

WP4: Integrating observations for coastal management (Roland Doerffer, Michael Schlüter)

We develop and integrate observation, modelling and information processing methods for monitoring the coastal zone and provide knowledge for its management.

Objectives and Challenges

The coast has become a hot spot in environmental issues. New national regulations, directives of the European Community and international treaties and programmes concerning the coastal environment require an elaborate information system, which is the essential for all management decisions.

Due to rapid global and regional changes, the demand for observational data and predictions has increased during the past years. These changes are not only gradual trends, but also increasingly abrupt shifts. Knowledge on the nature of these changes, their starting points and their dynamics is essential for management. Changes with significant impact on the coastal environment include the physical forces, in particular temperature and wind, and their impact on processes, which determine coastal safety such as sea level rise, waves, currents and flooding. Further changes come from coastal urbanisation, economic exploitation and the introduction of alien species. These changes have a significant impact on the health status of key species, such as marine mammals, as well as on the changes in biodiversity and natural habitats.

New technologies for observation, simulation and information processing provide us with data of a high spatial and temporal density. This allows not only faster recognition of trends but also improved analysis of cause-effect relationships, and the production of more reliable short-term predictions and the development of new scenarios. Improved prediction skills will help to

develop the best mitigation strategies for unwanted change. To acknowledge the complex linkages between ecology and society, other observation and knowledge systems, such as long-term stakeholder observations on local environmental conditions, can be integrated into scientific data. These new tools comprise automatic and autonomous measurement systems, remote sensing, biological and chemical analytical tools, modelling and data management. They have to be further developed so that each component of the individual system can be integrated into a synergistic information system. This will enable us to extract products for different management requirements and to communicate information to decision bodies at different levels and to the public in an understandable manner. Questions on coastal management and from the public have to be picked up in turn and used to adapt the information system as requested.

This WP will address these new information requirements for changing coastal management. It will consist of research and pre-operational service parts and will be guided by the following three challenges and objectives:

- To observe the state of and processes in coastal waters the observation capabilities will be increased via an integrated observation system, which will consist of sensor packages on platforms of opportunity and autonomous carriers. Advanced remote sensing techniques will provide the required spatial resolution. To investigate and assess ecosystem health new instruments and methods will also be developed enabling identification of indicator species and the health of top predators (e.g. seals and harbour porpoises). All new measurement methods will be characterized as to their scope;
- The data from multiple platforms and sensors will be integrated using statistical and process models to assimilate heterogeneous data sets. These models will be used to clarify complex cause-effect relationships and linkages between events on different spatial and temporal scales;
- The infrastructure required for management and dissemination of information acquired in Topic 2 and for knowledge communication to various stakeholders and the public, will be built.

Implementation

The core strategy of this work package is to develop a Synergistic Monitoring and Information System (SYMONIS). The goal of this strategy is to integrate different levels of monitoring elements into a flexible system to answer questions and serve coastal management. This involves advanced sensors and platforms, data evaluation and processing, numerical modelling and information retrieval and dissemination. All methods will be assessed with respect to their applicability for different monitoring issues. Examples are eutrophication, the development of coastal habitats or the impact of changing physical forces on safety of shipping and offshore constructions and, thus, the protection of the coast. The different parts and the whole system will be elaborated and qualified in form of demonstration projects (in co-operation with WP 1-3). These projects will address issues of coastal safety, which are affected by floods, wind, waves and erosion processes. Seasonal patterns of physical conditions will be analyzed with respect to plankton development and eutrophication, where we expect a strong impact increased water temperatures. Also the exchange and transport of matter between different coastal compartments and the shelf will be investigated using remote sensing data and modelling. Coastal habitats will be mapped using hydro-acoustic methods. Of additional interest to monitoring include sampling strategies, diagnostic sites, indicators and proxy relationships between variables. These strategies aim to reduce effort and optimize the information flow. Areas of interest will cover the North Sea coast and selected Arctic coastal sites, where most rapid changes are to be expected in near future. In particular the changes in permafrost as well as increasing economic activities require new monitoring methods applicable to these sensitive arctic environments.

To communicate the results and interact with users we will make use of the Norddeutsches Klimabüro and the International LOICZ office, hosted at GKSS. These offices maintain a large information base on coastal facts and issues and also of national and international contacts. The results of all WPs will be used to provide knowledge at various levels including coastal management, political decisions, public awareness and education.

