Census of Antarctic Marine Life
SCAR-Marine Biodiversity Information Network

BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN

▶ CHAPTER 5.20. SOUTHERN OCEAN CUMACEA.

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THE BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN

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5.20. Southern Ocean Cumacea

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1. Introduction

Cumacea (Peracarida, Crustacea) are mainly marine benthic animals inhabiting all depths of the World Ocean. As in all Peracarida, their offspring develop in the female's brood pouch (marsupium), without free larval stages. Adult males move into the water column during circadial migrations, whereas females leave the bottom only during mating. Consequently, the active and passive range of their dispersal is very limited; adults are thought to disperse by swimming short distances. Hence, the order Cumacea represents a good model to test hypotheses concerning biogeography and speciation.

The size of cumaceans generally ranges between 2 and 20 mm; the largest species known is *Diastylis goodsiri* (35 mm) from Arctic waters. Although gigantism has been reported for other peracarid orders (i.e. Antarctic isopods, amphipods) as well as for other invertebrates (e.g. pycnogonids, echinoderms, sponges), it has not been observed in Southern Ocean cumacean species. However, in most cases, cold-water cumaceans are larger than their tropical congeners. Most cumaceans spent their lives buried in the sediment and feed on detritus or small organisms like diatoms; however, some groups are supposed to be scavengers or suspension feeders.

Photo 1 *Leucon* (*Crymoleucon*) *intermedius* Mühlenhardt-Siegel, 1996, female, habitus. Image: U. Mühlenhardt-Siegel © Zoologisches Museum, Hamburg.

2. Diversity in the Southern Ocean

Eight families of Cumacea are known to be distributed worldwide and members of all these families are represented in the Southern Ocean (SO s.l.):
- Family Pseudocumatidae: 1 species off the Kerguelen Islands out of 35 species worldwide (3%);
- Family Ceratocumatidae: 1 species off the Kerguelen Islands and west of the Antarctic Peninsula (unpubl.) out of 12 species worldwide (8%);
- Family Gynodiastylidae: 1 species in the Ross Sea out of 105 species worldwide (1%);
- Family Bodotriidae: 9 out of 388 species worldwide (2%);
- Family Lampropidae: 12 out of 118 worldwide (10%);
- Family Nannastacidae: 19 out of 466 species worldwide (4%);
- Family Diastylidae: 20 out of 336 species worldwide (6%);
- Family Leuconidae: 30 out of 166 species worldwide (18%).

Since past benthic sampling efforts were mainly concentrated in the Antarctic shelf region, very little information was available concerning the fauna from continental slope and abyssal depths.
Only during the last decade, the deeper parts of the sea floor beyond the shelf areas have been investigated (Corbera 2000, Mühlenhardt-Siegel 2011a, b). Since the deep-sea floor at great depths is characterised by a low productivity and low structural diversity, its biodiversity was assumed to be equally low. Surprisingly, investigations on cumacean species richness in the Angola Basin resulted in an astonishingly high number of new species (42 new species or 57% for the region; Mühlenhardt-Siegel 2005a–e). For the SO, a comparable amount of unknown species was expected.

Ninety-three cumacean species are currently known from Antarctic regions (Mühlenhardt-Siegel 2011a, b), including newly described species

