Census of Antarctic Marine Life
SCAR-Marine Biodiversity Information Network

BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN

▶ CHAPTER 5.28. CLASSIFICATION AND SPATIALLY EXPLICIT ILLUSTRATION OF ANTARCTIC MACROBENTHIC ASSEMBLAGES: A FEASIBILITY STUDY.

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THE BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN

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5.28. Classification and spatially explicit illustration of Antarctic macrobenthic assemblages: a feasibility study

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Macrobenthos form substantial and varied assemblages on continental shelves around the Southern Ocean. It includes all benthic organisms >1mm and, thus, also the megabenthos, which is often less clearly defined. These macrobenthic assemblages cover considerable gradients in abundance, species composition (Photo 1) and in ecological functioning. They can take the form of 'forests' of sessile bioconstructors, which are mainly suspension (filter) feeders, such as sponges, corals and bryozoans, or clumps of animals such as hydroids, gorgonians, sea-squirts (ascidians) or brachiopods (Dayton 1990, Clarke & Johnston 2003). Some of these provide substratum for speciose epibiotic symbioses (see Schiaparelli chapter 5.31, this volume). Siphons of buried bivalve molluscs, polychaetes and other deposit feeders omnivorous species or grazers (often echinoderms) form low-lying shapes (see e.g. Sumida *et al.* 2008). Seeps and vents in the Southern Ocean have recently been explored in detail (see Rogers & Linse chapter 5.30, this volume). Representatives from groups such as suspension feeders, predators, deposit feeders, and grazers can each locally dominate the benthic system in its functioning and biodiversity (Kaiser *et al*. 2013). Patchiness occurs across many spatial scales in depth and geography ranging from almost circumpolar in distribution (biogeographic features) to small-scaled but high concentrations of a variety of organisms e.g. on single drop stones surrounded by near desert conditions. Abundances, biomass or proxies thereof range from almost the lowest (e.g. beneath floating ice shelves) to the highest recorded in the world, (e.g. in dense sponge communities); for review see Gutt *et al.* (2012).

Ship-based surveys of benthic structure have a long tradition, but were well underway by the late 1950s. Process orientated ecological experiments and shallow water studies have mainly been carried out from land-based research stations. Pioneering work in the 1960–1980s by Paul Dayton and colleagues investigated benthic communities in McMurdo Sound and, consequently, this location is one of the best understood areas for Antarctic benthos. Shelf areas all around the continent and islands down to 300 m deep are known to be mechanically disturbed by ice, particularly by icebergs grounding (termed scouring) with such intensity and frequency that only rapid recolonisers and growers (pioneers) are locally abundant. Anthropogenic impacts, mainly by bottom trawling and long-line fishing, have been considerable in some areas in the past and still have a destructive effect on Antarctic benthic assemblages, but these have never been comprehensively quantified. On the other hand, a number of measures of nature conservation have recently been adopted. New sampling programmes, especially within the framework of the Census of Antarctic Marine Life (CAML), have greatly increased wider knowledge but we still have only a rudimentary understanding of community structure and the physical drivers which underlie them (Gutt *et al*. 2012). This has been recognised by the two new biology programmes of SCAR, "Antarctic Thresholds - Ecosystem Resilience and Adaptation" (AnT-ERA) and "State of the Antarctic Ecosystem" (AntEco), which focus on ecosystem functioning in a changing environment and large scale patterns shaped by long term evolution, respectively.

Below the continental shelves we know little about macrobenthic assemblages, although the continental slope and Antarctic deep-sea are increasingly being considered in survey design and sampling. However, the high species richness, large size of the Southern Ocean, and cost in time and money of deep-sea sampling means that comprehensive assemblage analyses are still very difficult and rare. In the last few years information

