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BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN

CHAPTER 5.7. STYLASTERIDAE (CNIDARIA: HYDROZOA).

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THE BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN

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5.7. Stylasteridae (Cnidaria, Hydrozoa)

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1. Introduction

Stylasterid corals, common name "lace corals", are calcified, often colourful, colonial hydrozoans of the phylum Cnidaria. Their aragonite/calcite skeleton (Cairns & Macintyre 1992), gross branching morphology, relatively large size, and their association with commensal invertebrates (e.g. polychaetes and asteroids) make them an important component of the deep sea fauna in most oceans (Cairns 2011). There are 27 described stylasterid genera, with 247 species world-wide (Cairns 2011). Fourteen genera and thirty three species are recorded from the Antarctic region, south of the Antarctic Front at 54°S (Cairns 1983, Cairns 1991) (Table 1, Map 1). There are no described stylasterids from within the Arctic Circle (Cairns 2011), and Southern Ocean diversity is comparatively higher than other oceans (e.g., only one species, *Errina aspera*, has been described from the Mediterranean). Stylasterids have been observed in Southern Ocean collections since the early 1800s (Stokes 1847) and the last biogeographic summary was published in 1983 (Cairns 1983). However, it is only in the past decade that modern remote video and sampling techniques have allowed us to glimpse images of them in their natural habitat. The Census of Antarctic Marine Life (CAML), in collaboration with the Scientific Committee on Antarctic Research Marine Biodiversity Information Network (SCAR-MarBIN) conducted between 2005 and 2010, has provided new data on Antarctic biodiversity with new distribution records, in situ photographs, and environmental data to offer a greater insight than ever before into Antarctic benthic biogeography.

Despite their high occurrence in Antarctic collections, stylasterids remain a highly understudied group. A synthesis of recent records is lacking, many collections remain unidentified beyond family level, and our knowledge on stylasterid distribution is superficial, with patchy and non-repetitive sampling across depths. This paper aims to summarise our current knowledge of the biogeography of stylasterid corals in Antarctica. Following on from this publication, the authors are working to describe new species, and photographic taxonomic literature is under development to improve stylasterid identification. This information can be used to further identify areas of high stylasterid biodiversity, and improve benthic identifications in Antarctica.

Photo 1 *Errina* sp., Larsen B (*Polarstern* ANT-XXIII/8, st. 720-2, 228–233 m). Image: J. Gutt © AWI/Marum, University of Bremen, Germany.

Table 1 Stylasterid species found in Antarctic and sub-Antarctic Regions, their geographic distribution, range extension records since 1983, confirmed depth range, original species reference and the collections examined by the authors. Invertebrate collections include the National Institute for Water and Atmospheric Research (NIWA), Smithsonian National Museum of Natural History (NMNH), Museum national d'Histoire naturelle (MNHN), Nathaniel B Palmer voyages in 2011 (NBP 11-03, NBP 08-05 and NBP 11-05) and the Collaborative East Antarctic Marine Census (CEAMARC) research voyage.

Antarctic Stylasterid species information					
Species	**Geographic location**	**Distribution**	**Range extension**	**Depth (m)**	**Antarctic Collections**
***Adelopora pseudothyron* Cairns, 1982 (Map 5)**	Southern Ocean Islands / Seamounts	Four sub-Antarctic Seamounts from the Scotia Ridge, Drake Passage, Chile Rise, and Eltanin fracture zone, South Pacific		298–915	NMNH
***Calyptopora reticulata* Boschma, 1968 (Map 8)**	New Zealand / Macquarie Ridge	Maquarie Ridge; Campbell Plateau; off Antipodes Islands, Bounty Islands, and Chatham Island		349–2010	NIWA, NMNH
***Cheiloporidion pulvinatum* Cairns, 1983 (Map 5)**	Magellanic Region / N Scotia Arc	Off Argentina, Cape Horn, Tierra del Fuego, Burdwood Bank, Shag Rocks	South West Atlantic (Bax & Cairns, new record)	18–771	NIWA, NMNH, NBP 11-03 and NBP 11-05
***Conopora verrucosa* (Studer, 1878) (Map 9)**	New Zealand / Macquarie Ridge / Magellanic Region / N Scotia Arc	Circum-Antarctic, excluding the Ross Sea		216–2355	NIWA, NMNH, NBP 11-03 and NBP 11-05
***Crypthelia formosa* Cairns, 1983 (Map 3)**	Magellanic Region / N Scotia Arc	Scotia Ridge from Tierra del Fuego to South Georgia		483–1841	NMNH
***Crypthelia fragilis* Cairns, 1983 (Map 8)**	New Zealand / Macquarie Ridge	Pacific Antarctic Ridge, Macquarie Ridge, off southern Campbell Plateau, and off Antipodes Islands		1336–2329	NIWA, NMNH, NBP 11-03 and NBP 11-05
***Crypthelia studeri* Cairns, 1991 (Map 8)**	New Zealand / Macquarie Ridge	Campbell Plateau, Macquarie Ridge, Bounty Plateau, Kermadec Ridge, and Three Kings Ridge.		343–1940	NIWA, NMNH
***Errina antarctica* (Gray, 1872)**	Magellanic Region	South America from Tierra del Fuego to Punta Rosario, Madre de Dios Archipelago, Chile: off Falkland Islands and Burdwood Bank and the Chilean fjords.		18–771, rarely deeper than 300	NMNH, NHM
***Errina boschmai* Cairns, 1983 (Map 3)**	Peninsula, Scotia Arc	Off South Shetland Islands, South Georgia.		100–659	NMNH, NBP 11-05
***Errina cheilopora* Cairns, 1983 (Map 8)**	New Zealand / Macquarie Ridge	Maquarie Ridge and off Antipodes Island		371–659	NIWA, NMNH
***Errina cyclopora* Cairns, 1983 (Map 5)**	Magellanic Region	Scotia Ridge, East of Burdwood Bank		1647–2044	NMNH
***Errina fissurata* Gray, 1872 (Map 2)**	Circum-Antarctic	Circum-Antarctic		146–796	NIWA, NMNH, NHM, MNHN, NBP 11-03 and NBP 11-05, CEAMARC
***Errina gracilis* von Marenzeller, 1903 (Map 2)**	Circum-Antarctic	Circum-Antarctic; South Georgia, South Shetland Islands, Ross Sea, Macquarie Ridge, Iles Crozet, sub-Antarctic, Seamounts in South Pacific, and east continental coast of Antarctica		218–1226 most records 300–600	NIWA, NMNH, NBP 11-03 and NBP 11-05