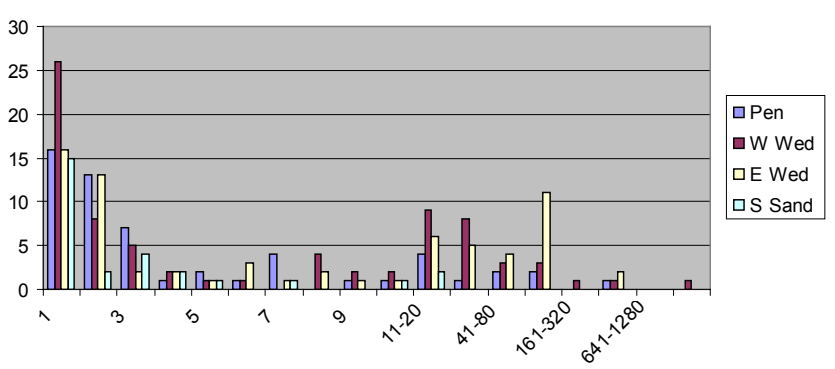
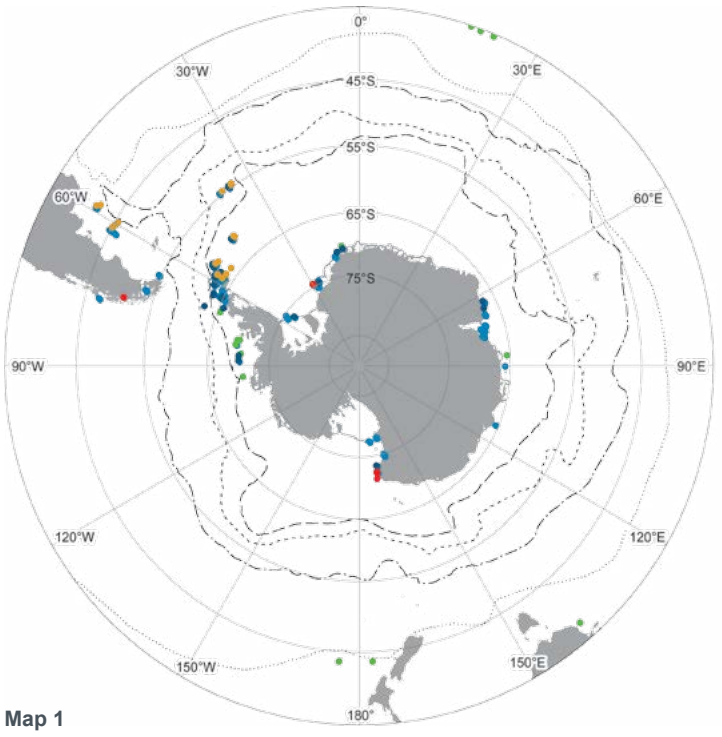


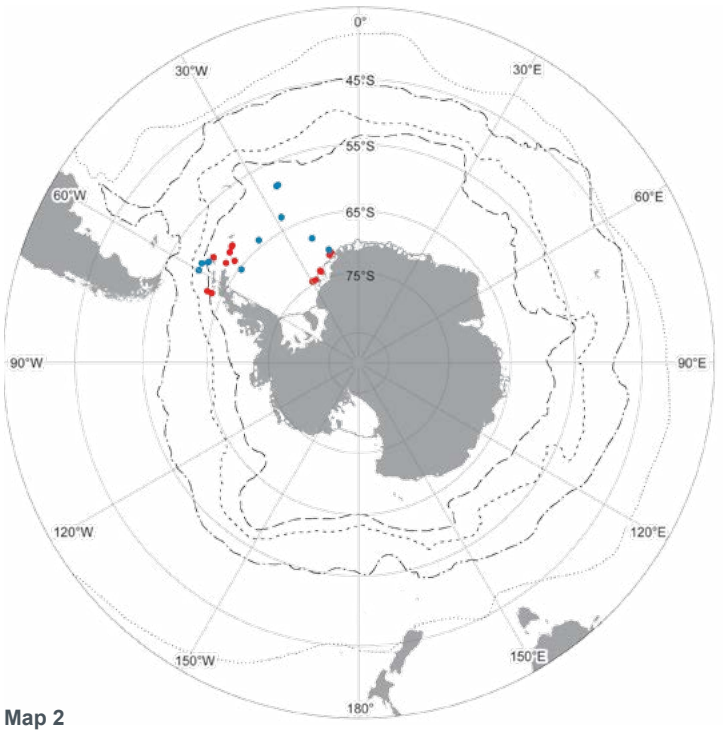
Figure 1 Cumacean species number (y-axis) against number of individuals sampled per species (x-axis) in the Southern Ocean deep sea (data obtained during the ANDEEP expeditions). Pen: Antarctic Peninsula region; W Wed: western Weddell Sea; E Wed: eastern Weddell Sea; S Sand: South Sandwich Trench.

Table 1 Depth distribution of the Southern Ocean Cumacea (number of species per genus).

