BA/02

# BIANZO II - Results

## Biodiversity of three representative groups of the Antarctic Zoobenthos Coping with change

DURATION OF THE PROJECT
01/07/2007 - 30/06/2011

BUDGET
791.350 €

KEYWORDS
benthos - climate change - ocean acidification - trophic interactions - cryptic diversity - habitat suitability model

### CONTEXT

The improvement of our understanding of ecological processes and the role of biodiversity in the Southern Ocean ecosystems remains a high priority on the research agenda in today's changing world and is inextricably linked to sustainable development policies on a global scale. Global environmental changes influence species distributions and consequently the structure of communities and ecosystems. Only advances in our knowledge of the Southern Ocean biodiversity and processes important for ecosystem functioning can allow us to address complex evolutionary and ecological questions and enable estimations of the expected change of the biota distribution and composition. Polar regions experience greater rates of global change than any other region in the world. Their biota are highly adapted to the extreme environment they are living in and appear vulnerable to shifts in environmental conditions. Antarctic marine species are especially more sensitive to temperature variation as their physiology is set to a narrow range of temperatures. Also changes in food quality and quantity, together with other environmental shifts such as in pH of the seawater, are likely to impact densities, biomass and community composition but also functional aspects of the Antarctic biota.

Because of the key-role of the Southern Ocean for the global ocean system and the growing impact of global environmental change, it is crucial to establish comprehensive baseline information on Antarctic marine biodiversity as a sound benchmark against which future change can be assessed reliably. It is equally important to understand better the ability of taxa to cope with changes in environmental parameters (temperature, pH, ice cover, food quantity and quality) linked to global change, and this from the individual to the community level. Imperative in this approach is to assess how structural and functional characteristics of the biota may be affected by a changing climate. Finally, advanced integrative spatial modelling of the distribution of key species in relation to environmental conditions is needed to predict the future of the marine ecosystems related to climate change.

These aspects are addressed in the Bianzo II project by focusing on benthic organisms and communities, specifically representatives from three different size classes of the zoobenthos: Nematoda (meiobenthos), Amphipoda (macrobenthos) and Echinoidea (megabenthos). These three groups are characterised by a high diversity and many of the well over 4000 Antarctic benthic species described so far (Clarke & Johnston, 2003) belong to these taxa.

These three selected benthic taxa are also ecologically important in terms of biomass, their role in biogeochemical cycles (C and N) and the trophic role they fulfil in the benthic ecosystem. Furthermore, they are characterised by different biogeographical and diversity patterns, speciation mechanisms, and reproductive and dispersal strategies. Because of these differences and the intrinsic ecological variability between these taxa, it is difficult to assess the extent to which global change will affect the Antarctic benthos in general. Rarely do biodiversity and ecological studies focus on multiple benthic groups. Yet, combining putative size groups in ecological/biodiversity research is imperative to understand the benthic ecosystem as a complex and interactive unity.

### OBJECTIVES

Climate change and its complex and interactive chain of associated effects will affect the physiology, distribution, phenology, and ontogeny of many Antarctic benthic organisms, but the resulting changes from the species to the community level remain poorly quantified and understood. Individual species may appear vulnerable to environmental shifts or regime changes, but community and ecosystem responses may not act accordingly. Therefore we investigated the biodiversity and responses of the three representative groups of benthic organisms to climate change effects from individual species, over populations, up to the community level

During its first phase (2007-2008), BIANZO II aimed at investigating (1) biodiversity patterns of the Antarctic zoobenthos and their causal processes by focussing on the three selected benthic groups (Work package 1: NOWBIO); Furthermore (2) trophodynamic aspects of each of the benthic groups, and their ability to cope with temperature and temperature-related changes (i.e. food composition and availability) but also the effect of pH of the seawater were on the benthos (Work package 2: DYNABIO).

