

Chapter 2

Southern Ocean Deep-Sea Isopod Biodiversity Research: From Census to Ecosystem Functioning

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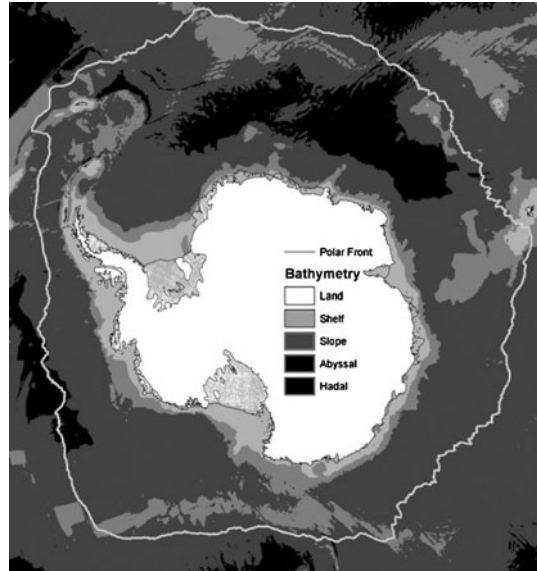
2.1 Introduction

The isolation of Antarctica makes this continent a perfect evolutionary laboratory for studies of marine biodiversity and biogeography. Attempts to describe and explain patterns of species diversity have become a major goal in biological research since the pioneering deep-sea investigations in the early 60s of the last century (Sanders et al. 1965; Sanders and Hessler 1969). Analyses of large-scale (global) patterns of deep-sea biodiversity include latitudinal gradients, apparent decreases in species richness among a number of taxa from the equator towards the poles (Poore and Wilson 1993; Rex et al. 1993, 1997). The Atlantic sector of the Southern Ocean (SO) does not seem to follow this pattern (Brandt et al. 2007b) although the deep seafloor of the SO remains the least studied even though it is the largest single benthic habitat (Clarke and Johnston 2003).

The Southern Ocean benthic marine shelf flora and fauna has been impacted over millions of years by plate tectonics and the resulting changes in the global climate. Tertiary palaeogeologic and -oceanographic changes (e.g. Brown et al. 2006; Zachos et al. 2008) successively generated the psychrosphere and the cold Antarctic Deep Water which is linked to the surface water in polar areas. These key events of cooling and glaciation followed by warmer periods shaped the evolution of many SO marine species. Following evolutionary extinctions some benthic marine invertebrate taxa radiated, others are remnants from the progressive retraction of cosmopolitan taxa established during the Jurassic and Cretaceous when Antarctica was still under greenhouse conditions, some disjunct distribution patterns resulted from vicariance events following the disintegration of

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Fig. 2.1 Bathymetry of the southern ocean, showing shelf, slope, abyssal and hadal regions (Kaiser and Barnes 2008)



the supercontinent Gondwana. Thus, the present Southern Ocean fauna has changed in biodiversity and composition over geological time scales and species have actively migrated in and out of the SO (depending on dispersal capabilities) during glacial and interglacial periods.

Today the Southern Ocean is characterized by unique environmental features, including a very deep and partly narrow continental shelf, a weakly stratified almost isothermal water column and formation of abyssal waters flowing to other basins. Most of the SO seafloor (27.9 million km², Clarke and Johnston 2003) is deep sea (Fig. 2.1). Characteristic for Antarctica is that the shelves are much deeper than the average, 450–500 m, and can exceed 1,000 m in places; the Antarctic shelf comprises 17% of the world's total shelf area. The SO deep-sea faunas are related both to adjacent shelf communities and to those in other deep oceans, and both submergence and emergence processes can occur. Nowadays, natural and anthropogenically driven climate change processes shape the Southern Ocean marine fauna and despite our knowledge of the evolutionary historic developments, it is difficult to anticipate how these processes will drive speciation, extinction or the SO food web in future.