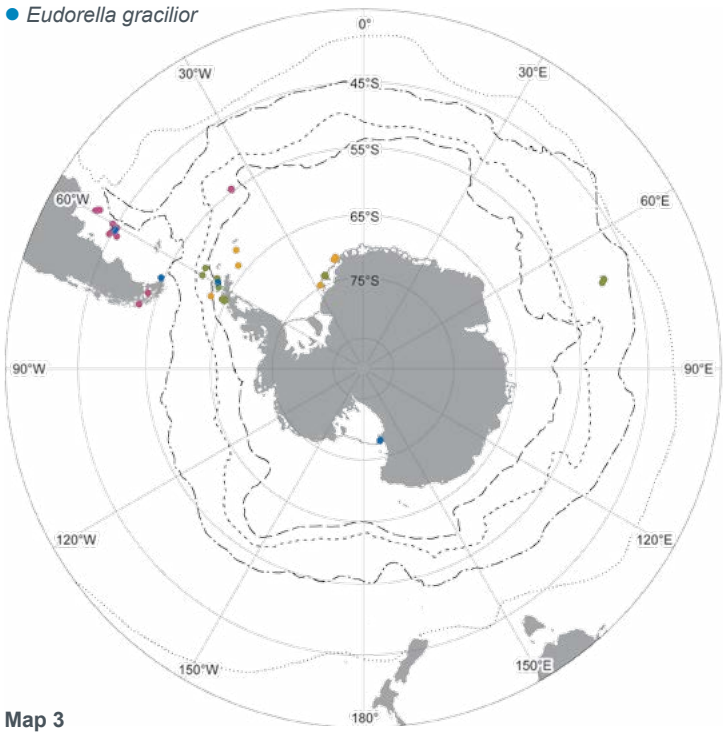
Family	Genus	shelf	slope	deep sea	eurybath	deep eurybath
		(0–1000m)	(1000–3000 m)	(>3000 m)	(0– >3000 m)	(1000– >3000 m)
Lampropidae	*Hemilamprops*	2		1	2	
Lampropidae	*Lamprops*			1		
Lampropidae	*Paralamprops*	5				
Lampropidae	*Platysympus*	1				
Bodotriidae	*Bathycuma*	1				
Bodotriidae	*Cyclaspis*	4				
Bodotriidae	*Gaussicuma*			1		
Bodotriidae	*Vaunthompsonia*	3				
Leuconidae	*Bytholeucon*					1
Leuconidae	*Eudorella*	5				1
Leuconidae	*Leucon*	10	1	1	5	5
Nannastacidae	*Atlantocuma*	1		1		
Nannastac+idae	*Campylaspis*	7			5	
Nannastacidae	*Cumella*	3			1	
Nannastacidae	*Procampylaspis*	4				
Nannastacidae	*Schizocuma*	1				
Diastylidae	*Diastylis*	6	1			2
Diastylidae	*Diastylopsis*	3				
Diastylidae	*Ekleptostylis*	3				
Diastylidae	*Holostylis*	1		1		
Diastylidae	*Leptostylis*	3				
Diastylidae	*Makrokylindrus*	1	1			
Pseudocumatidae	*Kerguelenica*	1				
Gynodiastylidae	*Gynodiastylis*	1				
Ceratocumatidae	*Cimmerius*	1				



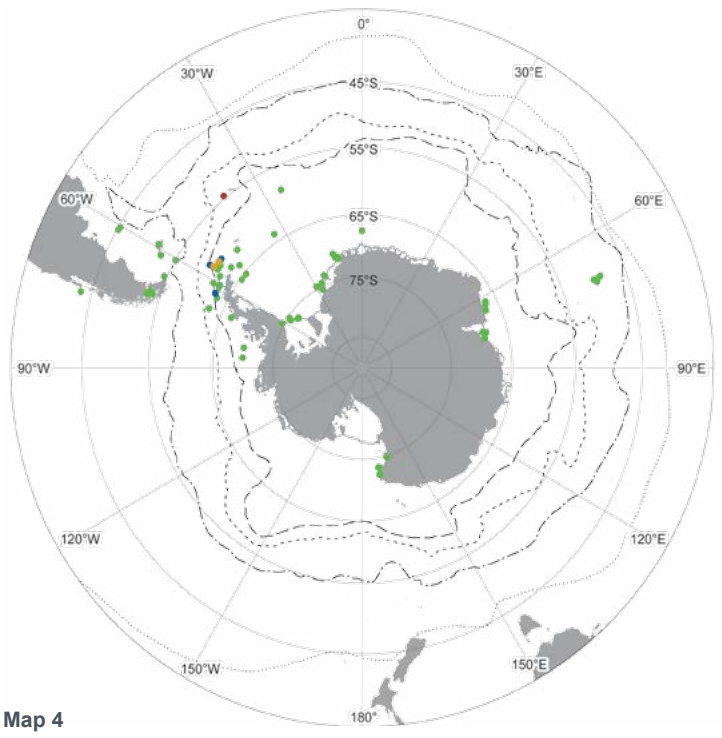
Map 1
- *Campylaspis maculata*
- *Eudorella fallax*
- *Eudorella gracilior*
- *Hemilamprops pellucidus*
- *Hemilamprops ultimaespei*