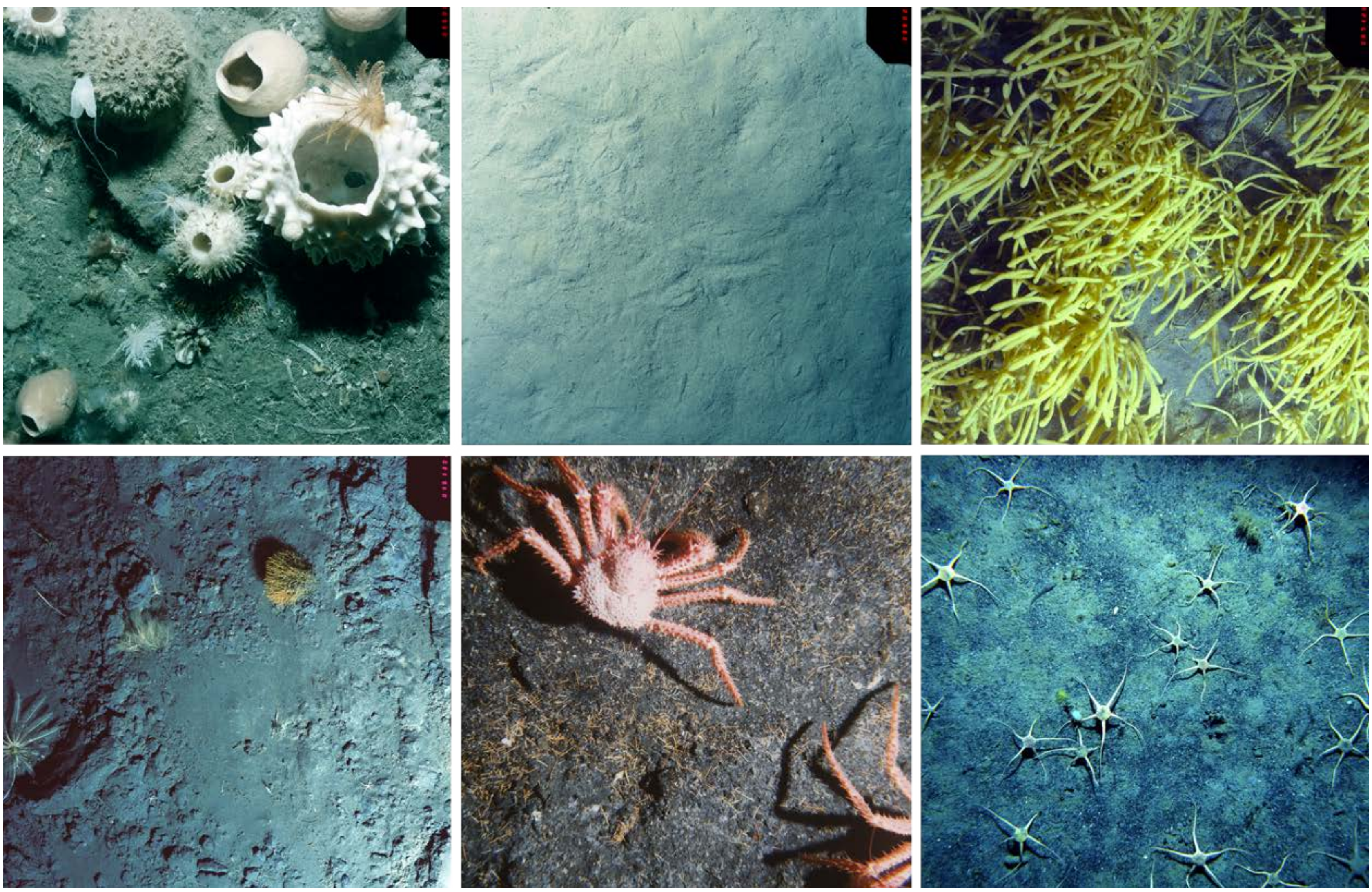
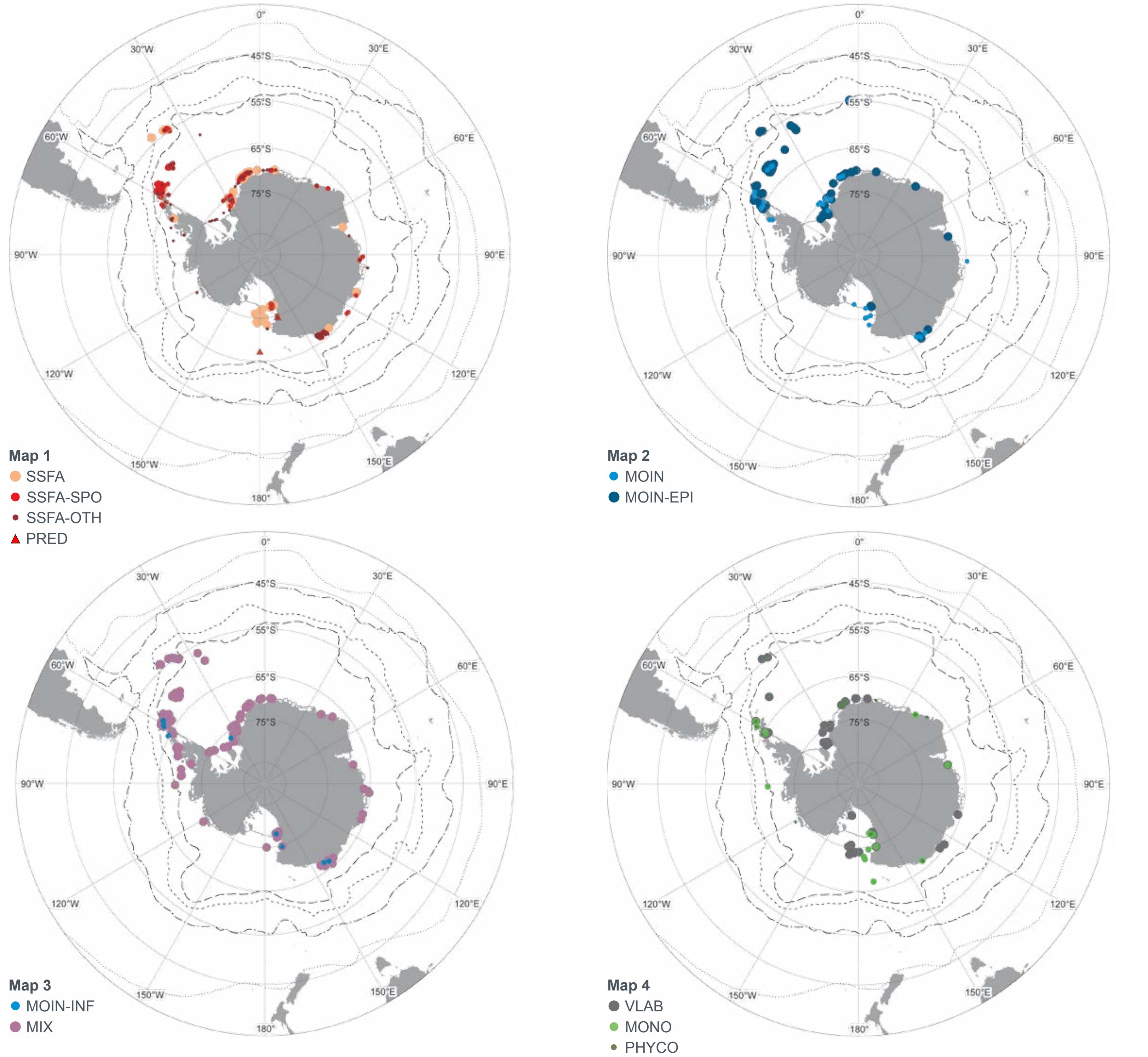