Antarctic Stylasterid species information					
Species	**Geographic location**	**Distribution**	**Range extension**	**Depth (m)**	**Antarctic Collections**
***Errina kerguelensis* Broch, 1942**	East Antarctic and sub-Antarctic Islands	Islands only; off Iles Crozet, Iles Kerguelen, Heard Island, and Balleny Islands		91–512	NMNH
***Errina laevigata* Cairns, 1991 (Map 7)**	New Zealand / Macquarie Ridge	Macquarie Ridge		113–371	NIWA, CEAMARC
***Errina latetrorifa* Eguchi, 1964 (Map 2)**	Circum-Antarctic	Circum-Antarctic		91–870	NIWA, NMNH, NHM, MNHN, NBP 11-03 and NBP 11-05
***Errina reticulata* Cairns, 1991**	New Zealand / Macquarie Ridge / N Scotia Arc	Macquarie Ridge and north of Auckland Island, Shag Rocks, and Sars Seamount		79–145	NIWA
***Errinopora cestoporina* Cairns, 1983 (Map 5)**	Magellanic Region	East of Burdwood Bank and off Tierra del Fuego		359–384	NMNH, NBP 11-03 and NBP 11-05
***Errinopsis fenestrata* Cairns, 1983 (Map 6)**	Magellanic Region / N Scotia Arc	Tierra del Fuego, Burdwood Bank, Sars Seamount and Interim Seamounts, South Georgia, Shag Rocks	Burdwood Bank, Herdman Bank, Discovery Bank	280–340	NMNH, NBP 11-03, NBP 08-05 and NBP 11-05
***Errinopsis reticulum* Broch, 1951 (Map 6)**	Magellanic Region	Tierra del Fuego, Burdwood Bank		250–771	NMNH, NBP 11-03 and NBP 11-05
***Inferiolabiata labiata* (Moseley, 1879) (Map 2)**	Circum-Antarctic	Circum-Antarctic		87–2100	NIWA, NMNH, MNHN, NBP 11-03 and NBP 11-05, CEAMARC
***Inferiolabiata lowei* (Cairns, 1983) (Map 3)**	Magellanic Region / N Scotia Arc	Bahia Blanca, Argentina, Tierra del Fuego, Burdwood Bank, South Georgia, Drake Passage		250–960	NMNH
***Lepidopora acrolophos* Cairns, 1983 (Map 6)**	N Scotia Arc / Magellanic Region	South Georgia, Drake Passage, Cape Horn	Sars Seamount	659–686	NMNH
***Lepidopora granulosa* (Cairns, 1983) (Map 3)**	Magellanic Region / N Scotia Arc	off the Falkland Plateau, Scotia Ridge from Tierra del Fuego to Shag Rocks		357–1874	NMNH, NBP 11-03
***Lepidopora sarmentosa* Boschma, 1968 (Map 7)**	New Zealand / Macquarie Ridge	Antipodes Islands, Macquarie Ridge, South Tasmania Rise, and Seamounts north of Scott Island on Pacific-Antarctic Ridge		915–1647	NIWA, NMNH
***Lepidotheca fascicularis* (Cairns, 1983) (Map 9)**	New Zealand / Macquarie Ridge / Magellanic Region / N Scotia Arc	Tierra del Fuego, off Burdwood Bank, off South Georgia, Macquarie Ridge, Campbell and Bounty Plateaus, Chatham Rise, Three Kings Islands, off Antipodes Islands and South West Atlantic		282–2010	NIWA, NMNH
***Lepidotheca inconsuta* Cairns, 1991 (Map 7)**	New Zealand / Macquarie Ridge	Endemic, type locality: Hjort Seamount		833–842	NMNH
***Sporadopora dichotoma* (Moseley, 1876) (Map 4)**	Magellanic Region / Scotia Arc	off Uruguay, Falkland Plateau, Scotia Ridge from Tierra del Fuego to South Georgia, South Shetland Islands		250–1498	NMNH, NBP 11-03 and NBP 11-05
***Stellapora echinata* (Moseley, 1879) (Map 4)**	Magellanic Region / Scotia Arc	Burdwood Bank, Cape Horn		357–1647	NIWA, NMNH, NBP 11-03, NBP 08-05 and NBP 11-05
***Stylaster densicaulis* Moseley, 1879 (Map 4)**	Magellanic Region / Scotia Arc	Southeastern South America from Rio de la Plata to Tierra del Fuego, Scotia Ridge to South Georgia		357–1244	NMNH,NBP 11-03, NBP 08-05 and NBP 11-05
***Stylaster eguchii* (Boschma, 1966) (Map 7)**	New Zealand / Macquarie Ridge	Macquarie Ridge, New Zealand Plateau including Auckland Island and Antipodes Islands		124–830	NIWA
***Stylaster profundus* (Moseley, 1879) (Map 4)**	Magellanic Region / N Scotia Arc	Rio de la Plata, Uruguay, off South Georgia, off southwestern Chile		631–1097	NMNH
***Stylaster robustus* (Cairns, 1983) (Map 4)**	Scotia Arc	Scotia Ridge from off Gibbs Island, South Shetland Islands to Black Rock (west of South Georgia)		177–631	NMNH

2. Methods, including limitations of coverage

Antarctic benthic samples were collected by either beam trawl, epibenthic sled (CAML 2006) or as by-catch in regulated fisheries (Parker & Bowden 2010). Due to the great expense and difficulties associated with Antarctic deep sea research, these collection methods are non-selective for stylasterids. Often depth data are uninformative, as a trawl, or fisheries long line that begins at one depth and ends at another encompasses many animals of differing benthic distributions collected along the trawl path. Hence depth specific patterns are speculative at best, and the confirmed depth range, where the shallowest deep and deepest shallow trawl ranges are used as a guide (as in Cairns 1983), is listed for each species (Table 1.). Current records suggest a high incidence of local endemism. However, a single trawl is only representative of a sample of the region. Consequently, discussions relating to rare or endemic species may be disproven with increased sampling.

