Polar Biol (2016) 39:761–764
DOI 10.1007/s00300-016-1937-7

EDITORIAL

High environmental variability and steep biological gradients in the waters off the northern Antarctic Peninsula: *Polarstern* expedition PS81 (ANT-XXIX/3)

Julian Gutt[1] · Bruno David[2,3] · Enrique Isla[4] · Dieter Piepenburg[5]

Received: 16 October 2015 / Revised: 22 March 2016 / Accepted: 23 March 2016 / Published online: 6 April 2016

The ocean off the northern Antarctic Peninsula is characterised by steep environmental gradients, if not discrete boundaries (Dorschel et al. 2015), as well as speciose benthic habitats (Griffiths 2010; De Broyer et al. 2014) and hotspots of biological productivity (Grange and Smith 2013). This region of the Southern Ocean (SO) attracts particular attention from scientists, decision-makers as well as the general public, because here the pace of atmospheric and oceanic climate change has been clearly above the global average over the past decades (Turner et al. 2014), and the local ecosystems are strongly affected by multiple stressors (Gutt et al. 2015a, b). Moreover, commercial bottom trawling disturbed the sea floor until it became prohibited in 1990, and whaling, sealing and exploitation of penguin and krill stocks modified the pelagic system in the twentieth century (Kock 1992; Knox 2007). In the austral summer (January–March) of 2013, this region was the target area of the cruise PS81 (ANT-XXIX/3) of the German research icebreaker *Polarstern* (for the PS81 cruise report, see Gutt 2013) (Figs. 1, 2 and 3).

During the cruise, Antarctic krill was investigated in the framework of a regular survey programme of the *Commission for the Conservation of Antarctic Marine Living Resources* (CCAMLR), and benthic ecosystems were studied applying an ecosystem-oriented multidisciplinary approach that integrated the analyses of a number of working groups and focussed on the overarching research question: *How does the variability of various environmental factors impact biological patterns and processes?* The project was developed to provide a sound basis for adequately addressing one of the scientific key issues identified in the *First SCAR Antarctic and Southern Ocean Horizon Scan* (Kennicutt et al. 2014) as being of highest priority for the next 20 years and beyond: How will threshold transitions vary over different spatial and temporal scales, and how will they impact ecosystem functioning under future environmental conditions? The project also contributed to the biology research programme *Antarctic Thresholds-Ecosystem Resilience and Adaptation* (AnT-ERA) of the *Scientific Committee on Antarctic Research* (SCAR), which addresses key questions (Gutt et al. 2013): (1) How do species traits impact community stability and key ecosystem processes? and (2) What are the

This article belongs to the special issue on "High environmental variability and steep biological gradients in the waters off the northern Antarctic Peninsula", coordinated by Julian Gutt, Bruno David and Enrique Isla

✉ Julian Gutt
julian.gutt@awi.de

Bruno David
bruno.david@u-bourgogne.fr

Enrique Isla
isla@icm.csic.es

Dieter Piepenburg
dieter.piepenburg@awi.de

[1] Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Am Alten Hafen 26, 27568 Bremerhaven, Germany

[2] UMR-CNRS 6282 Biogéosciences, Université de Bourgogne France-Comté, 6, boulevard Gabriel, 21000 Dijon, France

[3] Muséum national d'Histoire naturelle, 57 rue Cuvier, 75005 Paris, France

[4] Institut de Ciències del Mar, Passeig Maritim de la Barceloneta, 37-49, Barcelona, Spain

[5] Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Am Handelshafen 12, 27570 Bremerhaven, Germany

Fig. 1 Research icebreaker *Polarstern* in thick pack ice in the western Weddell Sea during expedition PS81 (ANT-XXIX/3), © J. Gutt

likely consequences of a changing environment for key ecosystem functions and services?