Photo 1 Selection of Antarctic macrobenthic shelf inhabiting assemblages. Upper left: dominated by barrel shaped hexactinellid sponges, associated fauna: demosponges, pencil sea urchin, crinoid, benthic ctenophore, bryozoans, gorgonians, ascidians, hemichordates (70.941°S 010°515°W, 260 m water depth, SE Weddell Sea, doi.pangaea.de/10.1594/PANGAEA.666982); Upper centre: assemblage with very low abundances, only one shrimp is visible but "Lebensspuren" indicate activity of other mobile organisms (54.429°S 035.684°W, 270 m water depth, South Georgia, doi.pangaea.de/10.1594/PANGAEA.220742); Upper right: assemblage dominated by one single species, the demosponge *Homaxinella* sp. Most likely this "monoculture" represents a relative early stage of recolonisation after physical disturbance due to iceberg grounding (71.107°S 011.532°W, 160 m water depth, SE Weddell Sea, doi.pangaea.de/10.1594/PANGAEA.319903); Lower left: recent iceberg scour, only few survivors are present (70.835°S 010.593°W, 275 m water depth, SE Weddell Sea, doi.pangaea.de/10.1594/PANGAEA.319904); Lower centre: predators like these king crabs (Lithodidae) at the Spiess Sea-mount close to Bouvet Island are rare in the Antarctic but discussed as possible thread for potential food organisms because of their durophagous feeding when invading large Antarctic shelf areas as a consequence of oceanic warming (54.733°S 000.092°W, 350 m water depth, doi.pangaea.de/10.1594/PANGAEA.691581); Lower right: assemblages dominated by deposit feeders such as ophiuroids (71.677°S 012.723°W, 235 m water depth, SE Weddell Sea, doi.pangaea.de/10.1594/PANGAEA.319888). All photographs represent approximately 1 m^2, with the exception of that in the lower centre representing 0.56 m^2.