A number of Antarctic collections are yet to be incorporated into biodiversity databases (e.g. World Register of Marine Species (WoRMS), international Barcode of Life (iBOL)). Newer collections remain unidentified or are named only to higher taxon level (e.g. family), rendering them uninformative at the species level for distribution. Therefore, a number of stylasterid specimens collected in Antarctica are not included in this review. Furthermore, distribution maps, particularly those for circum-Antarctic species, may be more indicative of sampling intensity in Antarctica, rather than a species' full range. For example, sampling effort is highly concentrated in the Antarctic Peninsula area, the Weddell Sea and more recently in East Antarctica.

This paper incorporates stylasterid species-level records from all known sources (Table 1), analysing 721 new records since the last revision of the group (Cairns 1983, who cited 461 records). Maps include collections that have been personally identified by the authors, and therefore identified to the lowest possible taxonomic level based on morphological analysis using available keys and descriptions (Cairns 1992), and where necessary scanning electron microscopy (SEM) to identify fine structure. These records are synthesised to provide an updated distribution map of stylasterid genera/species from the SCAR-MarBIN/AntaBIF occurrence database ANTOBIS (www.scarmarbin.be/AntobisMapper.php).

3. Biodiversity and biogeography of stylasterid corals

Thirty three species are recorded from the Antarctic region, south of the Polar Front at 54°S (Cairns 1983, Cairns 1991). Within this geographic area four distribution patterns predominate for Antarctic stylasterids:

(1) Circum-Antarctic field-forming corals: *Errina fissurata* (Grey, 1872), *Errina laterorifa* (Eguchi, 1964), *Errina gracilis* (von Marenzeller, 1903) and *Inferiolabiata labiata* (Moseley, 1879) (Map 2).
The recent discovery of field-like aggregations of *Errina fissurata* on the Antarctic continental shelf has highlighted the importance of deep sea stylasterid coral populations in the Southern Ocean (Post *et al.* 2010). Subsequently, an area of dense *Errina* spp. aggregations in the Dumont d'Urville Sea has been listed as a Vulnerable Marine Ecosystem (VME). *Errina* species are also listed as VME indicator taxa through The Commission for the

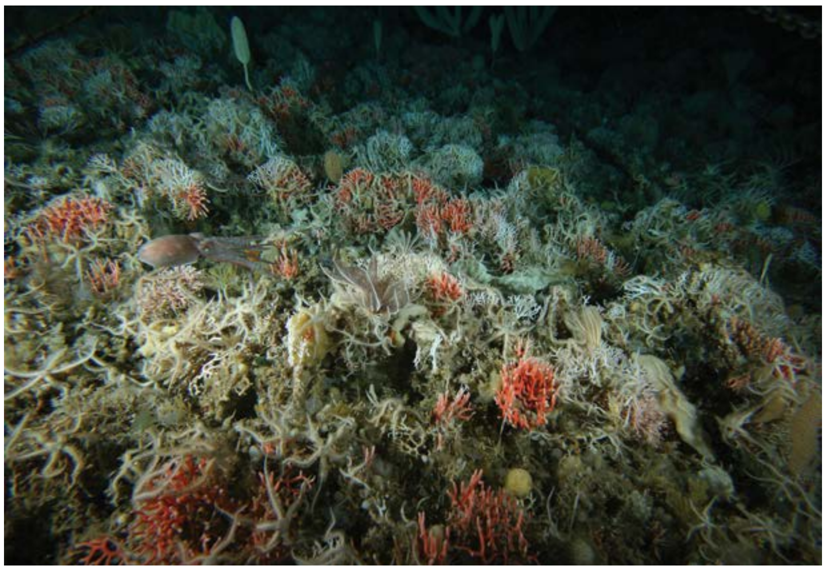


Photo 2 Coral field of *Errina* spp. at >450 m in the Dumont d'Urville Sea discovered during the Collaborative East Antarctic Marine Census (CEAMARC) research cruise in 2007/2008. Image © AAD.

Conservation of Antarctic Marine Living Resources (CCAMLR 2012). These classifications recognise that the conservation of these species is crucial to maintaining regional biodiversity. *Errina fissurata* is listed by Cairns (1983) as collected in great abundance (hundreds of broken branches) from 18 sampling stations in the western Ross Sea, with *E. fissurata* normally the dominant coral component of the assemblage. However, it is invariably collected with another orange *Errina*, *Errina laterorifa*, and on occasion a white morphotype representing either *Inferiolabiata labiata*, or *Errina gracilis* (Bax pers. obs.). Distribution maps show a similar circum-Antarctic overlap for all four species of field-forming stylasterids (Map 2). Of these species, *E. fissurata*, *E. gracilis* and *E. laterorifa* are described as circum-Antarctic, and *E. fissurata* and *E. laterorifa* are morphologically similar and often occur in sympatry (Cairns 1983). We now know from video transects and collections that this '*Errina* species' assortment is representative of stylasterid coral-fields in the Ross Sea and Dumont d'Urville Sea (Bax *et al.* unpublished) (Photos 2–3).

Although not circum-Antarctic, the coral *Errina antarctica* (Gray, 1872) from the Antarctic Peninsula, and Patagonian fjord region of South America is notable, as it has been found in extensive field-like aggregations in shallow waters (10–30 m) off the southern Chilean fjords between the Central Patagonian Zone (48°S) and Tierra del Fuego (55°S) (Häussermann & Försterra 2006).

