

Book Review

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Biogeographic Atlas of the Southern Ocean

Edited by Claude de Broyer and Phillippe Koubbi
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The *Biogeographic Atlas of the Southern Ocean* is a milestone product of 21st century Antarctic Science. During the last quarter of the 20th century, ecology became dominated by hypothesis-driven science and the labour-intensive systematic accumulation of environmental and taxonomic/distributional data became unfashionable and difficult to fund; just at the time when knowledge of biodiversity and environmental shifts became crucial to our understanding of climate change and its present and likely future impacts. Thankfully the last two decades have seen a reversal of this short-sighted policy, notably by virtue of the 10 year Census of Marine Life, a US\$650 million global programme initiated by the Alfred P. Sloan Foundation of New York in 2000. The whole Census occupied around 2700 scientists from 80 countries. The Census of Antarctic Marine Life (CAML) was a subset of the global programme and centred upon fieldwork and associated meetings and symposia that mostly took place during the third International Polar Year (IPY: 2007–09). The *Biogeographic Atlas* is effectively a summary document of the results and their analysis. It represents over one million records of around 9000 species ranging from phytoplankton to marine birds and mammals. The Scientific Committee on Antarctic Research Marine Biodiversity Information Network (SCAR-MarBin) archived and provided access to data, thus facilitating the use of standard survey and analysis protocols.

The volume has 165 direct contributors drawn from all continents; their expertise encompasses taxonomy, biogeography, ecology, molecular genetics, informatics, GIS and mathematical modelling. Their efforts have been augmented by numerous data providers and a host of reviewers who have helped provide excellent quality control. The weighty (3.2 kg, 28 × 37 × 3 cm!) paperback tome is subdivided into 12 parts and 64 separate chapters, most of which are reviews of survey findings and their relationship to the literature and development of the relevant fields. Each chapter is accompanied by a comprehensive reference list. These lists reveal that hundreds of scientific papers have already stemmed from the CAML and IPY, and that numerous interactive

websites have been constructed. Therefore, they represent a most valuable resource for researchers. Throughout, the large glossy page format and small print combine to pack huge amounts of information into the volume's 498 pages.

Part 1 (Introduction) provides a cogent history of Antarctic marine biodiversity initiatives from the late 18th century onwards, together with a summarization of the literature devoted to the variety of biogeographic schemes that have been proposed or adopted since the late 19th century. The introduction also outlines the events and funding sources that led to the production of the *Biogeographic Atlas*, emphasizing the multinational nature of the enterprise.

Part 2 (Methods) I found rather perfunctory and unsatisfying. It tells us little of data collection, but gives good accounts of standardization of data mapping, data gap analysis and distribution modelling. All of this is written in the form of research papers and I am dubious of its accessibility to a varied readership.

Parts 3 (Evolutionary setting) and 4 (Environmental setting) are much more impressive and readable. Part 3 is made up of two chapters, the first of which is an interesting and highly detailed four-page paper highlighting advances in knowledge of Antarctic marine species richness and understanding of the evolutionary history of Antarctic marine faunas. The second chapter provides an excellent update of present knowledge of plate tectonic reconstructions of the Southern Ocean and Antarctic regions. Part 4 consists of a single 18-page chapter that reviews current knowledge of Antarctic bathymetry, oceanography, geomorphology, sediments and sea ice; all of which impinge upon biodiversity and distributions.

Part 5 (Biogeographic patterns of the benthos) is the first of four sections that make up the 'meat' of the *Atlas*. It starts with a series of 27 chapters that are each devoted to a particular benthic macroalgal or animal group (e.g. Foraminifera, Cnidaria, Harpacticoida, Bivalvia, etc.). There is a standard physical format where taxon distributions are presented on South Pole centred stereographic projections. The production quality of these, and associated figures, tables and photographs, is excellent. Individual chapter length is variable, with poorly studied groups being represented by a few text pages and distributional maps, whereas well studied groups (e.g. amphipods, molluscs) yield rich and lengthy reviews. These are succeeded by four more general contributions. The first of these is a too-short summary of a feasibility exercise introducing a novel approach to the identification and classification of benthic assemblages. It is also something of an acronym feast, though that criticism can be levelled

at the whole volume, which cries out for a glossary. The second is a more useful summary of Southern Ocean deep sea biodiversity and biogeography, while I found the next (Chemosynthetic communities) a fascinating and erudite account of communities associated with a variety of vents, seeps and whale falls that rely on local carbon fixation. It is clear that this aspect of Antarctic marine biology is at an early stage, but the authors provide a detailed and readable account, particularly of the likely evolutionary history of these communities. Part 5 ends with a short and somewhat unsatisfying chapter devoted to predatory, commensal and parasitic biotic interactions.