Macrobenthic Assemblages Maps 1–4. Illustration of macrobenthic communities on the Antarctic shelf. For definition of acronyms see Fig. 1. A first interpretation is extreme patchiness across spatial scales. Despite the general dominance of sessile suspension feeders, it appears to be regionally fractal in nature. If one zooms into the patterns they do not get less heterogeneous.

systems have begun to provide easier access to many recent and historic data sets. These are facilitating the first attempts to map the occurrence of species and biogeographic analyses of taxa. To date, this is virtually all based on presence/absence data because of the rarity of truly quantitative and comparable sampling. However, improved imagery platforms and use of equipment such as mega-cores are rapidly improving estimates of abundance and density. Such studies provide a basis for more advanced macroecological studies e.g. correlative approaches linking the environment and biota (for example see Cummings *et al.* 2010), spatial predictions based on potential habitats (for review see Gutt *et al.* 2012), projections of responses of marine life to ongoing climate change, such as warming, sea-ice loss and gain as well as acidification (see e.g. Clarke *et al.* 2007, Turner *et al.* 2008, Brandt & Gutt 2011). Community analyses and studies of ecosystem functioning require more complex data and interdisciplinary coordination. Standardisation of ecological methods and approaches remains in its infancy, and thus results from different studies are so far statistically comparable only within limited areas and taxa, or if carried out by the same research team.

To date, comparison and classification of assemblages at a circumpolar scale is only possible at the level of expert best knowledge (interpretation of data) and not by statistical methods. A first step in this direction was a coarse classification of macrobenthic assemblages, defined by taxa being dominant - predominantly in terms of biomass, volume or sea-floor cover and by a few known ecological processes (Fig. 1). Using information from the literature (references cited below) was a first attempt to assemble data from historic