(2) Magellanic / Scotia Arc species: *Errina boschmai* (Cairns, 1983), *Crypthelia formosa* (Cairns, 1983), *Inferiolabiata lowei* (Cairns, 1983), *Lepidopora granulosa* (Cairns, 1983), *Sporadopora dichotoma* (Moseley, 1876), *Stellapora echinata* (Moseley, 1879), *Stylaster densicaulis* (Moseley, 1879), *Stylaster profundus* (Moseley, 1879), *Stylaster robustus* (Cairns, 1983) (Maps 3–4).

The Magellanic region and the adjacent areas immediately south of the Polar Front are the most species-rich region of the Southern Ocean s.l. consisting of 16 of the 33 described species. Within this region the Burdwood Bank, Cape Horn, South Georgia and Shag Rocks have particularly high levels of stylasterid diversity. The Cape Horn region surveyed by Waller & Robinson (2011), found extensive aggregations of the coral *Stylaster densicaulis* (pers. obs.). Recent collections and video surveys have also identified *Errinopsis reticulum* (Broch, 1951) in great abundance (Bax *et al.* unpublished, Fillinger pers. com., Waller pers. com.) at Burdwood Bank. *Errinopsis reticulum* is a large coral (up to 24 cm tall and 14 cm across (Cairns 1983), which forms a 3D, matrix-like sieve often providing habitat for a diverse fauna. There are also new records of this coral near South Georgia, and south of Cape Horn. However, the field-like coverage appears to be restricted to the Burdwood Bank, an area of high biodiversity for a number of Antarctic invertebrate groups (Clarke & Johnson 2003).

Photo 3 Coral field of *Errina* spp. at >300 m depth in the Ross Sea. Image: David Bowden © NIWA.

In contrast there is only one new record for *Errina boschmai*, two new records of *Lepidopora granulosa* at Cape Horn, and no new records for *Crypthelia formosa*, *Inferiolabiata lowei*, *Stylaster robustus* or *Stylaster profundus* post 1983. *Sporadopora dichotoma* and *Stellapora echinata* are more frequently sampled; however, no range extensions are recorded since 1983. A new species of the genera *Stellapora* from Burdwood Bank is currently being described by Bax and Cairns.

(3) Localised and potentially endemic species: *Adelopora pseudothyron* (Cairns, 1982), *Cheiloporidion pulvinatum* (Cairns, 1983), *Errina cyclopora* (Cairns, 1983), *Errinopora cestoporina* (Cairns, 1983), *Errinopsis fenestrata* (Cairns, 1983), *Errinopsis reticulum* (Broch, 1951) and *Lepidopora acrolophos* (Cairns, 1983) (Map 5–6).

Seven Antarctic species are considered rare or endemic, and are thus rarely sampled. *Errina cyclopora* and *Errinopora cestoporina,* are restricted to a small number of seamounts, and very few records exist for these species. *Lepidopora acrolophos* is only described from South Georgia, with new records at Burdwood Bank and Cape Horn (Map 6). *Adelopora pseudothyron* has only been documented on four sub-Antarctic seamounts (Cairns 1983). *Errinopsis reticulum*, *Errinopsis fenestrata* and *Cheiloporidion pulvinatum* are also listed by Cairns (1983) as only known from their type localities. However, we now know that the range of these species is more widespread.

(4) Species endemic to or present in New Zealand waters extending into Antarctic territory include: *Calyptopora reticulata* (Boschma, 1968), *Crypthelia fragilis* (Cairns, 1983), *Crypthelia studeri* (Cairns, 1991), *Errina cheilopora* (Cairns, 1983), *Errina laevigata* (Cairns, 1991), *Errina reticulata* (Cairns, 1991), *Lepidopora sarmentosa* (Boschma, 1968), *Lepidotheca inconsuta* (Cairns, 1991) and *Stylaster eguchii* (Boschma, 1966), (Map 7–8).

Nine species are described from the sub-Antarctic region south of New Zealand, five are considered endemic (Table 1) (Cairns 1983, 1991). The Macquarie Ridge area appears to be a hot spot of stylasterid biodiversity, as all nine species are described from this Region. *Lepidopora sarmentosa* has been recorded on the Tasmanian Ridge, Macquarie Ridge, and South of the Polar Front. *Errina cheilopora* and *Stylaster eguchii* appear to form the dominant component of the Macquarie Ridge samples, accounting for up to 70% of the National Institute of Water and Atmospheric Research (NIWA) stylasterid collection (pers. obs.). *Calpytopora reticulata*, a large (~20 cm wide) fan-shaped coral has been documented in field-like accumulations off New Zealand (Schnabel pers. com.), with only a few colonies described further south along the Macquarie Ridge.

4. Stylasterids from abyssal depths

Limited sampling dictates that an accurate vertical bathymetric pattern from the near shore benthos to the abyssal plain remains elusive. Stylasterids belong to a typically deep water family (Cairns 2011). Generally, Antarctic collections are taken from the shelf region (100–500 m), very few voyages have sampled below 600 m, even fewer have sampled the Antarctic abyssal zone of >2000 m (e.g., Linse *et al.* 2007, Janussen & Reisweg 2009). Therefore, like most Antarctic animals their maximum depth limit is unknown.