Part 6 (Biogeographic patterns of pelagic and sea-ice biota) opens with a review of biodiversity in tintinnid ciliates. This is based upon more than a century's painstaking sampling and microscopy. It is followed by a fascinating chapter on the utility of remote-sensing, satellite-based ocean colour assessment that currently allows reliable separation of five dominant phytoplankton groups. This juxtapositioning highlights the enormous range of technologies that now contribute to Antarctic bioscience. The rest of Part 6 consists of further chapters devoted to specific groups: gelatinous zooplankton, pteropod gastropod molluscs, squid, copepods, hyperiid amphipods, euphausiids and sea-ice metazoans. I was particularly drawn to the chapter on 13 species of euphausiids ('krill'). This draws on data provided by 11 world-wide institutes to identify 'suitability habitats' for each species (and life history stage within species) to predict probable future biogeographical distributions. This involves high level distributional modelling techniques and showcases the scope of scientific co-operation, computing power and statistical analysis available in the 21st century.

Part 7 (Biogeographic patterns of fish) is a 32-page single chapter written by 17 authors who were aided by 18 extra data providers. It is authoritative, up-to-date and highly detailed. Antarctic fish biogeography has been studied for 180 years and the cumulative known species total (currently around 350) still rises exponentially. Use of ever more powerful ship-based technologies, supplemented by remotely operated vehicles, combines with molecular tools that can elucidate phylogenies as well as reveal cryptic species to uncover a much richer diversity of ichthyofauna than generally recognized. The review is also useful as it clarifies the recent revision of the taxonomy of the dominant group of nototheniid fish. The illustrations are excellent and the detailed knowledge of the palaeoclimatological and evolutionary influences on the make-up of the Antarctic ichthyofauna shine through in this great piece of scholarship.

The single-chapter Part 8 (Biogeographic patterns of birds and mammals) considers flying birds, penguins, pinnipeds and cetaceans in an unusual manner; it relies

mainly on at-sea sightings data rather than using the wealth of available data from nesting (birds) and haulout sites (pinnipeds) or satellite-tracking data. This allows comparability with the rest of the *Atlas* and keeps the chapter down to a manageable size (21 pages). It gives a wealth of detail about the ecology of these animals, especially their trophic biology. It is very readable, as well as delivering many interesting nuggets of information about less well-known species.

Parts 9 (Changes and conservation in the Southern Ocean) and 10 (Patterns and processes of Southern Ocean biogeography) in many ways form the least satisfactory large sections of the *Atlas*. Their structures are not especially coherent and the chapters that make them up are generally much too short for their wide-ranging titles. I felt that oceanic acidification was underestimated as a factor in future scenarios (Part 9), while some chapters in Part 10 (e.g. Benthic regional classification and Pelagic regional classification) would surely have been better positioned much earlier in the volume and generally had little relationship to each other. However, Chapter 9.3 (Assessing status and change in Southern Ocean ecosystems) was an excellent summary of the holistic changes that have been monitored in the Southern Ocean, plus recommended focuses for future monitoring and integration of climatic and ecosystem information. Finally, I enjoyed Chapter 10.4 (Bipolarity), a nice summary of the current understanding of bipolar species' distributions and their likely evolutionary history.

The *Atlas* ends with two short parts. Part 11 is a two-page vision of how it is hoped (in principle and technically) that the *Biogeographic Atlas of the Southern Ocean* will develop as a dynamic on-line entity (BASO) that will ensure that the hardcopy version reviewed here becomes expanded and continually updated in the future (see <http://atlas.biodiversity.aq>). Part 12 is a short summary of the approach adopted in the decade-long gestation of the volume, plus its broad conclusions; it is well written and beautifully referenced. There is an erratum listing already posted on <http://atlas.biodiversity.aq/errata.html>.

Overall then, a substantial tour-de-force, with a few flaws that no doubt stem from the admirable speed with which this book has been produced, plus the increasing unwillingness of scientists to display their most exciting research findings in a forum other than high-impact research journals. Necessarily the market for this book is limited, but it is a landmark reference volume that should be in the libraries of all marine institutes and every university that teaches and researches life and environmental sciences. It is an excellent showcase of the value of modern scientific power combined with co-operative and altruistic endeavour.

JOHN DAVENPORT