In the second phase (2009-2010) of the project, a joint review paper dealing with the effects of global climate change on the Antarctic zoobenthos is being written, based on the results of experiments, field results and literature data. Information collected in previous studies and in the first two work packages of this project was also used to develop a habitat suitability model in order to identify the drivers of benthic distribution patterns and forecast possible changes of benthic communities related to global change (Work package 3: FOREBIO).

## CONCLUSIONS

### i) NOWBIO

***(1) Benthic biodiversity in new ice free habitats***

Due to large-scale ice-shelf disintegration events, the Antarctic Larsen A and B areas along the Eastern Antarctic Peninsula recently became ice-free. Our study is the first one to investigate benthic communities and their response to the collapse of ice shelves in this area. At the time of sampling, meiofauna community structure at the inner stations, most remote from the original ice margin, was not or only slightly influenced by colonization, and might be structured by local environmental conditions. Communities living close to the former ice-shelf edge are believed to be at an intermediate or late stage of succession. Densities and diversity here were comparable to those at other more northern Antarctic stations in the Weddell Sea, whereas they were considerably lower at the inner stations.

The three echinoid species collected in Larsen A&B areas are good candidates as pioneering species in a changing marine environment. They are known as indirect developers (or at least non-brooders), consistent with high dispersal capabilities. Moreover, this is congruent with the wide Antarctic distribution of these species. These examples stand in contrast to other Antarctic echinoids which are known as direct developers that brood their young and, accordingly, are supposed to present low dispersal capacities. The three Larsen species also display a ‘generalist’ feeding behaviour which can also be considered a characteristic of pioneering species. Furthermore, the symbiotic communities of echinoids in the Larsen area showed a low diversity and a strong similarity with epibionts present on stones, something which has not been observed in other regions so far. These results suggest that ectosymbioses linked to cidaroids could contribute to benthic colonization of the seafloor in these new ice free areas.

The Larsen ice-shelf disintegration also led to the discovery of a low-activity methane seep. The observation of elevated densities, subsurface maxima and high dominance of one nematode species was similar to other cold-seep ecosystems world-wide and suggested a dependence on a chemosynthetic food source. However, stable 13C isotopic signals were indicative of phytoplankton-based feeding. This implied that the community was in transition from a chemosynthetic community to a classic phytodetritus feeding community, a temporary ecotone as it were. The characteristic parthenogenetic reproduction of the dominant species is rather unusual for marine nematodes and may be responsible for the successful colonisation by this single species.

***(2) Cryptic diversity***

There is evidence that the species richness of Antarctic amphipods is underestimated, not only for the poorly known deep sea but also for the better-studied shelf fauna. Given the fact that we mainly focused on the Atlantic sector (and the Ross Sea to a lesser extent), we expect that the total Antarctic diversity is even much higher and undocumented. Therefore, additional samples from other areas in Antarctica are needed to assess the real diversity, and evaluate whether some amphipod species have a true circumpolar distribution.

The discovery of cryptic diversity has potentially profound implications for evolutionary theories and biogeography and may be a potentially important factor influencing future conservation decisions. Furthermore, the Census of Antarctic Marine Life (CAML) stated that there is an urgent need for more genetic barcode studies on Antarctic organisms, especially in view of the rate of climate-driven habitat changes which might lead to extinctions. Species identification by DNA barcoding has been shown here to be efficient for amphipod taxa and will facilitate future taxonomic studies, enabling non-specialists to discriminate taxa that are otherwise difficult to identify. It will thus make species identifications faster and more accessible at a lower cost at the same time. In poorly known amphipod groups, high intraspecific genetic divergences suggest overlooked species or species complexes. The barcode application can provide a preliminary signal of species richness.

***(3) Biogeographical distribution***

Based on extensive datasets with distribution records of the three target taxa, a common biogeographical analysis was undertaken, aiming at comparing geographical and bathymetrical distribution patterns, focusing on the differences between meio-, macro- and megabenthos. The analysis aimed to match these patterns with the biogeographical schemes of other benthic taxa known from literature and to identify potential drivers of the observed patterns. This detailed comparative analysis, which is still ongoing, provides new insights into geographical and bathymetrical distribution patterns, hotspots of species richness and endemism, centre(s) of radiation, circumpolarity and cryptic species, eurybathy, and potential causal factors of the observed patterns.