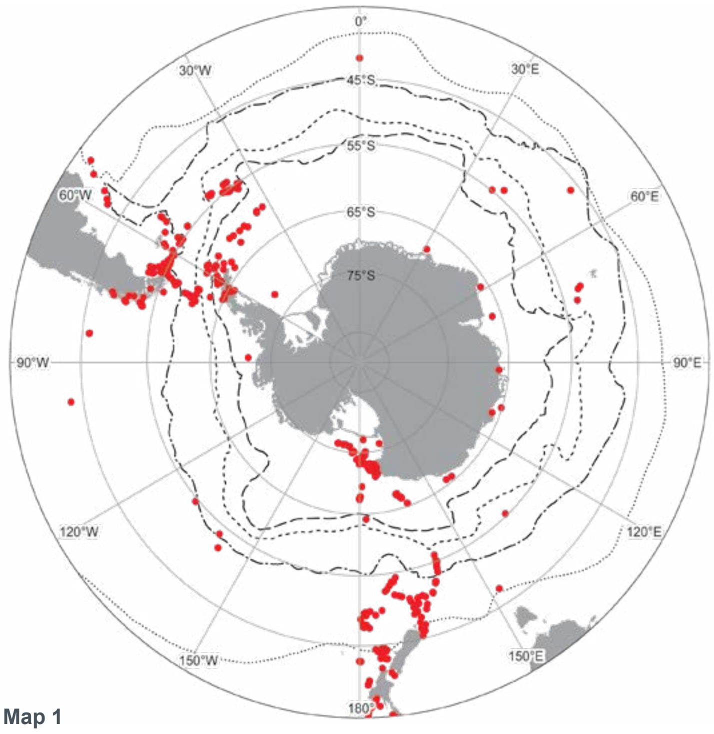
Errina kerguelensis (Broch, 1942), *Lepidotheca fascicularis* (Cairns, 1983) and *Conopora verrucosa* (Broch, 1951) do not conform entirely to the former distribution maps displayed here, as their ranges encompass both New Zealand and the Magellanic Region. Two of them are mapped on Map 9. Both of these species are found across a broad depth range of ~200–2000 m (Cairns 1983). Therefore their disjunct distribution may reflect a lack of sampling at great depths around Antarctica. This limited sampling may also affect our understanding of the distribution of other deeper stylasterid species (e.g. *Crypthelia fragilis* one of the deepest recorded stylasterids ~2305 m (Cairns 1983).

5. Physical factors affecting depth distribution

There is speculation that stylasterids are most abundant below the region of ice scour (Post *et al.* 2010). Ice scour has an effect up to ~400 m depth in the Antarctic (Dowdeswell & Bamber 2007, Massom *et al.* 2009), and Post *et al.* (2010) document stylasterid coral fields in the Dumont d'Urville Sea at >450 m (photo 2 a), below the main region of ice scour. More than 60% of stylasterid records are from below this depth range (Table 1). However, stylasterids have been recorded as shallow as 11 m (Table 1) and in field-like occurrence at ~160 m and 240 m as documented from a recent German voyage to the Larsen B ice shelf where 14–26 stylasterid colonies/m^2 were documented during video transects (Gutt *et al.* pers. com.), well within the region of ice scour. It must be noted that not all shallow areas are affected by ice scour; some regions are protected by surrounding banks and promontories, which may block or deflect icebergs.

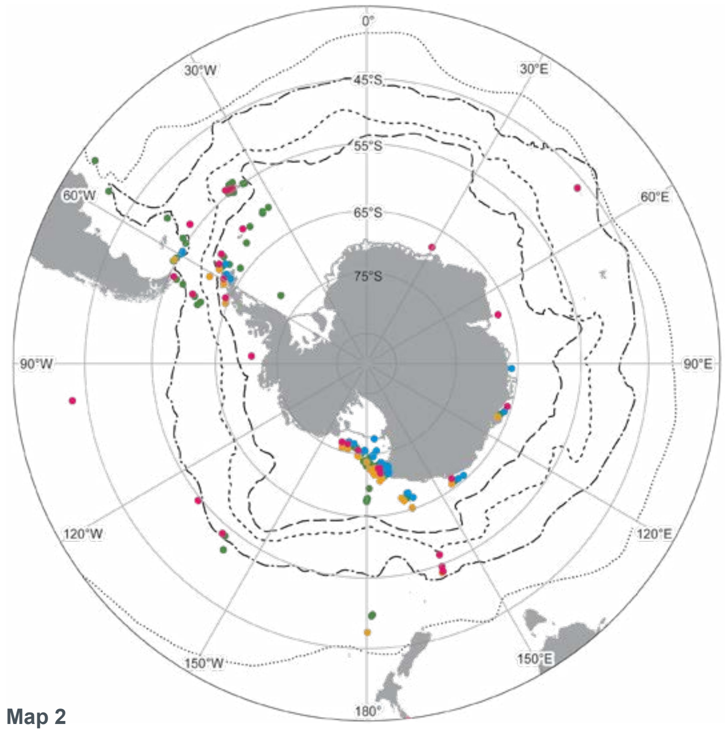
The shallowest cold water stylaterid populations in fjord regions extend from 10 m depth suggesting stylasterid corals can have a eurybathic distribution (Grange 1990, Miller *et al.* 2004, Häussermann & Försterra 2007).

Based on sampling to date we can say with certainty that stylasterid corals require hard substrate on which to settle during the larval phase (Cairns 1992). It has also been found that nutrient rich currents correlate with the presence of field-like stylasterid assemblages (Post *et al.* 2010, Bowden pers. com.). The most diverse Antarctic stylasterid assemblages have been found below