2.2 Programmes and Expeditions to the SO Deep Sea

Since the early exploratory phase of Antarctic research, and in the course of modern programs such as EPOS, EASIZ, ANDEEP, CAML, EBA, LGP (e.g. Dayton 1990; Arntz et al. 1997; Brandt 1991; Arntz and Clarke 2002; De Broyer et al. 2003;

Clarke and Johnston 2003; Clarke et al. 2006; Brandt et al. 2007a, b, c), benthic life of the SO has been a subject of great interest. However, none of the deep-sea biology studies in the Southern Ocean was devoted exclusively to the deep sea. Between 1950 and 1960, during Russian and U.S. expeditions of the RVs *Eltanin*, *Glacier*, *Akademik Kurchatov*, and *Akademik D. Mendeleiev*, deep-sea samples had been taken occasionally. The first deep-sea expedition with HMS *Challenger* sampled the Beagle Channel and several deep-sea stations.

Later, in 1994, the Magellan area was sampled again during the IBMANT programme (Interactions between the Magellan Region and the Antarctic, RV *Polarstern*) (Arntz and Rios 1999). During EPOS (European Polarstern Studies) and EASIZ (Ecology of the Antarctic Sea Ice Zone), some deep-sea data were obtained from the slope but rarely from abyssal sites. However, both programmes have been biologically outstanding and have provided a wealth of benthic data on species of all taxonomic groups and functional guilds of the high Antarctic Weddell Sea and the Antarctic Peninsula (Arntz and Gutt 1997; Arntz and Clarke 2002; Arntz and Brey 2003). Most information on the ecology of benthic deep-sea fauna in the Weddell Sea comes from a few stations sampled during EASIZ II in 1998 (Arntz and Clarke 2002). The ANDEEP (ANTarctic benthic DEEP-sea biodiversity: colonisation history and recent community patterns) expeditions took place in 2002–2005 in order to investigate this little known realm of the SO and provide first insights into the biodiversity and biogeography of the SO deep sea. ANDEEP contributed to the CoML (Census of Marine Life) projects CeDAMar (CENSus of the Diversity of Abyssal Marine Life) and CAML (Census of the Antarctic Marine Life) and aimed to conduct the first comprehensive survey of megafaunal, macrofaunal and meiofaunal deep-water communities in the Scotia and Weddell Seas.

2.3 Patterns of Biodiversity in the Deep Sea

2.3.1 High Levels of Novel Biodiversity in the Southern Ocean

SO benthic shelf communities display high levels of endemism, gigantism, slow growth, longevity and late maturity. In the deep sea it still remains virtually impossible to obtain animals alive and undamaged from abyssal depths and thus knowledge of the deep-sea faunal composition, particularly in the SO, is still scarce in comparison with that from shelf and upper slope environments and we know almost nothing about the physiology, autecology or life histories of the SO deep-sea organisms. During the ANDEEP project the Scotia and Weddell seas were sampled (Brandt et al. 2004, 2007) and the geological and sedimentological backgrounds of this region were reviewed by Thomson (2004) and Howe et al. (2004). A novel approach of this project was sampling across a broad range of taxonomic groups. This was crucial because large-scale biodiversity and biogeography patterns largely depend on size, biology (feeding mode and reproductive patterns) and mobility of the taxa, their gene flow (compare also Rex et al. 2005),

as well as geological history, productivity, predation and the relationship between regional and local species diversity (Witman et al. 2004).

The SO deep-sea communities are unique and highly diverse. The high percentage (often >90%) of new species in most taxa (Brandt et al. 2007a, b, c) and the high degree of endemism of many groups may reflect undersampling of the area. The high benthic diversity can probably be attributed to the constant, cold environment since about the last 34 m.y. The true deep-sea benthic fauna occurred at depths between 1,500 and 2,500 m depending on the taxon (Brandt et al. 2007c). There is a deep-sea affinity with the Antarctic shelf (Lipps and Hickman 1982; Brandt 1991; Brandt et al. 2007b), but some of the species can also be found in adjacent abyssal deep-sea basins (Brandt et al. 2004; Brandt et al. 2007a, b, c). This can be explained by repeated submergence and emergence processes during the evolution of invertebrate taxa and also by the eurybathy of the slope and deep-sea inhabitants (Brey et al. 1996). For example, Foraminifera, revealed close biogeographic links at the species level between deep Weddell Sea localities and those from similar depths in the North Atlantic and Arctic. The interesting biogeography of Arctic and Southern Ocean foraminiferan species might be due to their occurrence in the Weddell Sea, a major source of the world's deep water production, which could enhance the deposition of organic matter to the SO deep-ocean floor (Thomas and Gooday 1996; Brandt et al. 2007b). Isopod and polychaete slope assemblages included species that have invaded from the shelf. In sponges and molluscs the shelf and slope assemblages were more distinct. Abyssal faunas showed stronger links to other oceans, particularly the Atlantic, but mainly within good dispersers such as foraminiferans and polychaetes (Brandt et al. 2007b, c). Poor dispersers, like isopods, ostracods and nematodes are SO species rich and include many "apparently endemic" species. In summary, the ANDEEP data provide a valuable basis for exploring the evolutionary significance of the varied biogeographic patterns observed in this remote environment (Brandt and Hilbig 2004; Brandt et al. 2007b, c; Brandt and Ebbe 2007 and references therein).

