CENSUS OF THE DIVERSITY OF ABYSSAL MARINE LIFE

CeDAMar

Programme

Census of Diversity of Abyssal Marine Life (CeDAMar)

Introduction

The abyssal of the world oceans is the target of an international biodiversity programme designed as a part of the multinational "Census of Marine Life" (CoML). **CeDAMar** will gather reliable new data on species assemblages of single ocean basins and on the large-scale distribution of species. The general objective of **CeDAMar** is "*the documentation of actual species diversity of abyssal plains as a basis for global change research and for a better understanding of historical causes and actual ecological factors regulating biodiversity*".
CeDAMar will establish sampling protocols for the standardization of deep-sea biodiversity studies, so that results from different ocean basins will be comparable today as well as in the future. The programme will focus on benthic, epibenthic and hyperbenthic organisms because of their high species-richness. Microorganisms, eukaryotic protists as well as metazoans of all size classes will be considered.

The scientific steering committee of **CeDAMar** is at present composed of the following persons but is open for new members when other initiatives will join the project:

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Responsibility for the coordination of the programme is with the "German Centre for Marine Biodiversity Research" ("Deutsches Zentrum für Marine Biodiversitätsforschung" (DZMB) - Forschungsinstitut Senckenberg):

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CeDAMar started as a national initiative in Germany. Pilot studies were carried out in the years 2000-2002. With its nomination as an initial field study of Census of Marine Life (CoML) in 2002 it became an international programme and is going to widen its scope in 2003 by the inclusion of projects from other countries devoted to the study of other ocean basins.

The programme itself will be structured into separate sub-projects. At present two ambitious projects are under way:

- DIVA, coordinated by Prof. Wägele and Dr. Türkay, focuses on the study of the abyssal plains in the Atlantic Ocean.
- ANDEEP, coordinated by Prof. Brandt, focuses on the poorly known Antarctic deep sea.

Future projects, actually in the planning phase, will include a joint German-Greek study of the abyssal fauna of the Mediterranean (coordinated by Dr. Türkay), and a joint Brazilian-German study of the Brazilian abyssal plains (will be included into DIVA).

A "call for projects" will be issued in 2003 in order to invite other international deep-sea initiatives to join the project.

A **CeDAMar** workshop will be held in Wilhelmshaven, Germany, 5-6th of June 2003.

The projects united in the international initiative "Census of Marine Life"

… were selected so that available resources could be concentrated on the assessment and explanation of biodiversity in poorly known habitats throughout the world's oceans (see http://www.coreocean.org/Dev2Go.web?id=205703&rnd=22592: "*The emphasis of the program is field studies, which are to be conducted in poorly known habitats as well as those assumed to be well known. In both coastal and deep waters, projects will identify new organisms and collect new information on ocean life. Through the field studies and other projects, ranging from analyzing historical documents to modelling future ecosystems, the CoML will enable scientists to compare what once lived in the oceans to what lives there now, and to project what will live there in the future.*"). Poorly known areas are most oceanic regions that are distant from continental margins as well as mesopelagic and deep-sea habitats.

Since only relatively few specialists are able to identify marine organisms, the steering committee of **CeDAMar** decided to concentrate all available expertise on the study of the biodiversity of the abyssal benthos. Rough grounds of sea-mountains, trenches and continental slopes will be avoided. These areas also have a much smaller surface than the abyssal plains. For a start the deep sea of the Atlantic Ocean and Antarctic waters has been selected. Other ocean basins will follow when projects from other countries become part of the programme. The Atlantic Ocean, this is true, has been studied more intensely during the

past 100 years than any other ocean but only in respect to its shallow water, not to its deep-sea communities.

It is a great challenge to collect reliable data on the large-scale distribution of species in one of the largest and almost inaccessible environments of the world. The task will require enormous scientific efforts which can be successful only if all available specialists join forces in a single coordinated endeavour.

CeDAMar profits from the experiences made during the expeditions DIVA 1 ("Meteor" expedition M48/1; July 2000) to the Angola Basin off Namibia and ANDEEP ("Polarstern" expedition ANT XIX/3-4, winter 2001/2002) to the Antarctic deep sea, during which equipment also needed for **CeDAMar** has been tested successfully. A large number of taxonomists is involved in the study of the material collected during these two expeditions.