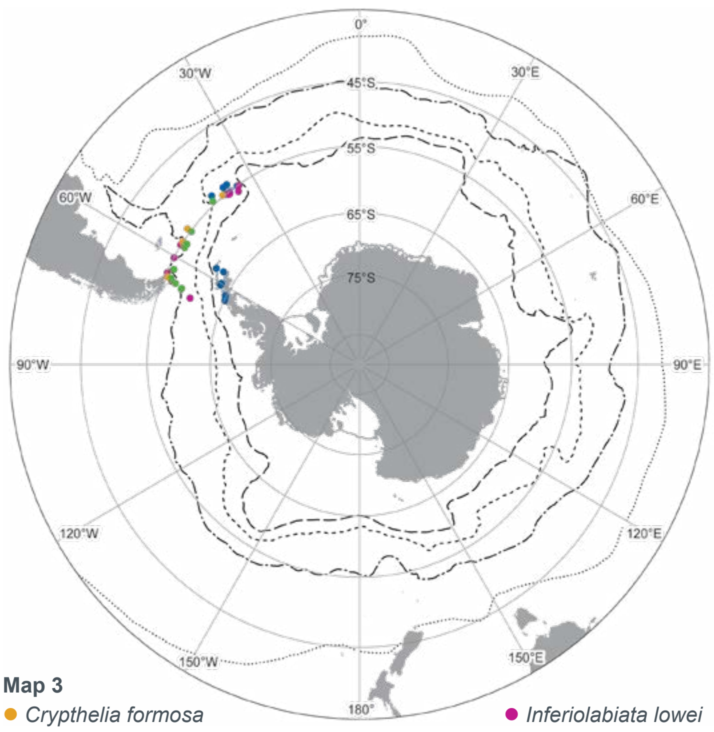
Map 1

- Records of the 33 stylasterid species found south of 54° S



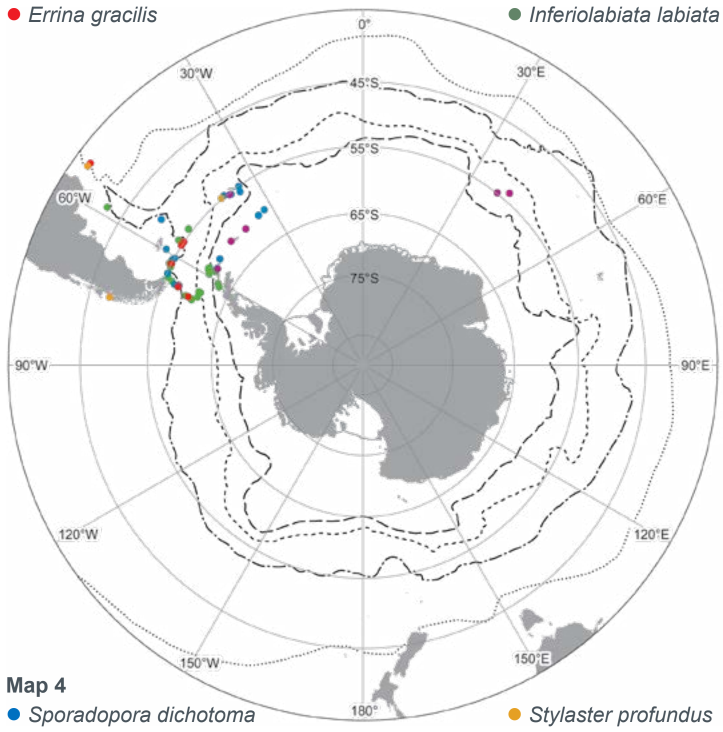
Map 2

- *Errina fissurata*
- *Errina gracilis*
- *Errina laterorifa*
- *Inferiolabiata labiata*



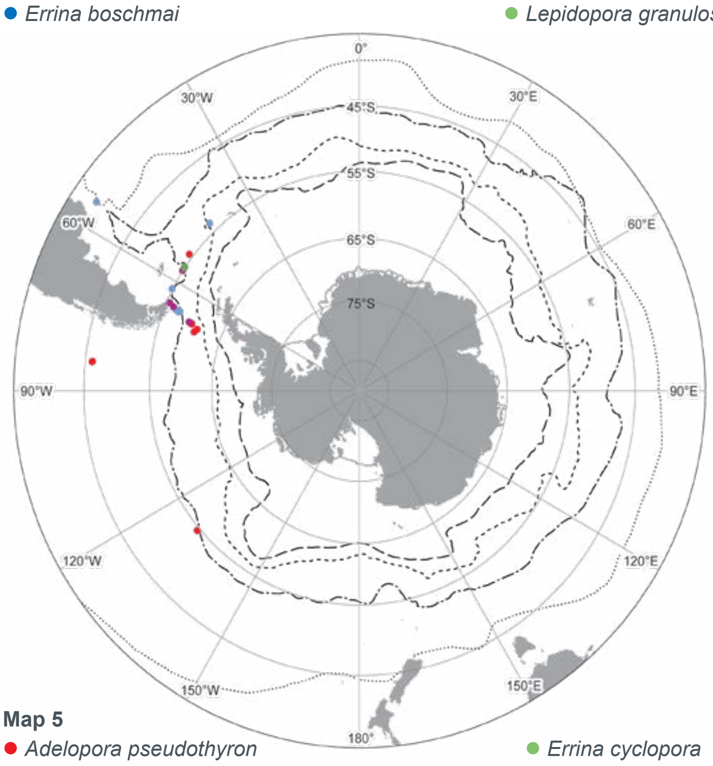
Map 3

- *Crypthelia formosa*
- *Errina boschmai*
- *Inferiolabiata lowei*
- *Lepidopora granulosa*



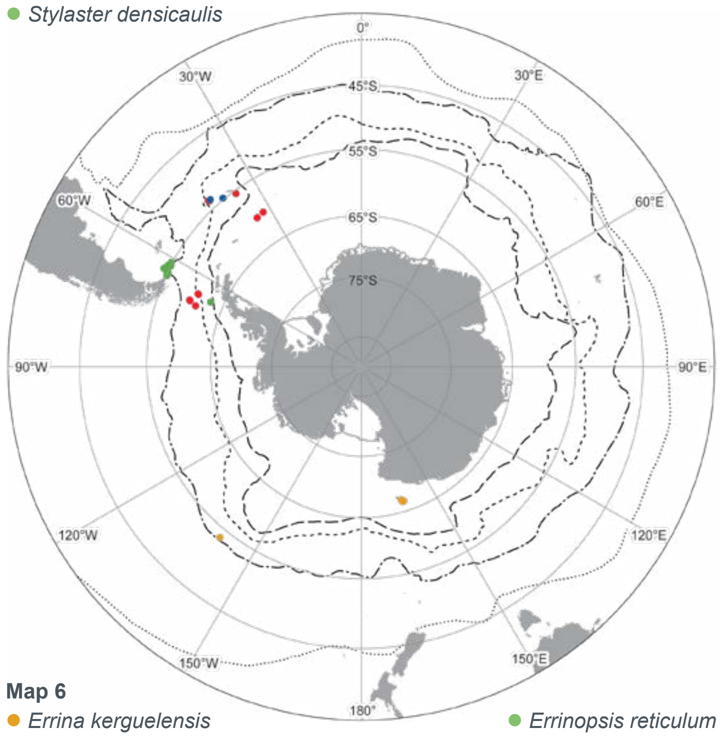
Map 4

- *Sporadopora dichotoma*
- *Stellapora echinata*
- *Stylaster densicaulis*
- *Stylaster profundus*
- *Stylaster robustus*