The 40 ANDEEP stations based on RV *Polarstern* in the deep Weddell Sea and adjacent areas (748–6,348 m water depth) have revealed high species richness. For instance, 158 live species of Foraminifera were sampled. Within meiofaunal nematodes, 57 species of typical cosmopolitan deep-sea genera were sampled with more than 50% of new species, and more than 100 ostracod species were distinguished, >70% of them new (Brandt et al. 2007b). Macrofaunal isopods were the most diverse benthic invertebrate taxon investigated with 674 species identified and 585 of these species being new to science. Prior to the ANDEEP project 371 isopod species were reported from Antarctica (Brandt et al. 2007c). From 200 polychaete species sampled only 81 were previously known (Schüller and Ebbe 2007). The ANDEEP stations yielded 160 species of shelled gastropods and bivalves; Compared to a total of 279 species known from the shelf (<1,000 m) based on more than a century of Southern Ocean research, numbers of molluscs have also increased remarkably (Brandt et al. 2007b). Megafaunal sponges recognized comprised 76 species, 37 of these were new for the SO and 17 new to science (Brandt et al. 2007b; Janussen and Tendal 2007). Species richness is highest for the peracarid

crustaceans, possibly because of the adaptive radiation of several species groups following the extinction of the decapod crustaceans. Some of the other taxa are also divers in other deep-sea areas. On a regional scale, diversity patterns vary strongly between major taxonomic clades (Clarke and Crame 2010).

Bathymetric and biogeographic trends varied among taxa depending on the mobility of the organisms and their reproductive mode. Particularly isopods are distinctive with many species presently unknown outside the SO (–90%). Among the most vagile janiroidean family Munnopsidae > 95% of the ANDEEP species are undescribed. This family comprised 50% of all isopods sampled during ANDEEP at 40 stations. Other important SO isopod families were the Desmosomatidae, the Haploniscidae and the Ischnomesidae. While we know that some species complexes have radiated in the deep SO (e.g. the Haploniscidae), it is unclear whether they have evolved here (and what the drivers of their evolution or potential radiation in the deep sea are) and subsequently spread into other ocean basins. The few known SO deep-sea isopod species show closest biogeographical links to Atlantic faunas. Many ostracod crustaceans are presently unknown outside the SO (Hartmann 1997), e.g. the ostracod family Macropyrididae was common in the SO material, but usually rare in deep-sea samples of other oceans. The majority (~75%) of mollusc species were also unknown outside the SO, and wide-ranging Atlantic deep-sea species, such as the gastropod *Benthonella tenella*, were not collected (Brandt et al. 2007b). Polychaetes of the families Spionidae, Paraonidae, and Cirratulidae are usually common and species-rich in deep-sea areas of temperate latitudes, but only represented by few species in the SO deep sea. Many nematode species are new in the SO and apparently confined to particular parts of the Weddell Sea (e.g. *Microlaimus*), although some have wider distributions. These biogeographic patterns may be linked to larval ecology. Poor dispersers such as isopods, ostracods and nematodes have a reduced gene flow with restricted species distributions and higher endemism (Brandt et al. 2007b).