In the framework of the overarching aim to investigate complex biological structures and link these to environmental factors, a number of different subprojects were carried out during the cruise. Their scientific results were discussed in the wider context of the expedition's objectives during a post-expedition workshop hosted by the University of Burgundy in Dijon, France, in September 2014. Three case studies have already been published, one with an interdisciplinary approach focussing on a flat-topped hill on the the northwestern Weddell Sea shelf (Dorschel et al. 2014), a second one on the ecology and diversity of free-living benthic nematodes (Hauquier et al.

Fig. 2 Participants of *Polarstern* expedition PS81 (ANT-XXIX/3) in January–March 2013

Fig. 3 Participants of the post-expedition workshop in Dijon/France, in September 2014

2015) and a third one on physiological effects of ocean acidification (Collard et al. 2015).

Like during the former *Polarstern* cruise PS69 that investigated an adjacent study area in 2006/2007, the basic sampling strategy was to deploy the wide set of sampling equipment at a number of selected stations. Such an integrative sampling within a spatially well-defined area, called a core station, has provided results that are not only representative for one spot, but also for a range of habitats in a region several square kilometres in size. The strategy to comparatively investigate several of such core stations comprising a set of habitats predefined according to their bottom topography provided the basis for distinguishing between faunas associated with different habitat types independently of a specific site. Some of the observed benthic and sediment parameters could serve as a proxy for food supply to the sea floor and thus provide evidence for the strength of the pelagic-benthic coupling across environmental gradients.

For the ecological studies presented in this special issue, the environmental setting was of high relevance. Thus, comprehensive ship-based information on bathymetry, seabed morphology, sediment properties and water-mass characteristics as well as satellite data on chlorophyll-a and sea-ice patterns was published by Dorschel et al. (2015), van Caspel et al. (2015) and Huneke et al. (2016).

The fauna investigated during the PS81 cruise ranged from the meiofauna collected from multi-corer samples, with emphasis on benthic free-living nematodes and copepods, to large sponges caught by the Agassiz trawl, as well as from the pelagic key organism krill surveyed within the regular CCAMLR survey to whales observed and counted along helicopter transects. A special focus among benthic systematic groups was on sponges (Berne et al. 2015; Kersken et al. 2016), amphipods (Verheye et al. 2016) and echinoderms (David et al. 2015; Ambroso et al. 2016). For echinoids, a shift in food preference with changing environmental conditions was studied (Michel et al. 2015). Not only organism-based aspects were investigated, but also ecological and sediment processes, including interactions between biota and biogeochemical factors (Isla 2015). The study on the spatial ecology of ascidians, which are assumed to be especially sensitive to environmental change (Segelken-Voigt et al. 2016), was based on seabed images, which are publicly available in the data repository PANGAEA (www.pangaea.de). An analysis of macrobenthic communities and their diversity was based on subsamples taken from Agassiz trawl catches (Gutt et al. 2015a, b). Interestingly, the most obvious large-scale macrobenthic distribution patterns separating the Drake Passage from the Bransfield Strait and the Weddell Sea resemble very much the composition patterns of whales (Herr et al. 2016), which utilise a different part of the SO ecosystem but are obviously directly or indirectly affected by the same set of environmental drivers.

The faunistic and environmental primary data collected during the PS81 cruise were uploaded to data repositories, e.g., ANTABIF (www.biodiversity.aq) or PANGAEA, to contribute to a more complete image of global and regional marine biodiversity and to a better understanding of marine ecosystem functioning. The results published in this special issue will provide a sound baseline to assess and predict the impact of ongoing and future environmental change in the sensitive marine ecosystems off the northern Antarctic Peninsula, where the pace of change is faster than elsewhere in the world ocean.