Map 2
- *Bytholeucon hartmannorum*
- *Leucon* (*Alytoleucon*) *polarsterni*



Map 3
- *Eudorella splendida*
- *Eudorella flokkeri*
- *Eudorella similis*
- *Eudorella sordida*



Map 4
- *Leucon* (*Leucon*) *adelae*
- *Leucon* (*Leucon*) *andeep*
- *Leucon* (*Leucon*) *assimilis*
- *Leucon* (*Leucon*) *quattuormulierum*

Cumacea Maps 1–4 Map 1. Antarctic cumacean species with a wide distribution: *Campylaspis maculata* Zimmer, 1907, *Eudorella fallax* Zimmer, 1909, *E. gracilior* Zimmer, 1907, *Hemilamprops pellucidus* Zimmer, 1908, *H. ultimaespei* Zimmer, 1921. Map 2. Distribution of Antarctic species of the genera *Bytholeucon* and *Leucon* (*Alytoleucon*): *B. hartmannorum* Mühlenhardt-Siegel, 2011 and *L.* (*A.*) *polarsterni* Ledoyer, 1993. Map 3. Distribution of Antarctic *Eudorella* species: *E. splendida* Zimmer, 1902, *E. flokkeri* Mühlenhardt-Siegel, 2011, *E. similis* Calman, 1907, *E. sordida* Zimmer, 1907. Map 4. Distribution of Antarctic *Leucon* (*Leucon*) species: *L.* (*L.*) *adelae* Petrescu, 1991, *L.* (*L.*) *andeep* Mühlenhardt-Siegel, 2011, *L.* (*L.*) *assimilis* Sars, 1886, *L.* (*L.*) *quattuormulierum* Mühlenhardt-Siegel, 2011.

from the SO deep sea. Most of these species are endemic to Antarctic waters.

It has to be noted that most of the species were singletons, i.e. only sampled as single specimens or at single stations in the deep sea (Fig. 1).

This might be explained by a low density combined with a patchy distribution, rendering the biogeographic interpretation less evident.

Under the assumption that species that are spatially represented by few specimens, are characterised by a limited distributional range within the SO, the high cumacean endemism rate of 80% (Mühlenhardt-Siegel 2011b) is not a surprising result. Indeed, the rate of species-level endemism is high (22 to 26%) within the better investigated regions i.e. the Antarctic Peninsula, the western and eastern Weddell Sea (Mühlenhardt-Siegel 2011b). Furthermore, the majority of Antarctic cumacean species characterised by a more widespread distribution yet are restricted to the SO deep sea. These widespread Antarctic species are represented in Map 1.