Molecular biological studies revealed cryptic species in certain circumantarctic serolid isopods (Held 2003; Raupach et al. 2009) and the bivalve *Lissarca notocardensis* (Linse et al. 2007). On the one hand, the existence of such ‘species flocks’ in the deep-sea biota may be a more general feature than is currently assumed (e.g. Raupach et al. 2007), on the other, genetic analyses have also revealed the existence of true cosmopolitan species in some planktotrophic taxa (e.g. in polychaetes) and also peracarid brooders (Held pers. communication). The widely distributed SO isopod shelf “species” *Ceratoserolis trilobitoides* (Serolidae), and *Glyptonotus antarcticus* (Valvifera) have been shown to represent complexes of cryptic species (Held 2003). The same proved true for *Betamorphia fusiformis* (Munnopsidae) (Raupach et al. 2007) and *Acanthaspidia drygalskii* (Acanthaspidiidae) (Raupach and Wägele 2006). Other species probably belong to paraphyletic genera such as *Eurycope* (Wilson and Hessler 1987). *Serolis paradoxa* from Patagonia and the Falkland Islands do not show effective gene flow, suggesting that these are also two cryptic species, but *Septemserolis septemcarinata* occurring at different sub-Antarctic islands shows different patterns (Leese et al. 2008; Leese pers. comm.).

Compared to other deep-sea areas, the isopod family Munnopsidae is the most speciose in the SO with 219 species from 3 expeditions and only 40 stations. In the North Pacific or Atlantic deep sea, roughly 50 munnopsid species have been recognized after more than 100 years of deep-sea research (Malyutina and Brandt 2007). It is not known to date which processes drive speciation of this family in the SO deep sea. Stable isotope analyses have revealed that species of Munnopsidae can have completely different diets (Würzberg et al. 2011a, b). Niche partitioning by using different food items could support speciation of the Munnopsidae and might have lead to adaptive radiation of this family; one of their prey items are foraminiferans which are available in high quantity and diversity. Maybe this isopod family radiated in the SO deep sea (due to resource partitioning or dietary specialization) like the Darwin finches on the Galapagos islands?

2.4 Understanding Processes in the Southern Ocean Deep Sea

2.4.1 SYSTCO: From Census to Ecosystem Functioning

While the ANDEEP project has revealed patterns of biodiversity within different faunal groups and documented that these can vary significantly (Brandt et al. 2007), we still know very little about the ecology and the role of deep-sea faunas for trophodynamic coupling and nutrient cycling in oceanic ecosystems. It is still unknown why only few species occur at many stations and with higher abundances, but most species are rare. To fill this knowledge gap, a successor to the ANDEEP project, ANDEEP-SYSTCO (SYSTem COupling) has been started in the Atlantic sector of the Southern Ocean within the framework of the International Polar Year (IPY) with a first expedition ANT XXIV-2 staged from board of RV *Polarstern* between 28.11.2008 and 4.2.2009. This new project seeks to find answers for the questions posed from the biodiversity and biogeography patterns observed during the ANDEEP campaigns. ANDEEP-SYSTCO addresses the processes responsible for the strong differences in biodiversity within and between taxa as well as between areas. SYSTCO aims to investigate the functional biodiversity and the ecology of dominant abyssal species and examine the trophic structure and functioning of abyssal communities of the Atlantic sector of Southern Ocean, focusing on the role and feeding of the abundant key organisms. In the SYSTCO project scientists from a wide variety of disciplines collaborated in the SO in order to try to understand atmospheric-pelagic-benthic coupling processes and gain initial insights into the trophic structure of the SO deep-sea. A second SYSTCO II expedition is planned for 2012 in order to elaborate the first results into a better understanding of the processes and food-web structure.

During the SYSTCO I expedition one station in the polar front at 52°S at about 3,000 m depth was revisited after six weeks and sediment oxygen consumption measurements showed higher values after a phytoplankton bloom. Veith-Köhler et al. (2011) argue that this has been attributed to an enhanced respiratory activity

of the living benthic component. The authors assume that low temperatures and ecological strategies are the most important factors for the delayed response of benthic deep-sea copepods. It is worth mentioning that neither meiofauna nor bacteria responded with an increase in individual numbers to the food input from the water column.

