

Census of Antarctic Marine Life
SCAR-Marine Biodiversity Information Network

BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN

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SCIENTIFIC COMMITTEE ON ANTARCTIC RESEARCH

THE BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN

The “Biogeographic Atlas of the Southern Ocean” is a legacy of the International Polar Year 2007-2009 (www.ipy.org) and of the Census of Marine Life 2000-2010 (www.coml.org), contributed by the Census of Antarctic Marine Life (www.caml.aq) and the SCAR Marine Biodiversity Information Network (www.scarmarbin.be; www.biodiversity.aq).

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1.2. The Census of Antarctic Marine Life (CAML)

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In 2000 the Alfred P. Sloan Foundation in New York launched a Census of Marine Life, an ambitious ten-year long international project that was to examine the world's oceans and log the occurrence and demise of marine species. Its principal objective was to assess the state of marine biodiversity at the start of the 21st century to enable predictions to be made about what species might inhabit oceans in the future. By supporting scientific coordination, rather than putting ships in the water, the Foundation leveraged over USD 650 million in total outlays. The Census ran until a final meeting in October 2010 in the Royal Society in London at which outcomes from the six ocean realms under study were presented. In total, some 2700 scientists from 80 nations participated in the Census, undertaking 540 research expeditions and producing over 2600 publications. A quarter of a million new species have been identified and recorded and there remain about three times that number waiting to be processed.

The ocean realm “Ice Ocean; Arctic and Antarctic” was the responsibility of two projects – Arctic Ocean Diversity (ArcOD) for the north of the globe, and the Census of Antarctic Marine Life (CAML) for the south. Both projects worked closely together and engaged in a number of joint initiatives. CAML started its activities mid-way through the Census, in 2005, following a decision to hold a third International Polar Year (IPY) in 2007–2009. The Scientific Committee on Antarctic Research (SCAR) accepted a proposal from its Life Sciences committee that CAML should go ahead as one of fifteen biological projects to be undertaken in Antarctica during the IPY; in the event CAML turned out to be the largest of them. The Alfred P. Sloan Foundation provided a grant of USD 1.4 million from 2005 until 2010 to SCAR for purposes of scientific co-ordination of CAML. SCAR contracted with the Australian Antarctic Division based in Hobart, Australia, to co-ordinate and manage the project, and appointed an international Steering Committee to oversee it and report back on progress. The Steering Committee met for the first time in Bremerhaven in October 2004 to write a scientific justification for Foundation support and in early 2005 Dr. Victoria Wadley was appointed as Project Manager. Working with Professor Michael Stoddart, Chief Scientist of Australia's Antarctic research program as CAML's Administrator, an initial workshop was held in Brussels in June 2005. This meeting set the broad objectives for CAML. The Steering Committee, supplemented by a number of experts, met annually or in some years more frequently, and held its last meeting at a Final Symposium held in Genoa, Italy, in May 2009. At this meeting decisions were made about final publications.

The main source of funds for CAML came from the National Antarctic Programs of a number of countries who, with a commitment to support the IPY, agreed to provide ship-time and research staff to work on CAML projects. France, Japan, New Zealand, Australia, UK, USA and a consortium of Latin-American countries provided research voyages dedicated to CAML; many other countries provided periods of ship-time for CAML work (Map 1). A conservative estimate of the value of National Antarctic program support to CAML is over USD 60 million, through their support of infrastructure and personnel. Thirty countries and fifty institutions participated on, and following, eighteen research voyages that delivered CAML data. The Washington Declaration on the International Polar Year and Polar Science, made at Baltimore, USA, in April 2009 urged “states, national and international scientific bodies, and other interested parties to cooperate to deliver a lasting legacy from the IPY, and to support appropriate infrastructures to achieve this...” and called upon “states, organisations, scientists, and other stakeholders to continue to engage with young people to cultivate the next generation of polar scientists, and to communicate with the general public to develop an awareness of the importance of polar research for life in all regions of the world...”. In both respects CAML achieved considerable success and can be confident it has materially advanced understanding of the biodiversity of the high latitude Southern Ocean.

CAML quickly established a series of scientific goals, as follows:

1. Undertake a species inventory of high-latitude Southern Ocean slopes and abyssal plains
2. Undertake an inventory of benthic fauna under disintegrating ice shelves
3. Undertake an inventory of plankton, nekton and sea-ice associated biota at all levels of biological organisation from viruses to vertebrates
4. Assess critical habitats for Antarctic top predators
5. Develop a coordinated network of interoperable databases for all Antarctic marine biodiversity data.