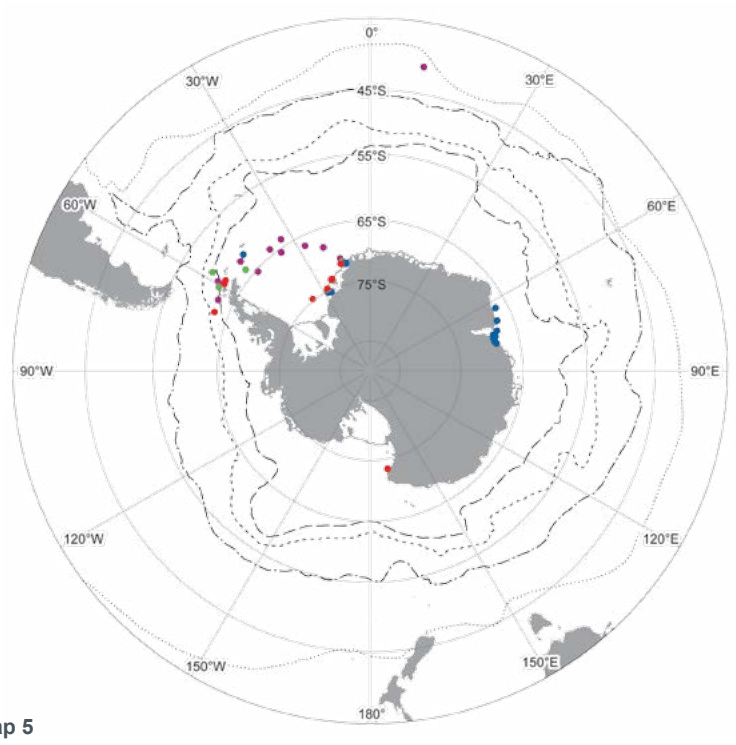
The comparison of the species richness for both polar regions indicates a slightly lower number of 98 cumacean species described for the SO, compared to 115 species for the Arctic region (including the Sea of Okhotsk and the Bering Sea). However, the endemism rate in the SO is of 80% whilst that of the Arctic is only of 16%. This can be explained by the fact that many more species from temperate waters invade northern polar waters from the south, being responsible for the high number of observed species.This leads us to another question: are there bipolar species?

From the published literature records, only two almost cosmopolitan species are known: *Eudorella fallax* and *E. gracilior* (see Map 1). Both species are known from Antarctic and Magellan regions and additional findings report their potential occurrence in Panama and Newfoundland or Nova Scotia waters, respectively (Petrescu 1991), an interesting finding that needs confirmation.

Many cumacean species cover a wide depth range. This might have facilitated submergence events of some cold water adapted species in the past, which might have submerged into the deep sea and emerged in warmer tropical surface waters. However, Zimmer (1940) already stated that the number of bipolar taxa considerably decreases and several cases have been rejected when investigating the morphology of specimens from distant sampling sites. Finally, little evidence exists for cosmopolitism among Cumacea species.

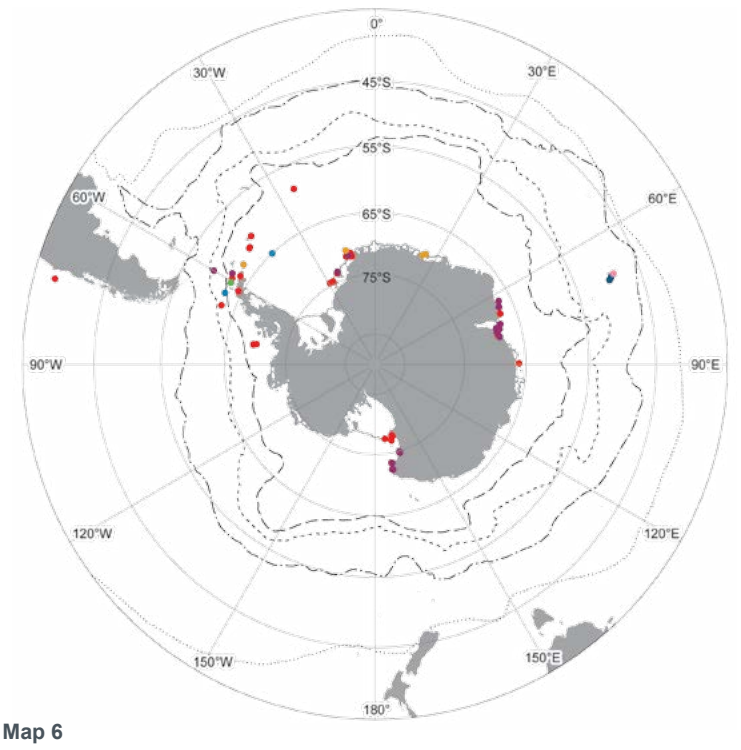
3. Depth distribution of Cumacea in the SO

From the 98 cumacean species of Antarctic and sub-Antarctic waters, 66 species (67%) are found in depth zones between 1 and 900 m. This zone represents more or less the shelf and upper slope area, since the continental slope in Antarctic regions starts much deeper than elsewhere in the world (at 500 to 900 m depth) due to the pressure of the continental ice masses.