Using a Surface and Under Ice Trawl, Flores et al. (2011) showed that in the Austral summer macrozooplankton biomass was dominated by ctenophores in open water and by Antarctic krill under the ice. These authors also emphasize the potential of a number of macro zooplankton and micronecton species to act as energy transmitters between productive sea-ice biota and the pelagic food web.

At Maud Rise (MR), the benthic fauna was investigated with reference to oceanographic features, biogeochemical properties and sediment characteristics, as well as the pelagic, benthic-pelagic and air-breathing fauna. The composition of the deep-sea fauna differed distinctly from surrounding deep-sea basins investigated during previous SO expeditions (ANDEEP) and the overall similarity between MR and adjacent stations was low. The taxon composition was characterised by extremely high abundances of *Vesicomya* spp. (Bivalvia), *Onoba subantarctica wilkesiana* (Gastropoda) and *Thylakogaster* spp. (Isopoda, Haplomunnidae). Members of the bivalve genus *Vesicomya*, characterized by non-reduced guts and no symbiotic chemoautotroph bacteria, have been reported (Krylova and Sahling 2010). Tube dwelling polychaetes occurring at Maud Rise were also not found at the comparison stations. Water-column sampling from the surface to the seafloor, including observations of top predators, indicated the existence of a prospering pelagic food web and local concentrations of top predators and zooplankton were associated with a rich ice-edge blooms located over the northern slope of MR, where the melting of the sea ice might be accelerated by the advection of warm water at intermediate depth. South of Maud Rise, high concentrations of *Euphausia superba* occurred under dense sea ice and attracted *Balaenoptera bonaerensis* and several seabird species. The biological prosperity over MR is likely related to oceanographic as well as sea-ice processes. Downward transport of the organic matter produced in the pelagic realm may be more constant than elsewhere due to low lateral drift over MR.

Investigations of the SO deep-sea food web performed using fatty-acid patterns of peracarid crustaceans revealed that some species feed on a wide variety of different food items including especially foraminiferans (Würzberg et al. 2011a, b), a potential reason why Munnopsidae (Isopoda) are so successful in the SO. Foraminiferans have also been found to play an important role in the diets of tanaidaceans, whereas the amphipods analysed seem to be carnivorous. In general, peracarid crustaceans fall into three dietary groups which are: Mainly phytodetritivore, mainly omnivore (with indications for foraminiferivory), or mainly carnivore. Antarctic demersal fish feed to a high percentage (50–80%) on amphipods, but also other fish, other crustaceans and gastropods (Würzberg et al. 2011a, b). Contrary to peracarid crustaceans, fatty acid analysis of fish indicates that all species except for the Channichthyidae have rather similar diets irrespective of their depth distribution; they mainly feed on benthic amphipods and polychaetes, except

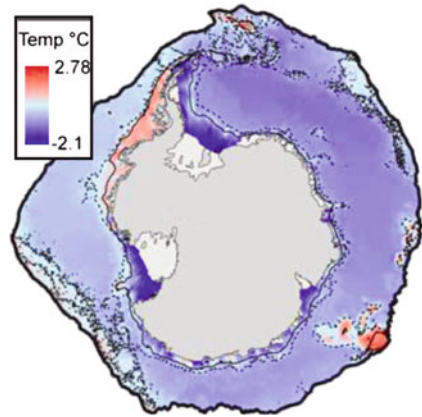
for younger (smaller) specimens which seem to feed primarily on zooplankton. Generally, the trophic position estimated based on $\delta^{15}\text{N}$ values reflects the assumed feeding habits of the organisms. Narrower trophic ranges compared to Arctic deep-sea systems (Iken et al. 2005) were established. Wide ranges in $\delta^{15}\text{N}$ ratios in most benthic taxa of Antarctic food webs indicate feeding across a range of trophic levels and are partly due to a high amount of omnivory (Würzberg et al. 2011a, b).