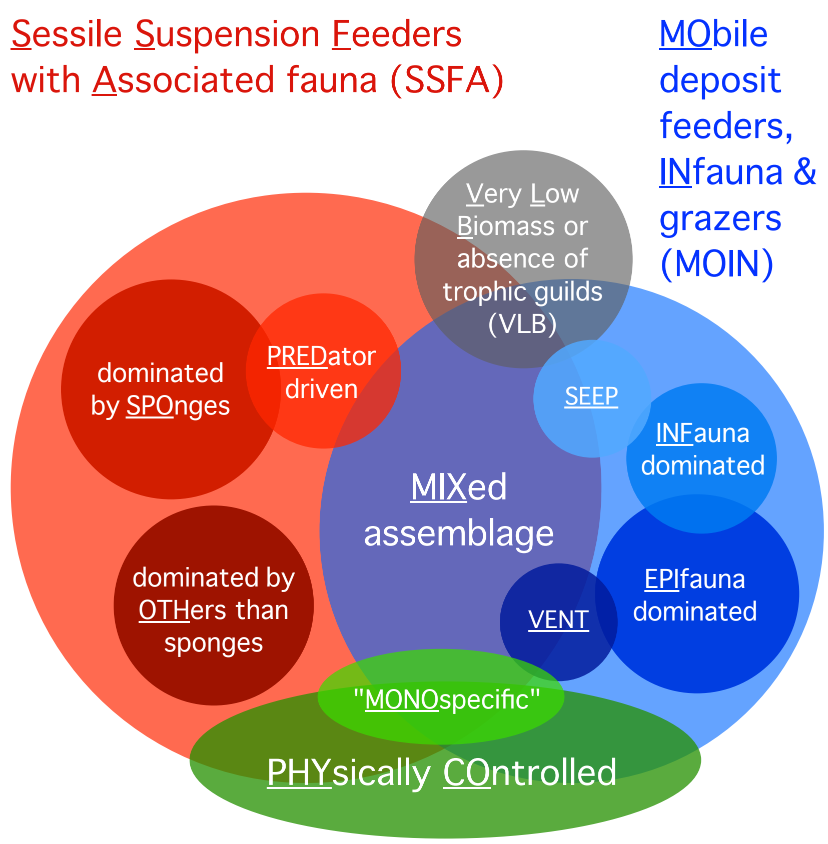


Figure 1 Classification of Antarctic macrobenthic assemblages changed after Gutt (2007) and Gutt *et al.* (2013b). Mobile suspension feeders such as crinoids are included in category SSFA-OTH. Mobile predators not being part of the suspension feeder assemblages (e.g., king crabs) are included in MOIN-EPI. SEEP includes visible bacterial mats and dead clams. Letters used for acronyms in capitals. ▶

and recent surveys and depict this information in a spatially explicit way (Maps 1–4). The meta-information of this data set was also published as a data paper (Gutt *et al*. 2013a) and a first careful analysis has been carried out (Gutt *et al*. 2013b). The collection, classification, and illustration of these data provide an overview for various further purposes (e.g. nature conservation measures or identification of scientific key sites) but do not necessarily represent all existing data sets. Thus, these circumpolar approaches are open for additions including additional size fractions, e.g. meiobenthos, and could be extended to outlying shelf areas such as around sub-Antarctic Islands and the deep-sea.

A better solution than to continue with this early staging-template approach would be to develop a standardised protocol for the acquirement of assemblage or community data. It should be applicable to all Antarctic macrobenthic assemblages and would provide the basis for quantitative (statistical) circumpolar analyses. Within this approach biomass should be determined for a complete range of larger taxonomic units including the possible absence of taxa similar to that of Lockhart & Jones (2008). If error can be quantified by some ground truthing, sea-floor cover could be used as proxy for biomass when using imaging methods. With similar precautions abundances can be translated to approximate biomass if conversion factors (and associated errors) are known and size classes are determined. The ecological aspect of this concept could be strengthened if a manageable number of ecologically important species and basic ecological drivers such as biological interactions, disturbance and strength between guilds are added. If this concept is realized an *a priori* classification may not be necessary anymore, instead analyses of assemblages can be applied and adjusted to the specific scientific question. As a consequence, problems of how to define details of the *a priori* classification, e.g. the dominance of functional groups, the thresholds between assemblages and the overlap between pure faunistic composition and ecological factors would be minimised. A convention for the area covering a single sample should be discussed since large scale surveys e.g. by video transects or trawl hauls are likely to integrate across habitats (Fig. 2) in contrast to spot grab samples.

The classification and zoogeographical distribution of assemblages arising from such an advanced approach are expected to become even more complex than the information depicted in Photo 1 and Fig. 1. Nevertheless, the results presented here mark a first step and potentially important basis to search for large-scale generality. In contrast they can also be used to examine fundamental differences within Antarctic benthic systems including links between habitat and biota, to understand their functioning, quantify ecosystem services and assess direct and indirect response to environmental changes.