WP4 addresses the following:

- The development of an observational basis, which will consist of automatic sensor packages installed on platforms of opportunity including ferries, cargo ships, offshore rigs, towers for wind energy research, coastal measurement poles and buoys. New sensors will be developed or refined such as algal specific sensors and an automatic plankton analyser based on video techniques. Automatic sensor packages will be integrated into undulating batfishes (towed by a vessel), autonomous gliders and coastal rovers.
- Remote sensing techniques, which will be refined and integrated to cover large areas. This task will include (1) optical remote sensing to determine bio-geochemical variables and processes such as suspended particulate matter (SPM) and phytoplankton-chlorophyll, (2) radar systems operated from space and ground to determine currents, wind and waves as well changes in shallow water topography and (3) hydro-acoustical techniques to map underwater topography and habitats.
- The health of marine mammals as top predators and, thus, important indicators of the functioning of coastal habitats will be assessed. Biochemical analytical procedures are already under development to detect contaminant-specific modification in protein expressions and to determine immunological indicators. Furthermore, sensors will be developed for marine mammals to track their temporal and spatial use of habitats.
- The merging of different data will be performed by using hydrodynamic models with forecasting capabilities and calibrated process modules. Circulation models will be coupled with ocean wave and SPM transport models representative for the coastal environment. In situ and satellite data will be assimilated into these models. A simplified version of the ecosystem model developed in WP1 will be coupled to the circulation and SPM transport models. Performance of both physical and bio-geochemical models will be improved by analysis and use of spatial and temporal patterns derived from remote sensing and in situ data.

Deliverables

- ICON/COSYNA observation system with autonomous sensor packages, remote sensing and information management. The results from the development and demonstration projects will include qualification reports and handling protocols for specific monitoring tasks such as habitat use by marine mammals, occurrence of harmful algal, zooplankton dynamics, morphodynamics by radar and the validation of remote sensing data;
- Biochemical indicators for marine mammal health regarding disease as well as contaminant-specific interpretation; it includes assays for health status monitoring, baseline and trends of marine mammal health;
- A coupled modelling system for describing the interaction between physical and bio-geochemical processes in coastal and shelf areas. This includes procedures for analysis of heterogeneous in situ and remote sensing data and the assimilation of physical variables into numerical models;
- Recommendations for monitoring strategies concerning spatial and temporal sampling and extreme event observations; identification of appropriate diagnostic sites, proxy variables and indicators; information products, which communicate results from this WP and other coast WPs to the public, one important deliverable of this category are the contributions to the Quality Status Report North Sea.

Milestones

- Implementation of the ICON/COSYNA observation system with new autonomous platforms and sensors (in form of different development steps, year 2-3)
- Data assimilation techniques pre-operational, for waves, suspended matter transport and primary production (year 3)
- Biochemical indicators for marine mammal health regarding disease- as well as contaminant-specific interpretation, assays for health status monitoring, baseline and trends of marine mammal health (year 3-5)
- Data and information system for all data sources pre-operational; it will be used to contribute to the Quality Status Report North Sea (year 2 and 5)

2.2.3 Expected results and Milestones

- Maintenance of ecosystem function: The structures and processes, which are pivotal to the function of the coastal ecosystem, will be identified. This includes the effect of changes in species composition and how diversity (both intra-specific as well as inter-specific) is related to the effective functioning of food webs and the rates of transfer of energy and matter
- Biological effects of toxic chemicals at all food chain levels: We will distinguish the consequences of the propagation of natural toxins and hazardous anthropogenic organic substances in food webs on ecosystem stability and health of humans and marine mammals.
 - Sensitivity assessment of the coastal system: We focus on the sensitivity of the coastal system and study the interactive effects of climate change and human impacts on the biota and society. We will apply this to shifts in the North Sea. We combine regional Earth System modelling with advanced statistical analyses- constructing change scenarios.
 - Surveillance of coastal waters and habitats: We will develop operational tools, models, and information systems for an improved coastal (eco)system assessment. We will develop strategies for determining the effects of processes such as eutrophication and implications for the safety of ship transport and offshore operations.
 - Integrated Coastal Zone Management practices will be revised. A prerequisite for this is a knowledge on past, recent and ongoing changes, scenarios will be developed on the responsible changing factors and on the perspectives for possible future changes. We will assemble this knowledge.
 - Transfer of expertise to other coasts: Existent expertise developed in previous programmes on change to genetic, physiological and ecological mechanisms and processes on key organisms and populations will be applied to ecosystem change in polar regions in cooperation with Topic 1.

