 1.007 | 13.831 |
| 2007 | November | 1.133 | 20.251 |
| 2007 | Dezember | 847 | 25.113 |

Für die Monate April und Mai 2007 liegen aus technischen Gründen keine kompletten Daten vor. Insgesamt hat sich Spezialisten-Datenbank etabliert. Besucher gehen gezielt auf die Seite, um Experten zu suchen.

5. Intranet – Nutzung seit Oktober 2007



Die Intranet-Seite wird ausschließlich von Mitgliedern im Cluster genutzt. Die mit 4863 höchste Anzahl an Aufrufen wurde im Februar 2008 kurz vor dem Internen Retreat in Salzac registriert.

6. Press related to school activities

| Title | tv/radio/press/www | Date |
|--|------------------------------|------------|
| Schüler erleben die "Faszination Naturwissenschaft" | Segeberger Zeitung | 3.2.2007 |
| Schüler experimentierten rund ums Thema Wasser | Lübecker Nachrichten | 3.2.2007 |
| Schüler erleben die "Faszination Naturwissenschaft" | Kieler Nachrichten | 3.2.2007 |
| Kongress machte Schülern Lust aufs Forschen | Basses Blatt | 6.2.2007 |
| Press echo on exhibition „Ozean der Zukunft“ | cf. report on exhibitions | |
| Forscherferien, Kurzinterview mit Prof. Demuth und Dr. Katrin Knickmeier | ZDF-heute nacht | 27.7.2007 |
| Schüler Forschen an der Schwentine | Stadtwerke Kiel Magazin | 05.07.2007 |
| Kieler Forschungsschiff "Alkor" nimmt Schüler auf | Lehrer-Online (website) | 10.10.2007 |
| Vorfriede auf eine besondere Forschungsfahrt | Kieler Nachrichten | 15.10.2007 |
| „Wie richtige Forscher geföhlt“ | Kieler Nachrichten | 23.10.2007 |
| Schwimmendes Klassenzimmer | DER SPIEGEL (national press) | 03.12.2007 |

7. School activities in 2007

- The first six-month course in the framework of Schleswig-Holstein's "Enrichment Program" for gifted students: 14 selected students from Kiel's secondary schools studied various topics of the Future Ocean under the title "Frank Schätzing's "Der Schwarm" – What is science, what is fiction?". Results of this course were presented to the public in student presentations at the "Enrichment Day" at the Kieler Gelehrtenschule in May and at IFM-GEOMAR's Open Day in September.
- A two-day Symposium "NaT-Working Marine Research" in Bad Segeberg in February, in which 120 students and 18 teachers from 7 schools participated together with Cluster scientists. In a rich program of students' and scientists' presentations and workshops, new cooperations between students and scientists were initiated.
- A one-day excursion on ALKOR to Kiel Bay in May, demonstrating measurement techniques to a group of 20 students to supplement their course project.
- Symposium "Research" For guided tours through the Cluster exhibition "Ozean der Zukunft" from June 2 to July 6, more than 120 school classes from Schleswig-Holstein and other parts of Germany needed to be coordinated.
- As a contribution to the project "Forscherferien" by IPN – Leibniz Institute for Science Education, a one-day excursion to Kiel Beach "Falckensteiner Strand" was carried out for 3rd grade students.
- 4 sets of literature on marine science, specifically selected to be suitable for school students, were provided in special boxes for teachers to borrow for use in their courses and to the library of IFM-GEOMAR
- A two-week laboratory work was hosted during summer vacation 2007 (Marieke Goeser, Gymnasium Heikendorf and Prof. Ruth Schmitz-Streit, IFAM, CAU), as well as a one-week practical in October (Lisa Kerl, Gymnasium Heikendorf and Dr. Martin Zimmer, CAU).
- Development of a board game "Spiel rund um die Arktis" (Gymnasium Bad Segeberg, IFM-GEOMAR and IPÖ, CAU).
- Selection of a teacher/student team for participation in the Canadian "Schools on Board" program in April 2008.
- In September, a visit at AWI led to a first contact between school projects in Kiel and Bremerhaven.
- One of the enrichment students represents the Kiel school projects at the NaT-Working Symposium by Bosch Foundation in Berlin in October.
- The second six-month course for gifted students "Lebensraum Ozean – wie lebt sich's unter Wasser?" (grade 6 to 8, 2007/2008) for 16 selected students. Results of this course were highlighted to the public in student presentations at the Theodor Heuss Schule in April 2008.
- In December, participation at a symposium by Körber Foundation in Hamburg prepared the ground for further contacts.
- the second six-month course for gifted students "Lebensraum Ozean – wie lebt sich's unter Wasser?" (grade 6 to 8, 2007/2008) for 16 selected students. Results of this course were highlighted to the public in student presentations at the Theodor Heuss Schule in April 2008.
- As a result of the first Enrichment course 2006/07, a presentation on tsunamis was given by 2 students and Prof. Martin Visbeck to 120 students (grade 11) in Heikendorf in December 2007.