Tasks of CeDAMar

… consist in:

- assessing the species diversity and describing latitudinal gradients
- analysing the factors causing latitudinal gradients
- estimating the number of species living in the deep sea as a contribution to the estimation of global species diversity
- estimating the size of areas colonized by single species and describing the species-turnover along transects
- producing keys for the determination of species of important taxonomic groups
- analysing gene flow between distant populations and studying radiation processes using molecular methods
- analysing factors favouring speciation differentiating divergences triggered by ecological processes (sympatric speciation by ecological specialization) from the effects of geographic isolation (distance effects etc.)
- analysing factors favouring regionalization of the fauna (isolating effects of currents, seamounts, trenches, ecological factors)

- describing dispersion abilities of benthic species
- correlating species numbers and the presence of higher taxa with ecological and historical factors
- identifying centres of high biodiversity

Strategies and Techniques

In order to obtain comparable samples from different regions sampling will be confined to abyssal plains and will be carried out with standardized methods. Abyssal plains are the largest habitats of the world oceans, so that samples from single selected transects should be representative for vast areas. A team of 40 – 50 specialists (many of them already cooperating in the DIVA and ANDEEP projects) will work on those taxonomic groups for which they are experts. They will describe in detail the species found and write keys in order to ensure reliable later identification of specimens collected during other expeditions or by other teams. It is intended to describe the change in species composition along transects and to compare different ocean regions to learn more about the composition of local communities, large-scale distribution of single species, the influence of sediment parameters as well as primary production on the diversity of benthic communities. Species data will also be related to the history and age of basins, present and hypothesized past bottom currents and palaeoclimatic data. Taxonomists will study the phylogeography of their groups to explain the geographic and phylogenetic origin of deep-sea species. A synthesis of all data will help to better understand the history of the deep-sea fauna, its present diversity and dependence on environmental parameters.

Samples will be collected along transects (each ideally about 1000 km long) at comparable depths from different ocean basins. To exclude small-scale variations which could influence biodiversity estimations, larger areas will be sampled with an epibenthic sledge and repeated box corer (or new devices with the same function) and multicorer hauls. To save time on board the ship new collecting devices will be developed. During DIVA 1 sampling was carried out along a transect of 700 km in the Angola Basin. A second expedition, DIVA 2 will

apply the same sampling methodology in the Guinea Basin. Such large-scale inventorying of the fauna has not been undertaken so far and is an innovative aspect of **CeDAMar**.

Reliable collecting devices will be used in order to avoid damage to fragile deep-sea animals. A new epibenthic sledge has been tested successfully in this respect. Its collecting range on the seafloor can be estimated with the help of a pinger, alternatives will be considered in the future. An Agassiz-Trawl has been used for collecting megafauna, box corer and multicorer for collecting macro- and meiofauna. Underwater cameras are available to document the morphology of the ocean bed, the effects of bioturbation and the abundance of macrofauna.

The collected material will be analysed with the help of methods of modern systematics including cladistics, population genetics and molecular phylogenetics. Data on samples and species will be made available via data bases of the DZMB (Deutsches Zentrum für Marine Biodiversitätsforschung) and via OBIS, the data base of the CoML (Census of Marine Life, Secretariat in Washington, USA).

The DZMB will coordinate the sorting of samples and will keep track of the work of taxonomists entrusted with material.

Pilot studies

During the expeditions DIVA 1 (Angola Basin) and ANDEEP (Scotia Sea) material was collected mainly at depths between 4000 and 6000 m. The collecting devices proved to be reliable and samples were of high quality. First results of DIVA 1 will be available within the next 12 months and will allow estimating the number of samples necessary for a complete survey of a local fauna. DNA extraction from small deep-sea isopods has been successful, even though part of the DNA was of low quality, while DNA of ANDEEP material collected at surface water temperatures of around 0°C was excellent.

Material collected during other expeditions will also be used, for example Russian material stored at the P.P. Shirshov Institute of the Russian Academy of Sciences. This material is available due to existing close co-operations.

New techniques

Based on the experience of the above-mentioned expeditions it became obvious that collecting techniques must be improved in order to save ship time and to get better preserved specimens. Samples obtained with the epibenthic sledge, where specimens are exposed to the surrounding sea water during hauling must be kept at deep-sea temperatures to preserve the DNA needed for molecular studies.

To save ship time it is intended to develop a completely new collection device for quantitative bottom samples. A group of biologists and engineers is currently developing new ideas. The new gear will not be an expensive robot but a sort of sledge that collects up to 10 samples of at least 0.25 m^2 of sea floor. This would allow for a drastic increase of sample size per ship time and a much better statistical estimation of abundances. To process a larger number of sediment samples on board the ship a new extraction method will have to be developed and tested based on the principle of decanting and filtering of the lighter particles.

A device not available in any participating German institution is a video-controlled trap-system that allows precise placement of recoverable baited traps to collect large mobile megafauna. This faunal element is usually not caught with grabs and smaller sledges, larger trawls often yield material in a bad condition. The same gear will carry sensors that can measure some of the sediment parameters (e.g. chlorophyll). The technique exists for most of the components of this system.

Hyperbenthic fauna has usually been collected with epinets mounted on epibenthic sledges. The hyperbenthic zone not only is the habitat of larvae and swimming stages responsible for the dispersal of benthic species but it also harbours a very specific planktonic fauna. To catch

smaller elements of this fauna a suction sampler is needed that filters several litres of water gently *in situ* through very fine sieves.

Companies that develop these devices will in future be able to offer them on the international market to oceanographic research institutes.