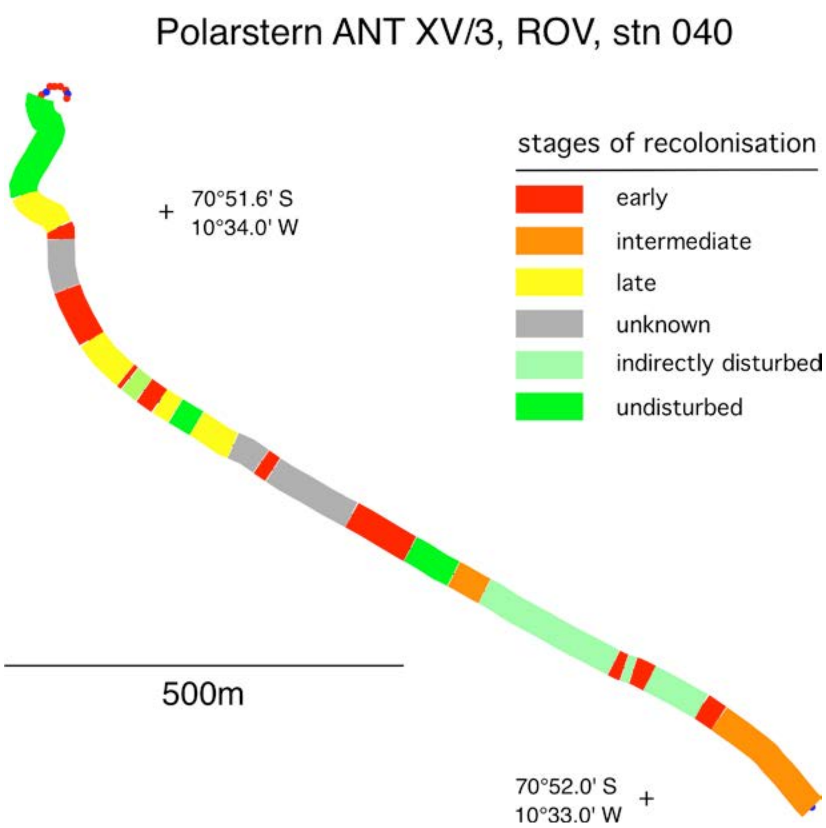


Figure 2 Different successive stages of recolonisation along a 946 m long ROV-video transect show how much and at which spatial scales the benthic habitat can be fractionised by the impact of grounding icebergs (South-eastern Weddell Sea, 240 m water depth). For further information and sea-bed photographs see doi.pangaea.de/10.1594/PANGAEA.198668.

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THE BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN

Scope

Biogeographic information is of fundamental importance for discovering marine biodiversity hotspots, detecting and understanding impacts of environmental changes, predicting future distributions, monitoring biodiversity, or supporting conservation and sustainable management strategies.

The recent extensive exploration and assessment of biodiversity by the Census of Antarctic Marine Life (CAML), and the intense compilation and validation efforts of Southern Ocean biogeographic data by the SCAR Marine Biodiversity Information Network (SCAR-MarBIN / OBIS) provided a unique opportunity to assess and synthesise the current knowledge on Southern Ocean biogeography.

The scope of the Biogeographic Atlas of the Southern Ocean is to present a concise synopsis of the present state of knowledge of the distributional patterns of the major benthic and pelagic taxa and of the key communities, in the light of biotic and abiotic factors operating within an evolutionary framework. Each chapter has been written by the most pertinent experts in their field, relying on vastly improved occurrence datasets from recent decades, as well as on new insights provided by molecular and phylogeographic approaches, and new methods of analysis, visualisation, modelling and prediction of biogeographic distributions.

A dynamic online version of the Biogeographic Atlas will be hosted on www.biodiversity.aq.

The Census of Antarctic Marine Life (CAML)

CAML (www.caml.aq) was a 5-year project that aimed at assessing the nature, distribution and abundance of all living organisms of the Southern Ocean. In this time of environmental change, CAML provided a comprehensive baseline information on the Antarctic marine biodiversity as a sound benchmark against which future change can reliably be assessed. CAML was initiated in 2005 as the regional Antarctic project of the worldwide programme Census of Marine Life (2000-2010) and was the most important biology project of the International Polar Year 2007-2009.

The SCAR Marine Biodiversity Information Network (SCAR-MarBIN)

In close connection with CAML, SCAR-MarBIN (www.scarmarbin.be, integrated into www.biodiversity.aq) compiled and managed the historic, current and new information (i.a. generated by CAML) on Antarctic marine biodiversity by establishing and supporting a distributed system of interoperable databases, forming the Antarctic regional node of the Ocean Biogeographic Information System (OBIS, www.iobis.org), under the aegis of SCAR (Scientific Committee on Antarctic Research, www.scar.org). SCAR-MarBIN established a comprehensive register of Antarctic marine species and, with biodiversity.aq provided free access to more than 2.9 million Antarctic georeferenced biodiversity data, which allowed more than 60 million downloads.