References

Ambroso S, Böhmer A, López-González P, Teixidó N (2016) Ophiuroid biodiversity patterns along the Antarctic Peninsula. Polar Biol. doi:10.1007/s00300-016-1911-4

Berne S, Kalauz M, Lapat M, Savin L, Janussen D, Kersken D, Avguštin JA, Jokhadar ŠZ, Jaklič D, Gunde-Cimerman Lunder M, Roškar I, Eleršek T, Turk T, Sepičić K (2015) Polar Biol. doi:10.1007/s00300-015-1835-4

Collard M, De Ridder C, David B, Dehairs F, Dubois P (2015) Could the acid-base status of Antarctic sea urchins indicate a better-than-expected resilience to near-future ocean acidification? Glob Change Biol 21:605–617. doi:10.1111/gcb.12735

David B, Saucède T, Chenuil A, Steinmetz E, De Ridder C (2015) A cryptic species complex finally detected in Antarctic echinoids? The taxonomic challenge posed by *Abatus bidens* and *Abatus cavernosus* (Schizasteridae, Echinoidea). Polar Biol. doi:10.1007/s00300-015-1842-5

De Broyer C, Koubbi P, Griffiths HJ, Raymond B, d'Udekem d'Acoz C, Van de Putte AP, Danis B, David B, Grant S, Gutt J, Held C, Hosie G, Huettmann F, Post A, Ropert-Coudert Y (2014) Biogeographic atlas of the southern ocean. SCAR and Scott Polar Reserach Institute, Cambridge

Dorschel B, Gutt J, Piepenburg D, Schröder M, Arndt J-E (2014) The influence of the geo-morphological and sedimentological settings on the distribution of epibenthic assemblages on a flat topped hill on the over-deepened shelf of the western Weddell Sea. Biogeosciences 11:3797–3817

Dorschel B, Gutt J, Huhn O, Bracher A, Huntemann M, Huneke W, Gebhardt C, Schröder M, Herr H (2015) Environmental information for a marine ecosystem approach for the northern Antarctic Peninsula (RV Polarstern expedition PS81, ANT-XXIX/3). Polar Biol. doi:10.1007/s00300-015-1861-2

Grange L, Smith CR (2013) Megafaunal communities in rapidly warming fjords along the West Antarctic Peninsula: hotspots of abundance and beta diversity. PLoS One 8:e77917. doi:10.1371/journal.pone.0077917

Griffiths HJ (2010) Antarctic marine biodiversity—what do we know about the distribution of life in the Southern Ocean. PLoS One 5(8):e11683. doi:10.1371/journal.pone.0011683

Gutt J (2013) The expedition of the research vessel "Polarstern" to the Antarctic in 2013 (ANT-XXIX/3). Ber Polarforsch Meeresforsch 665:1–150

Gutt J, Adams B, Bracegirdle T, Cowan D, Cummings V, di Prisco G, Gradinger R, Isla E, McIntyre T, Murphy E, Peck L, Schloss I, Smith C, Suckling C, Takahashi A, Verde C, Wall DH, Xavier J

(2013) Antarctic thresholds-Ecosystem resilience and adaptation a new SCAR-biology programme. Polarforschung 82:147–150

Gutt J, Bertler N, Bracegirdle TJ, Buschmann A, Comiso J, Hosie G, Isla E, Schloss IR, Smith CR, Tournadre J, Xavier JC (2015a) The southern ocean ecosystem under multiple climate stresses—an integrated circumpolar assessment. Glob Change Biol 21:1434–1453. doi:10.1111/gcb.12794

Gutt J, Alvaro MC, Barco A, Böhmer A, Bracher A, David B, De Ridder C, Dorschel B, Eléaume M, Janussen D, Kersken D, López-González PJ, Martínez-Baraldés I, Schröder M, Segelken-Voigt A, Teixidó N (2015b) Macro-epibenthic communities at the tip of the Antarctic Peninsula, an ecological survey at different spatial scales. Polar Biol. doi:10.1007/s00300-015-1797-6

Hauquier F, Durán Suja L, Gutt J, Veit-Köhler G, Vanreusel A (2015) Different oceanographic regimes in the vicinity of the Antarctic Peninsula reflected in benthic nematode communities. PLoS One 10:e0137527. doi:10.1371/journal.pone.0137527