2.5 Climate Change

Acidification might become one of the largest problems for the long-term stability of the SO ecosystem, in both the pelagic and benthic realms. As a consequence of increasing atmospheric CO_2 most of the SO is expected to become undersaturated by 2,100 in both calcium carbonates, aragonite and calcite, the first being the major component of the skeleton of molluscs and corals, the latter of foraminiferans and coccolithophorids (Orr et al. 2005). The marine realm is at threat in the shallow as well as in deep water because at the sea surface it is directly exposed to increased CO_2 , and in deeper water layers saturation principally decreases with increasing pressure. Therefore, the deep sea is undersaturated as is most of the Antarctic shelf. The polar oceans are especially threatened because calcium carbonate saturation is positively correlated with temperature and the uptake of atmospheric CO_2 is above global average. Despite the lack of a general understanding of the ecological consequences for benthic systems, it is generally known that the problems for organisms to build up their skeletons is species-specific. While some suffer, e.g. sea urchins, some even seem to benefit, e.g. tunicates (Dupont and Thorndyke 2009). It has to be considered that such animals are extremely rare in the deep sea. However, on the shelf, echinoderms, hydrocorals and gorgonians will belong to the potentially threatened calcifying organisms. Finally, in the SO deep sea regional abyssal warming and acidification may not be detected for some time due to the buffering effect of the huge volume of water (Kaiser and Barnes 2008; Brandt and Gutt 2011).

Environments have changed continually throughout the Earth's history and the SO marine biota appear to have been remarkably resilient to major, sometimes rapid, temperature and ice changes in the past. For instance, despite the last Ice Age ending only ca. 11,000 years ago, the Antarctic shelf biota has recovered and is exceptionally rich across taxonomic levels (Clarke and Johnston 2003). Nevertheless, recent ecophysiological studies indicate that the strong stenothermy displayed by many Antarctic marine biota makes them vulnerable to ocean warming, as experimental exposure to higher temperatures results in the loss of critical physiological and behavioural functions (Peck et al. 2009). In an ecological context, anthropogenic or natural disturbance comprises temporal and spatial changes in a variety of environmental conditions over different scales, such as for example sea ice, ice scouring, anchor-ice formation, "drop stones", large-scale glacial or pack-ice melt due to temperature increase, sediment instability, CO_2 ,

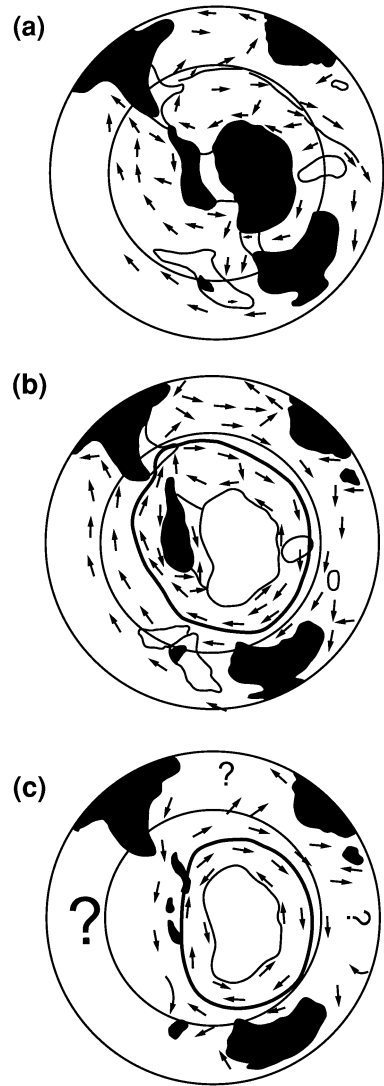
Fig. 2.2 Spatial distribution of bottom (seabed) potential temperatures around Antarctica (after Clarke et al. 2009)



UV-B radiation, and precipitation (Barnes and Conlan 2007). Critical for the SO can be sudden or prolonged temperature changes, and perhaps Milankovitch cyclicity (Clarke and Crame 2010). Amongst the most serious temperature effects of climate change the benthic fauna has to cope with are changes in the extent and quality of the ice sheet which might even lead to new sea-ways. Changes in ice-berg dynamics as well as fresh water flow causing temperature, salinity and stratification changes and near shore sedimentation will influence benthic communities. The potential biological responses are difficult to measure or anticipate because physiological experiments analyzing adaptation and macrophysiological processes are employed at rates of change 10–100,000 times faster than climatically induced oceanic changes (Peck et al. 2009). Changes will first impact molecular levels before determining individual and population fitness and species interactions (e.g. food-web structure) and ultimately influence fundamental ecosystem services such as biogeochemical carbon cycling. Whether the same sensitivity is present in their natural environment, or whether appropriate adaptive responses can occur over decadal to centennial timescales not available to experimenters, are important but as yet unanswered questions.