Map 5

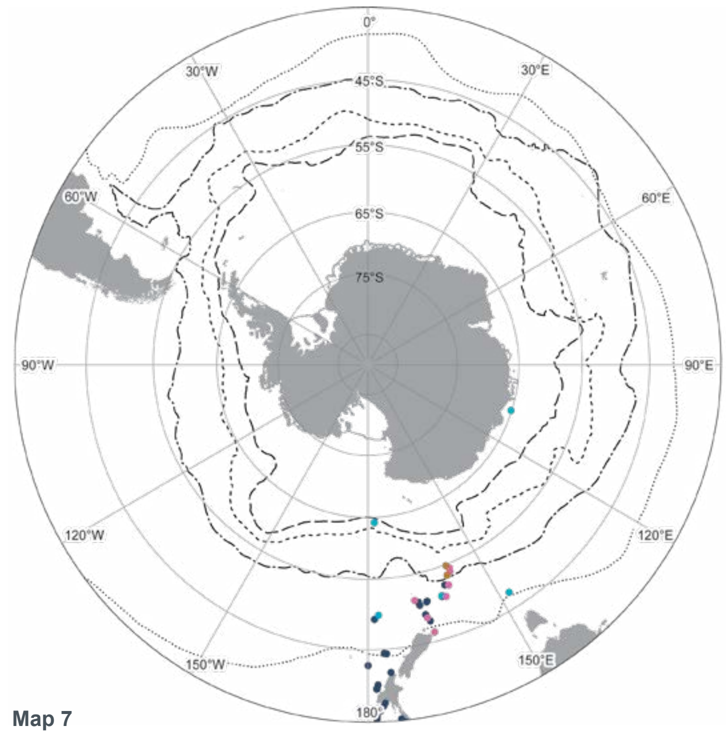
- *Adelopora pseudothyron*
- *Cheiloporidion pulvinatum*
- *Errina cyclopora*
- *Errinopora cestoporina*



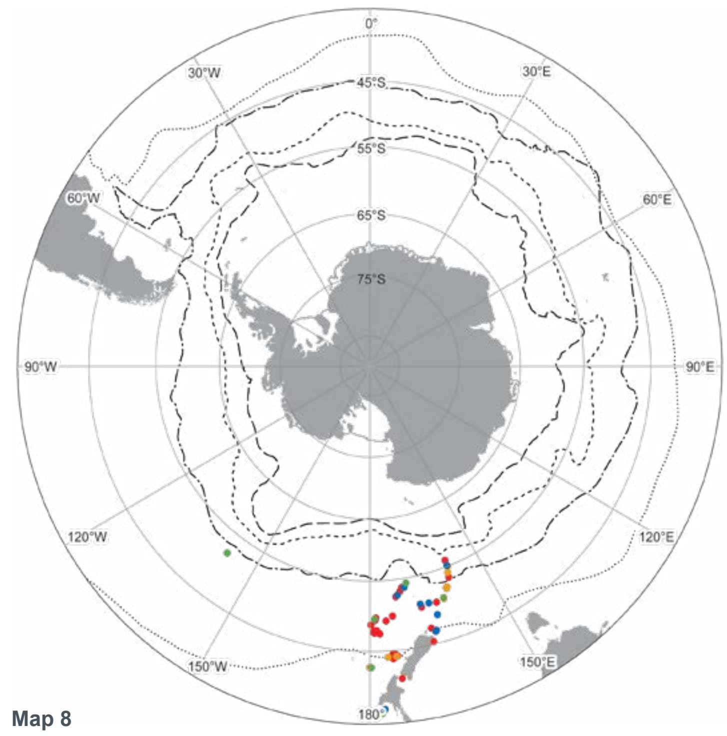
Map 6

- *Errina kerguelensis*
- *Errinopsis fenestrata*
- *Errinopsis reticulum*
- *Lepidopora acrolophos*

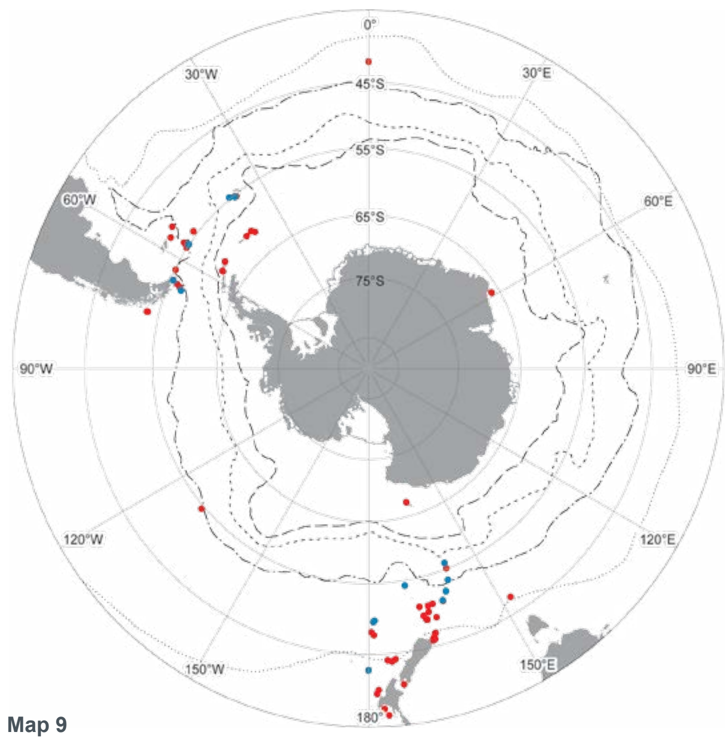
Stylasteridae Maps 1–6 Map 1. Records of the 33 stylasterid species found in the Southern Ocean, south of 54°S (average latitude of the Polar Front); many of them extend their distribution farther north into surrounding oceans. Map 2**.** Records of the 4 stylasterid species considered as circum-Antarctic field-forming corals: *Errina fissurata*, *Errina gracilis*, *Errina laterorifa*, and *Inferiolabiata labiata*. Maps 3–4. Stylasterid corals listed in the Magellanic / Scotia Arc region (bordered to the north by the Sub-Tropical Convergence and reaching the north of the Antarctic Region to the south): *Crypthelia formosa*, *Errina boshmai*, *Inferiolabiata lowei*, *Lepidopora granulosa*, *Sporadopora dichotoma*, *Stellapora echinata*, *Stylaster densicaulis*, *Stylaster profundus* and *Stylaster robustus*. Maps 5–6. Stylasterid corals considered as localised and potentially endemic species: *Adelopora pseudothyron*, *Cheiloporidion pulvinatum, Errina cyclopora, Errinopora cestoporina, Errina kerguelensis*, *Errinopsis fenestrata*, *Errinopsis reticulum* and *Lepidopora acrolophos*.