Herr H, Viquerat S, Siegel V, Kock K-H, Dorschel B, Huneke WGC, Bracher A, Schröder M, Gutt J (2016) Model based humpback, fin whale and krill distribution—results of a snapshot study from the West Antarctic Peninsula. Polar Biol. doi:10.1007/s00300-016-1927-9

Huneke WGC, Huhn O, Schröder M (2016) Water masses in the Bransfield Strait and adjacent seas, austral summer 2013. Polar Biol. doi:10.1007/s00300-016-1936-8

Isla E (2015) Organic carbon and biogenic silica in marine sediments in the vicinities of the Antarctic Peninsula: spatial patterns across a climatic gradient. Polar Biol. doi:10.1007/s00300-015-1833-6

Kennicutt MC II, Chown SL, Cassano JJ, Liggett D, Massom R, Peck LS, Massom R, Rintoul SR, Storey J, Vaughan DG, Wilson TJ, Allison I, Ayton J, Badhe R, Baeseman J, Barrett PJ, Bell RE, Bertler N, Bo S, Brandt A, Bromwich D, Cary SC, Clark MS, Convey P, Costa ES, Cowan D, DeConto R, Dunbar R, Elfring C, Escutia C, Francis J, Fricker HA, Fukuchi M, Gilbert N, Gutt J, Havermans C, Hik D, Hosie G, Jones C, Kim YD, Le Mahon Y, Lee SH, Leppe M, Leychenkov G, Li X, Lipenkov V, Lochte K, López-Martínez J, Lüdecke C, Lyons W, Marenssi S, Miller H, Morozova P, Naish T, Nayak S, Ravindra R, Retamales J, Ricci CA, Rogan-Finnemore M, Ropert-Coudert Y, Samah AA, Sanson L, Scambos T, Schloss IR, Shiraishi K, Siegert MJ, Simões JC, Storey B, Sparrow MD, Wall DH, Walsh JC, Wilson G, Winther JG, Xavier JC, Yang H, Sutherland WJ (2014) A roadmap for Antarctic and Southern Ocean science for the next two decades and beyond. Antarct Sci 27:3–18. doi:10.1017/S0954102014000674

Kersken D, Feldmeyer B, Janussen D (2016) Sponge communities of the Antarctic Peninsula: influence of environmental variables on species composition and richness. Polar Biol. doi:10.1007/s00300-015-1875-9

Knox GA (2007) Biology of the southern ocean, 2nd edn. CRC Press, Boca Raton

Kock K-H (1992) Antarctic fish and fisheries. Cambridge University Press, Cambridge

Michel LN, David B, Dubois P, Lepoint G, De Ridder C (2015) Trophic plasticity of Antarctic echinoids under contrasted environmental conditions. Polar Biol. doi:10.1007/s00300-015-1873-y

Segelken-Voigt A, Bracher A, Dorschel B, Gutt J, Huneke W, Link H, Piepenburg D (2016) Spatial distribution patterns of ascidians (Ascidiacea: Tunicata) on the continental shelves off the northern Antarctic Peninsula. Polar Biol. doi:10.1007/s00300-016-1909-y

Turner J, Barrand NE, Bracegirdle TJ, Convey P, Hodgson D, Jarvis M, Jenkins A, Marshall G, Meredith MP, Roscoe H, Shanklin J, French J, Goosse H, Gutt J, Jacobs S, Kennicutt MC II, Masson-Delmotte V, Mayewski P, Navarro F, Robinson S, Scambos T, Sparrow M, Summerhayes C, Speer K, Klepikov A (2014) Antarctic climate change and the environment: an update. Polar Rec 50:237–259

van Caspel M, Schröder M, Huhn O, Hellmer HH (2015) Precursors of Antarctic Bottom Water formed on the continental shelf off Larsen Ice Shelf. Deep Sea Res I 99:1–9

Verheye ML, Backeljau T, d'Udekem d'Acoz C (2016) Looking beneath the tip of the iceberg: diversification of the genus *Epimeria* on the Antarctic shelf (Crustacea, Amphipoda). Polar Biol. doi:10.1007/s00300-016-1910-5