The Editorial Team

Claude DE BROYER is a marine biologist at the Royal Belgian Institute of Natural Sciences in Brussels. His research interests cover structural and ecofunctional biodiversity and biogeography of crustaceans, and polar and deep sea benthic ecology. Active promoter of CAML and ANDEEP, he is the initiator of the SCAR Marine Biodiversity Information Network (SCAR-MarBIN). He took part to 19 polar expeditions.

Huw GRIFFITHS is a marine Biogeographer at the British Antarctic Survey. He created and manages SOMBASE, the Southern Ocean Mollusc Database. His interests include large-scale biogeographic and ecological patterns in space and time. His focus has been on molluscs, bryozoans, sponges and pycnogonids as model groups to investigate trends at high southern latitudes.

Cédric d'UDEKEM d'ACOZ is a research scientist at the Royal Belgian Institute of Natural Sciences, Brussels. His main research interests are systematics of amphipod crustaceans, especially of polar species and taxonomy of decapod crustaceans. He took part to 2 scientific expeditions to Antarctica on board of the *Polarstern* and to several sampling campaigns in Norway and Svalbard.

Bruno DANIS is an Associate Professor at the Université Libre de Bruxelles, where his research focuses on polar biodiversity. Former coordinator of the scarmarbin.be and antabif.be projects, he is a leading member of several international committees, such as OBIS or the SCAR Expert Group on Antarctic Biodiversity Informatics. He has published papers in various fields, including ecotoxicology, physiology, biodiversity informatics, polar biodiversity or information science.

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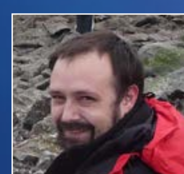

Anton VAN DE PUTTE works at the Royal Belgian Institute for Natural Sciences (Brussels, Belgium). He is an expert in the ecology and evolution of Antarctic fish and is currently the Science Officer for the Antarctic Biodiveristy Portal www.biodiversity.aq. This portal provides free and open access to Antarctic Marine and terrestrial biodiversity of the Antarctic and the Southern Ocean.

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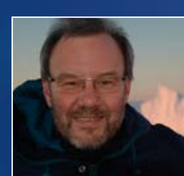
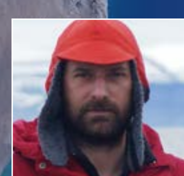


Julian GUTT is a marine ecologist at the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Bremerhaven, and professor at the Oldenburg University, Germany. He participated in 13 scientific expeditions to the Antarctic and was twice chief scientist on board Polarstern. He is member of the SCAR committees ACCE and AnT-ERA (as chief officer). Main focii of his work are: biodiversity, ecosystem functioning and services, response of marine systems to climate change, non-invasive technologies, and outreach.

Graham HOSIE is Principal Research Scientist in zooplankton ecology at the Australian Antarctic Division. He founded the SCAR Southern Ocean Continuous Plankton Recorder Survey and is the Chief Officer of the SCAR Life Sciences Standing Scientific Group. His research interests include the ecology and biogeography of plankton species and communities, notably their response to environmental changes. He has participated in 17 marine science voyages to Antarctica.

Alexandra POST is a marine geoscientist, with expertise in benthic habitat mapping, sedimentology and geomorphic characterisation of the seafloor. She has worked at Geoscience Australia since 2002, with a primary focus on understanding seafloor processes and habitats on the East Antarctic margin. Most recently she has led work to understand the biophysical environment beneath the Amery Ice Shelf, and to characterise the habitats on the George V Shelf and slope following the successful CAML voyages in that region.



Yan ROPERT COUDERT spent 10 years at the Japanese National Institute of Polar Research, where he graduated as a Doctor in Polar Sciences in 2001. Since 2007, he is a permanent researcher at the CNRS in France and the director of a polar research programme (since 2011) that examines the ecological response of Adélie penguins to environmental changes. He is also the secretary of the Expert Group on Birds and Marine Mammals and of the Life Science Group of the Scientific Committee on Antarctic Research.