### ii) DYNABIO

***(1) Trophodynamics***

Investigating food preferences in Antarctic benthos is of crucial importance since the ongoing climate change may alter the natural balances and the functionality of polar ecosystems. Rises in air and water temperature have been claimed to explain shifts in the size range of phytoplankton communities, which may, in turn, affect those biological components that depend on it. Moreover, warming trends may result in shifts in microbiological activity.

The results of this study indicate that shallow-water meiofauna prefer a phytoplankton food source rather than microbial food. This stands in contradiction with what is found for deep-sea nematodes in the Antarctic, where a microbial food source seems to be preferred over phytodetritus. In shallow waters, however, phytoplankton is of higher quality than in the deep sea where it has been degraded as a result of the sinking process. So these observations may reflect a preference for the most qualitative food, rather than a difference between preferences of deep-sea and shallow-water nematodes.

Also for echinoids it was shown that trophic flexibility can differ according to species, with euechinoid species appearing more “flexible” than cidaroids towards changes in food sources.

Therefore, aptitudes to cope with change in food availability clearly need further studies on the Antarctic and Sub-Antarctic benthic fauna, from species to ecosystem level.

*(2) Acidification*

Although echinoids, having a magnesium calcite skeleton, are assumed to be most vulnerable to ocean acidification, experiments have shown that some species appear robust to changes in pH. Our results suggest acclimatization of natural populations to low pH effects in intertidal and sub-Antarctic areas. However it is not yet possible to precisely answer how the echinoid fauna would face global change and how complex communities will be impacted. This situation partly results to the lack of data on the proximal stress-tolerance processes, and on the nature and weight of interspecific interactions in changing communities. In that context, changes in community components along gradients crossing contrasted environmental conditions should be more precisely examined.

**iii) FOREBIO**

We also analysed actual species distributions in the Southern Ocean and modelled the mechanisms that structure them. The primary data used for the model were continuously developed within the NOWBIO work package (e.g. for echinoids the database covers more than 4000 georeferenced localities in the Southern Ocean, and more than 6000 when the surrounding cold temperate areas are included). This has increased the power of the modelling approach and makes it now able to compute relevantly species distribution models at the scale of the entire Southern Ocean and enables testing for the impact of environmental variables and future climate scenarios (“single species” approach).

## CONTRIBUTION OF THE PROJECT TO A SUSTAINABLE DEVELOPMENT POLICY

The achievements of the BIANZO II project contribute significantly to the major objectives formulated in the SCAR-EBA-programme and the IPY core activity Census of Antarctic Marine Life. Furthermore, not only were several results of BIANZO included in the Antarctic Climate Change and Environment (ACCE) report, with the BIANZO II achievements we contributed considerably to filling in the earlier listed gaps in knowledge, for which the answers are urgently required for policy makers (Turner et al., 2009).
The BIANZO consortium illustrated the potentially high sensitivity of several marine taxa which are major components of the benthic ecosystem to climate related changes such as changes in food supply, ice shelf collapse, seawater acidification and temperature rise. By means of sensitivity tables based on what we know from own research and a literature review for each of the taxa at different levels of biological organization (from populations to communities or habitats) we illustrated high sensitivity for specific climate related changes in the Antarctic environment, but we also identified major gaps in our knowledge. Furthermore, molecular approaches showed the high cryptic biodiversity present in many of the Antarctic taxa, illustrating that what we know about biodiversity so far is only the tip of the iceberg. Since the climate-induced shift in the food regime leads to a decrease in the rich Antarctic seabed biodiversity, we are currently losing biodiversity of which we will never know the characteristics or its importance. Finally, by developing a spatial model we attempted to forecast the potential impact of climate-related changes on the distribution of selected BIANZO taxa.

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