2.2.4 Cooperations

TOPIC 2 “Coastal Change” is underpinned by 50-60 international, bi-lateral co-operations, 4 international multi-lateral co-operations and 35 national, bi-lateral/multi-national co-operations. These were previously established and used in the MARCOPOLI programme. Some of the foremost partners important to our research topic are given below:

National Partners:

University of Bremen	Bremen
University of Hamburg	Hamburg
University of Kiel	Kiel
BSH (Federal Maritime and Hydrographic Agency)	Hamburg
FTZ-Westküste	Büsum
University/ICBM	Oldenburg
MPI, ZMAW and the University	Hamburg
Jacobs University	Bremen
BAW (Federal Institute for Waterways)	Hamburg
MPI, Marine Microbiology	Bremen

International Partners:

Bedford Institute of Oceanography	Halifax	Canada
ESA	Noordwijk	NI
ESA	Frascati	Italy
IFREMER	Brest	France
Station Biologique	Roscoff	France
NERSC	Bergen	Norway
Stazione Zoologia	Naples	Italy
Institute for Marine Sciences (ICM) (CSIC)	Barcelona	Spain
Institute for Marine Research	Flødevigen/Bergen	Norway
Netherlands Institute for Sea Research	Texel	NI
National Oceanographic Centre	Southampton	UK
Netherlands Institute for Ecology	Yerseke	NI
Sir Alistair Hardy Foundation for Ocean Science	Plymouth	UK
Russian Academy of Sciences	St. Petersburg and Moscow	Russia

2.2.5 Contributions of Centres

The Programme Topic “Coastal Change” will be managed by both GKSS and AWI in such a way that it integrates the work on dynamics of the coastal system and implications of Global Change into the overall framework of PACES. The Topic Speaker from GKSS is responsible for the overall coordination and implementation of the Coastal programme. The CO Speaker will also act as the principal representative in maintaining effective links with the PACES Speaker and with the other programme Topics. He will be assisted in this role by the Deputy Speaker from AWI, who is responsible for the overall coordination of the AWI component of the Work Packages and will serve as institutional liaison between AWI and GKSS. Each of the Work Packages has a speaker as well as a corresponding representative from the partner institution. Administration of the CO Topic will be coordinated by a Steering committee consisting of the Topic speaker (GKSS), the Deputy Speaker (AWI), and one representative each from GKSS and AWI for each Work package. Within each Work Package, ad hoc groups and project meetings will be organized as required under the direction of the Work Package Speaker. Working Groups will be formed to deal with the crosscutting aspects, such as the Coastal and Polar interactions.

Expertise from both centres enables us to work in a highly interdisciplinary manner on the questions posed above. Whereas AWI in this Topic delivers primarily ecological knowledge and genetic expertise, GKSS covers a variety of modelling experience as well as coastal surveillance expertise. Further intensification of the already established cooperation during the MARCOPOLI phase, leading a high level of synergy between the two centres.

2.2.5.1 AWI

Contributions of the AWI are in all Workpackages, however, the AWI scientific emphasis is in WP1, WP2 and WP3 due to the emphasis on ecosystem function and evolutionary adaptation of organisms to change in these two packages. The work of the AWI is also based on the results of field and experimental observations and with the help of GKSS their incorporation into ecological models. In WP3 the AWI delivers long-term data sets, partially based on GKSS technology as well as long-term ecological expertise especially for the North Sea and comparatively speaking in the Arctic. The AWI activities in WP4 are smaller than those of GKSS and involve the integration of AWI's Coastal Technology and analyses techniques into the GKSS-driven modelling and management concepts for society.

2.2.5.2 GKSS

Contributions of GKSS are primarily in WP1, WP3 and WP4. In WP2 only a small contribution related to the detection of proteins under the influence of contaminants in marine mammals is to be expected. The contribution in WP1 is strongly based on the results of field and experimental observations also from the AWI and their incorporation into ecological models. In WP3 a strong combination of efforts from both centres is planned with complementary expertise. In WP4 main activities are in the field of observations, analysis and interpretation of the data collected and the presentation of environmental marine information to other users, own modelling groups and the wider public.