In addition CAML participated strongly in the Barcode of Life Data System (BOLD). Over 11,500 sequences (C01) from more than 2,330 morpho-species in 18 phyla have already been completed, providing a solid basis for future research.

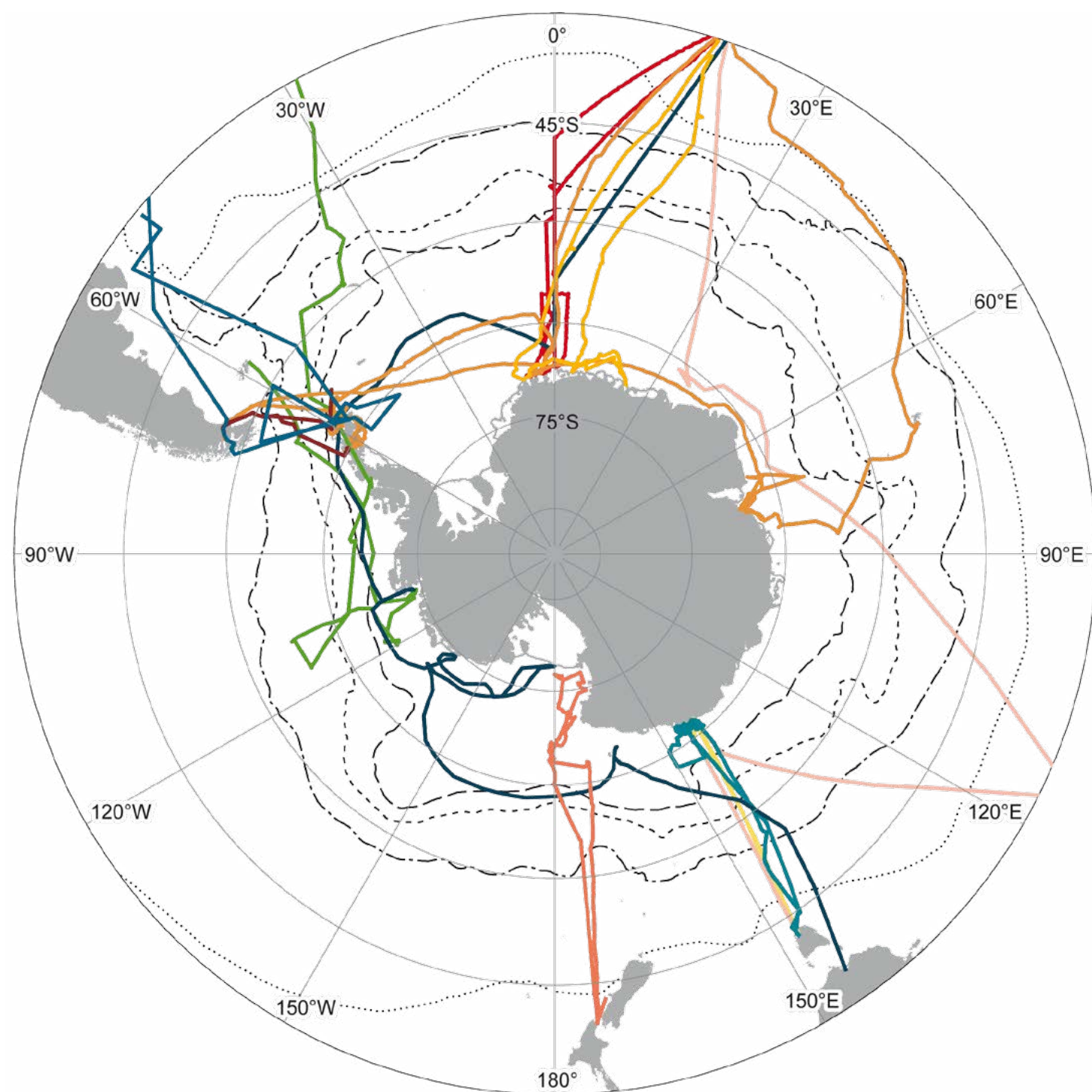
A key element in CAML's success as a project was its close association with SCAR's Marine Biodiversity Information Network (SCAR-MarBIN, www.scarmarbin.be), a data portal initiated by the Royal Belgian Institute of Natural Sciences in Brussels, implemented by the Belgian Biodiversity Platform and supported financially by the Belgian Science Policy Office. It was accepted by SCAR as the main repository for marine biodiversity data in 2005. SCAR-MarBIN became CAML's database. SCAR-MarBIN has recently transmogrified into an Antarctic Biodiversity Information facility (AntaBIF), financially supported by a number of countries with ongoing interests in Antarctic marine biodiversity. SCAR-MarBIN established data protocols and developed a suite of analytical tools for interrogating the data. A register of Antarctic marine species currently carries information on over 25,000 taxa (De Broyer *et al.* 2013), and almost 3 million occurrence data records (<http://www.marinespecies.org/rams/>, www.biodiversity.aq). The mass of data is growing since then, with data quality assured by an international editorial panel. Many successful ventures are springing from this central data portal, including a dynamic Antarctic field guides system (<http://afg.biodiversity.aq>), the Biogeographic Atlas of the Southern Ocean. CAML (<http://atlas.biodiversity.aq>) or the Microbial Antarctic Resource System (<http://mars.biodiversity.aq>). CAML succeeded in drawing together over 200 distributed databases for inclusion in SCAR-MarBIN, and captured publications dating from the very beginning of Antarctic exploration. It catalogued the largest collection of marine biodiversity data in Russia, at the Zoological Institute of St Petersburg, adding almost 300 publications and about 1.7 million data items relating to over 15,000 taxa occurrences. This is only one example of data that might otherwise be lost or inaccessible, which are now preserved for permanent access by the scientific community.