In the SO, the western Antarctic Peninsula is experiencing one of the fastest rates of regional climate change on Earth, resulting in the collapse of ice shelves, the retreat of glaciers and the exposure of new terrestrial habitat (Barnes and Peck 2008; Meredith and King 2005). Regional atmospheric warming of the Antarctic Peninsula area is linked to oceanographic changes, for example winter sea ice in the Bellingshausen and Amundsen seas has decreased in extent by 10% per decade, and shortened in seasonal duration. Surface waters have warmed by more than 1 K since the 1950s, and even the Circumpolar Deep Water of the Antarctic Circumpolar Current became warmer (Clarke et al. 2007). Clarke et al. (2009) showed a distinct latitudinal gradient in the difference between seabed temperatures on the shelf and in the deep sea. The deep sea is warmer (up to 2 K) at high latitudes and colder (by 2 K) around sub-Antarctic islands (Fig. 2.2). This impact or at least differences of regional climate change will likely have consequences for benthic

Fig. 2.3 Development of the circum- Antarctic current system; **a, b**: redrawn from Crame (1999); **c**: new image of one potential future scenario). **a** Late Eocene, (a) plate tectonics have isolated Antarctica, but shelf connections are present between Australia and Antarctica, West and East Antarctica and between South America and the Antarctic Peninsula. **b** Middle Miocene, East Antarctica is isolated and glaciated, a shallow water current system around East Antarctica separates East and West Antarctica. **c** Potential future scenario in 10 million years. Based on (b) current measurements (Antarctic Climate Report) and the fact that the West Antarctic Peninsula is rapidly warming while the eastern part of Antarctica is rapidly cooling (compare also geologic scenarios, e.g. Fox 2010; Jamieson et al. 2010) (c)



ecology and biogeography of the Antarctic marine biota. However, the complexity of the Southern Ocean food web and species' physiological adaptations as well as interactions make predictions of ecological responses to future changes impossible to date and we can only guess which species will migrate in or out of the SO, which ones will be able to adapt to the changing conditions or become extinct.

It is difficult to assess the influence of climate change on deep-sea ecosystems. Shelf communities will be affected in the immediate future and most likely influence deep-sea communities at a much later stage. Smith et al. (2008) have reviewed abyssal food limitation, ecosystem structure and climate change and emphasize the

importance of monitoring and modelling efforts. As abyssal food availability will also be driven by climate change, this influence will be especially dramatic in the SO deep sea because of the close coupling of the surface and deep-water layers due to deep-water production especially in the Weddell and Ross Seas (Fig. 2.3).

Based on recent measurements of temperature change one might have to wonder how Antarctica and the current system might develop in the long-term future (e.g. in 10 my). If the warming along the WAP continues and possibly increases and the temperature in the Ross and Weddell seas decrease or stay cold, then the area and islands of the Antarctic Peninsula could be free of sea ice and the Weddell and Ross Sea vanish. In fact, the glacial intensity could resemble that of Miocene times (10–14 my ago; Fox 2010; Jamieson et al. 2010). This in turn would shift and change the Circum Antarctic Current. Consequently, the deep-water production might occur circumantarctically and be less extensive than today and following these changes the world ocean circulation will be governed by different forces than today. If the knowledge of a temperate system during a glacial period could act as a case study for the future of the SO it can be expected that the retreat of the sea-ice in a period of warming and, consequently, a shift in the pelagic community would be mirrored on the sea floor sooner or later, e.g. as recorded in the ostracod and diatom composition (Cronin and Raymo 1997).

A problem with the impact assessment on deep-sea communities is that we do not know the drivers of biodiversity there and how these influence deep-sea assemblages (Kaiser and Barnes 2008).

It is therefore extremely important to study abyssal biodiversity and the key factors generating and maintaining it in order to generate a solid benchmark against which future change can be measured.

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