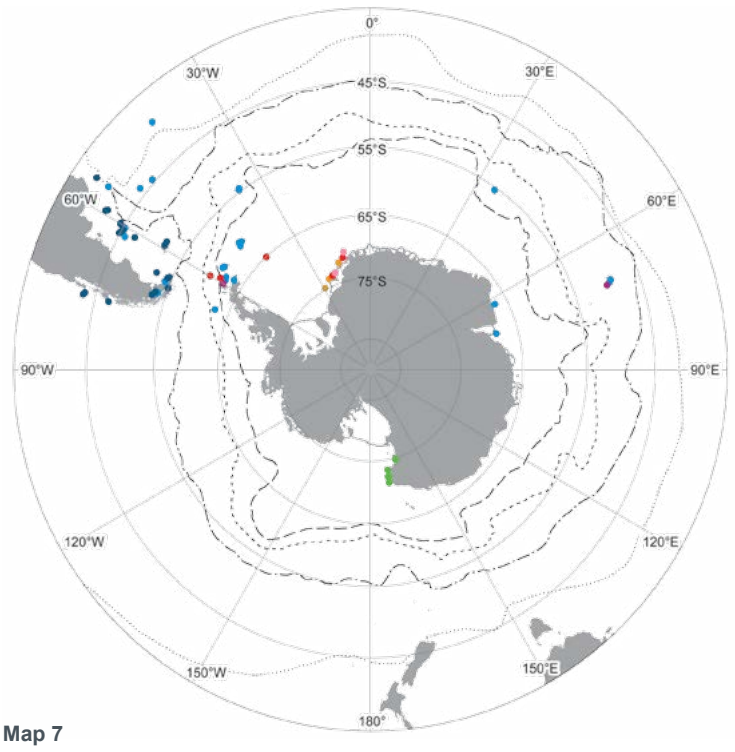
Map 5

- *Leucon* (*Macrauloleucon*) *complexus*
- *Leucon* (*Macrauloleucon*) *parasiphonatus*
- *Leucon* (*Macrauloleucon*) *weddelli*
- *Leucon* (*Macrauloleucon*) *weigmanni*



Map 6

- *Leucon* (*Crymoleucon*) *antarcticus*
- *Leucon* (*Crymoleucon*) *breidensis*
- *Leucon* (*Crymoleucon*) *costatus*
- *Leucon* (*Crymoleucon*) *grandidentatus*
- *Leucon* (*Crymoleucon*) *inexcavatus*
- *Leucon* (*Crymoleucon*) *intermedius*
- *Leucon* (*Crymoleucon*) *kerguelenensis*



Map 7

- *Leucon* (*Crymoleucon*) *longirhinus*
- *Leucon* (*Crymoleucon*) *parantarcticus*
- *Leucon* (*Crymoleucon*) *rossi*
- *Leucon* (*Crymoleucon*) *sagitta*
- *Leucon* (*Crymoleucon*) *septemdentatus*
- *Leucon* (*Crymoleucon*) *vanhoeffeni*
- *Leucon* (*Crymoleucon*) *weddellensis*

Cumacea Maps 5–7 Map 5. Distribution of Antarctic *Leucon* (*Macrauloleucon*) species: *L.* (*M.*) *complexus* Mühlenhardt-Siegel, 2011, *L.* (*M.*) *parasiphonatus* Mühlenhardt-Siegel, 1994, *L.* (*M.*) *weddelli* Ledoyer, 1993, *L.* (*M.*) *weigmanni* Mühlenhardt-Siegel, 2011. Map 6. Distribution of Antarctic and Subantarctic *Leucon* (*Crymoleucon*) species (part 1): *L.* (*C.*) *antarcticus* Zimmer, 1907, *L.* (*C.*) *breidensis* Gamo, 1987, *L.* (*C.*) *costatus* Corbera, 2000, *L.* (*C.*) *grandidentatus* Mühlenhardt-Siegel, 2011, *L.* (*C.*) *inexcavatus* Ledoyer, 1977, *L.* (*C.*) *intermedius* Mühlenhardt-Siegel, 1996, *L.* (*C.*) *kerguelenensis* Zimmer, 1908. Map 7. Distribution of Antarctic and Subantarctic *Leucon* (*Crymoleucon*) species (part 2): *L.* (*C.*) *longirhinus* Mühlenhardt-Siegel, 2011, *L.* (*C.*) *parantarcticus* Mühlenhardt-Siegel, 2011, *L.* (*C.*) *rossi* Rehm & Heard, 2008, *L.* (*C.*) *sagitta* Zimmer, 1907, *L.* (*C.*) *septemdentatus* Zimmer, 1902, *L.* (*C.*) *vanhoeffeni* Zimmer, 1907, *L.* (*C.*) *weddellensis* Mühlenhardt-Siegel, 2011.