Relevance for Global Change Research

Two different aspects with a formative effect on the biodiversity found in an ocean basin have to be distinguished: the climatic and phylogenetic history of a local fauna determine the "raw material" present today, the actual ecological parameters such as climatic changes, changes in nutrient input and disturbance affect the present and future state of this fauna.

Global changes will not be noted if the inventorying of the organisms is delayed until *after* global warming or *after* pollution of the sea. That many coral reefs are in a bad shape today is known because of previous documentation of what healthy reefs look like.

Climatic changes will reach deep-sea environments considerably later than shallow-water habitats, but the effects are likely to be dramatic due to the assumed physiological specialization of the stenothermic fauna. However, it is not only the direct effect of temperature that will influence benthic communities, but also changes in the productivity of surface waters. This will happen much faster and has indeed already been documented in some cases. At present, composition of the fauna, seasonal variations, and the influence of productivity are not known well enough to allow recognition of profound changes. **CeDAMar** will lay the foundations on which any future study of the effects of global warming or of any kind of human interference will have to rely. The abyssal plains are ideal for such basic work because they are far away from the coasts where local anthropogenic effects usually are more pronounced and irregular.

Unfortunately, there are no data on the species composition of untouched communities for most marine benthic habitats. Most previous (including German) activities in polar oceans,

the North Atlantic, the Mediterranean, the Red Sea etc. took place in littoral or bathyal areas and were usually focussed on ecological questions which did not include a comprehensive description of local faunas at the species level. German projects in Antarctica included several taxonomic studies, however most personnel of the Alfred Wegener Institute for Marine and Polar Research were engaged in other priority programmes (e.g. on population dynamics, krill research, fisheries, and projects of non-biological disciplines).

A second goal of **CeDAMar** is to assess the impact of historical climatic changes. The climatic history is imprinted in extant biota and its effects can be inferred from the phylogenetic age and distribution of deep-sea organisms. Fossil evidence for the effect of historical climatic and oceanographic changes is available for few, mostly unicellular organisms (foraminiferans, coccolithophorids, among metazoans: ostracods). These have been studied extensively, yet they represent only a minor fraction of marine biodiversity. For those taxa that are not found in the fossil record phylogenetic and biogeographic analyses including the use of the molecular clock are needed to get data on the phylogenetic age of taxa, their origin and present as well as past distribution in the world oceans.

In Germany there are the logistic requirements for a coordinated large-scale inventory of abyssal fauna, including a sorting centre (DZMB), ships, equipment and the taxonomic expertise. If further research teams of other countries were to join CeDAMar with deep-sea projects in other parts of the world there could be the chance for a unique and substantial contribution that would become the indispensable basis for future studies of the effects of global warming on the largest habitat of the world. Without this documentation it will be impossible to make meaningful statements on the impact of global change on the abyssal benthos. Any team studying these effects in the future will have to refer to the data of **CeDAMar**.

Advantages of biodiversity research in the deep sea

The deep sea harbours vast numbers of species, most of which are still unknown. Global estimates of the number of marine species vary between 500.000 and 10 million. Since there

is no inventory of the fauna of even a single ocean basin, extrapolation of total species numbers of the global abyssal fauna is impossible or at best very speculative.

Compared with littoral and many terrestrial regions the study of the deep sea offers a number of advantages:

- Environmental factors appear to be more homogeneous in the deep sea and are easier to measure due to the relative uniformity of large areas.
- Anthropogenic effects are reduced compared with many littoral habitats, communities are for the most part found in their natural state.
- Work can be carried out outside territorial waters and does not require collection permits.
- Geological information on kinds and age of sediments is available from past and from ongoing projects.

Other advantages

- **CeDAMar** will stimulate new interest in taxonomic research of marine organisms and enhance cooperation of systematists from different countries and institutions.
- **CeDAMar** and its projects will offer the opportunity to train a new generation of marine systematists in order to compensate for the continuous loss of expertise in this field during the last 30 years.

Existing expertise

The programme outlined here is based on the experience of a team of around 50 scientists from 14 institutes that is already cooperating in the project DIVA 1 with support from the German Science Foundation (DFG). This project shows that there still is a good number of taxonomists and marine biologists that are able to identify and describe marine species. However, for several groups of organisms the few remaining experts are so overloaded with other material that there is no hope of interesting them for this project. There are also many taxa for which no young experts are available.

International cooperation

Large scale biodiversity research requires international cooperation for several reasons. DIVA 1 is one of the flagship projects of **IBOY**, the International Biodiversity Observation Year (see http://www.nrel.colostate.edu/_IBOY/index2.html). The current evaluation of samples collected during DIVA 1 and also of during ANDEEP 1 and 2 is only possible because of the participation of scientists from several countries. Nevertheless, the results of DIVA 1 are relevant only for a small oceanic area and it is essential that similar studies be carried out in other parts of the world's oceans. For some taxa there is a global lack of experts which greatly impedes progress in biodiversity research. A new generation of specialists has to be educated in all countries that invest in scientific research.