A significant legacy of CAML is a series of special publications that have appeared over recent years, stemming from CAML's association with national Antarctic programs, e.g. “BIOPEARL Expedition in the Scotia Sea” (Linse 2008), “Antarctic Biology in the 21st Century” (Fukuchi *et al.* 2010), “Cooperative East Antarctic Marine Census CEAMARC” (Hosie *et al.* 2011), “Diversity and Change in the Southern Ocean Ecosystems” (Schiaparelli & Hopcroft 2011).

Many other papers appeared in the normal scientific literature, including in several special IPY and CoML publications (e.g. Bathmann 2010, Gutt *et al.* 2010, Danis *et al.* 2013, Schiaparelli *et al.* 2013). Together these publications carry almost 161 papers on Antarctic marine biodiversity.

The need to understand the marine diversity of the high latitude Southern Ocean didn't stop with CAML. Knowing what is there, and the environmental conditions that support the biota is still needed for the successful conservation management of the region, and for understanding the consequences of climate change. SCAR has initiated two new major Scientific Research Programs (SRP): the “Status of the Antarctic Ecosystem” (AntEco), and “Antarctic Thresholds – Ecosystem Resilience and Adaptations” (Ant-ERA). These complementary programs are successors to the long-running SRP Evolution and Biodiversity of Antarctica (EBA), of which CAML was a part. Ant-Eco seeks to “understand the patterns of biodiversity across the marine environments, as well as the terrestrial, limnological and glacial marine environments within the Antarctic, sub-Antarctic and Southern Ocean regions.” Ant-ERA will examine “the current biological processes in all Antarctic ecosystems, to define their thresholds and thereby determine resistance and resilience to change.” CAML has contributed much groundwork to these new programs, ensuring a solid base for future studies.

When SCAR's Steering Committee met for the first time in Bremerhaven in 2004 few people could have imagined how CAML would grow and capture the imagination of countless people around the world. Through the highly efficient media arm of the Census of Marine Life, CAML scientists gained much international exposure for their work and reached out to the general public about the need for an awareness of what cannot be seen beneath the sea's surface. The Washington Declaration asked no more of us, and we delivered. We are still delivering, with the Biogeographic Atlas being our latest initiative.



Map 1

- | | |
|-----------------------------|-----------------------------|
| — Akademik Fedorov, 2007/08 | — Polarstern, 2006/07 |
| — Ary Rongel, 2007/08 | — Polarstern, 2007/08 |
| — Aurora Australis, 2007/08 | — Tangaroa, 2007/08 |
| — James Clark Ross, 2007/08 | — Umitaka Maru, 2007/08 |
| — L'Astrolabe, 2007/08 | — Yuzhmorgeologiya, 2007/08 |
| — Papanin, 2008-2009 | |

CAML Map 1 Tracks of selected CAML-dedicated cruises

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Huw Griffiths (BAS, Cambridge) and Anton Van de Putte (RBINS, Brussels) prepared the map. This is CAML contribution # 89.

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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.



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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.