Thirteen species (13%) cover a wide depth range, i.e. from shelf waters down to more than 2000 m.

Nineteen species (19%) are found exclusively deeper than 2000 m. The genera and the number of species for the depth zones are given in Table 1.

The most speciose family in the SO is the family Leuconidae. In the following paragraph, this family will be presented as an example to discuss species' distributions in more detail.

The family Leuconidae is subdivided into 15 genera. Eight of them are monotypic, i.e. only one species is described for each genus. Seven genera comprise more than one species; however, only three of these genera have representatives in the SO: the genera are *Bytholeucon* (1 species out of 5; Map 2) *Eudorella* (7 out of 37 spp.; Maps 1 and 3) and *Leucon*.

The latter represents the most speciose genus in the leuconid family, with 100 species known so far worldwide. This genus is subdivided into six subgenera (Watling 1991): *Leucon* (35 spp.), *Crymoleucon* (30 spp.), *Epileucon* (17 spp.), *Macrauloleucon* (12 species), *Alytoleucon* (5 spp.) and *Diaphonoleucon* (1 sp.).

Crymoleucon (Maps 6 and 7) represents the most speciose leuconid subgenus in the SO (s.s.), defined by CCAMLR south of the Polar Front (which excludes the sub-Antarctic Kerguelen Islands). It comprises 12 SO species (40% of all species worldwide). This subgenus is followed by the subgenera *Leucon* and *Macrauloleucon* (4 spp. each; Maps 4 and 5), and one species of the subgenus *Alytoleucon* (Map 2). Hence, it is likely that the subgenus *Crymoleucon* has undergone a recent radiation in the Southern Ocean, with almost half of the species number of this subgenus being described in the SO.

Nevertheless, the origin of the SO cumacean fauna remains still unsolved. The submergence and emergence hypotheses need to be tested, as well as the hypothesis of he SO being a transition zone between the oceans basins to the north, as suggested by Corbera *et al.* (2009). Where is the origin of the SO cumacean fauna? Did they invade the SO via the deep sea or are they of shallow water origin? Or is the SO a transition zone?

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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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Falk HUETTMANN is a 'digital naturalist' he works on three poles (Arctic, Antarctic and Hindu-Kush Himalaya) and elsewhere (marine, terrestrial and atmosphere). He is based with the university of Alaska-Fairbank (UAF) and focuses primarily on effective conservation questions engaging predictions and open access data.

Philippe KOUBBI is professor at the University Pierre et Marie Curie (Paris, France) and a specialist in Antarctic fish ecology and biogeography. He is the Principal Investigator of projects supported by IPEV, the French Polar Institute. As a French representative to the CCAMLR Scientific Committee, his main input is on the proposal of Marine Protected Areas. His other field of research is on the ecoregionalisation of the high seas.

Ben RAYMOND is a computational ecologist and exploratory data analyst, working across a variety of Southern Ocean, Antarctic, and wider research projects. His areas of interest include ecosystem modelling, regionalisation and marine protected area selection, risk assessment, animal tracking, seabird ecology, complex systems, and remote sensed data analyses.

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.

Bruno DAVID is CNRS director of research at the laboratory BIOGÉOSCIENCES, University of Burgundy. His works focus on evolution of living forms, with and more specifically on sea urchins. He authored a book and edited an extensive database on Antarctic echinoids. He is currently President of the scientific council of the Muséum National d'Histoire Naturelle (Paris), and Deputy Director at the CNRS Institute for Ecology and Environment.

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.