Map 7
- *Errina laevigata*
- *Lepidopora sarmentosa*
- *Lepidotheca inconsuta*
- *Stylaster eguchii*



Map 8
- *Calyptopora reticulata*
- *Crypthelia fragilis*
- *Crypthelia studeri*
- *Errina cheilopora*



Map 9
- *Conopora verrucosa*
- *Lepidotheca fascicularis*

Stylasteridae Maps 7–9 Maps 7–8. Stylasterid species considered as endemic to or present in New Zealand waters extending into Antarctic waters: *Errina laevigata*, *Lepidopora sarmentosa, Lepidotheca inconsuta*, *Stylaster eguchii*, *Calyptopora reticulata*, *Crypthelia fragilis*, *Crypthelia studeri, Errina cheilopora*. Map 9. Stylasterid species found in both New Zealand and the Magellanic / Scotia Arc region: *Conopora verrucosa* and *Lepidotheca fascicularis.*

400 m (Waller & Robinson 2011, Post *et al.* 2010), most likely due to habitat and nutrient availability, rather than a depth-specific preference for the group.

Very little is known of stylasterid larval longevity, but from the few studies available stylasterid larvae do not survive past 18 days (Fritchman 1974), and often settle within 24 hours, usually very close to parent colonies (Stratford 2002, in Miller *et al.* 2004). Hence the deep Antarctic channels such as the channel between Shag Rocks and Burdwood Bank (~1000 m deep and 607 km wide) likely inhibit larval dispersal. This pattern is evident in a number of Magellanic species, where there are no records of stylasterids within this channel, or at the South Sandwich Islands. However, other species have been recorded at both the Burdwood Bank and Shag Rocks (e.g. *S. densicaulis*, *S. dichotoma* and *C. verrucosa*). Therefore, depending upon the location of the source population, colonisation across Antarctic channels may be possible (Ramirez-Llodra *et al.* 2010). To discern if this is possible for stylasterid corals, genetic studies are needed to assess gene flow between regions. Based on the only two genetic studies to date, stylasterid coral populations appear significantly isolated (Bax 2009, Miller *et al.* 2004).

6. Endemism and range extensions

Many Antarctic and sub-Antarctic species are thought to be endemic to isolated portions of the Southern Ocean s.l., e.g. Tierra del Fuego and the Burdwood Bank (Maps 5–6). However, there are a number of range extensions based on recent collections that suggest a wider coral distribution than previously thought. Three species, *Lepidopora acrolophos, Cheiloporidion pulvinatum,* and *Errinopsis fenestrata*, have been collected in locations where they were previously unreported. Furthermore two species, *Inferiolabiata lowei* and *Errinopsis fenestrata*, from the Antarctic Peninsula have also been recorded in waters close to South Africa (Cairns & Zibrowius new record). *Cheiloporidion pulvinatum* was previously only described from the type locality (Cairns 1983). However, recent sampling suggests that *C. pulvinatum* may be a common and abundant coral with a range extending into the South West Atlantic (Bax *et al.* new record). Hence a more realistic hypothesis may be that, although dispersal is limited for this group, a competitive advantage has allowed them to successfully colonise portions of Antarctica over evolutionary time. Lindner *et al.* (2008) outlines, a similar hypothesis regarding stylasterid corals originating in the deep sea, and their subsequent multiple colonization's of shallow tropical and temperate environments. Genetic investigations are needed to test this for the Antarctic, and it is likely that in the process new cryptic species will be identified. Diversity appears to be underestimated for this group (e.g. Bax 2009), where three new species await description (Bax & Cairns new record), and likely many more with increased sampling in Antarctic waters.

7. Conclusions

Stylasterid corals are classified under CITES Appendix II, whereby they are not considered endangered, but may become so in the future. Due to the inaccessibility of Antarctic waters, trade is not considered a major threat and there is little to no commercial interest in the taxon. However, it is probable that stylasterids possess vulnerable life history characteristics (e.g. slow growing, late to mature, long lived (Miller *et al.* 2004). Their skeletal structure is extremely fragile and easily damaged by fishing gear and iceberg scour. Investigations of these populations to date suggest a skewed and isolated population demography making them particularly vulnerable. Therefore, further investigation, documentation and conservation of these coral populations is vital, especially in light of recent evidence on the vulnerability of deep sea ecosystems (UNEP 2006) to rapid climate change (IPCC 2007) and the burgeoning demand of deep sea fisheries in the Southern Ocean (Cochrane & Doulman 2005).

Isolation among stylasterid coral populations is evident based on the discovery of biodiversity hot spots, with dissimilar stylasterid species compositions in the Burdwood Bank, Shag Rocks and Cape Horn regions, along the Macquarie Ridge and within the Weddell, Ross and Dumont d'Urville Seas. Therefore conservation priority should be given to these regions, in particular the Magellanic Region between Tierra del Fuego and Burdwood Bank, which contains 15 of the 21 known Peninsula species. The Sub-Antarctic Region south of New Zealand, including Macquarie Ridge, is shown to have a potentially endemic fauna, and may act as a transition region between New Zealand and the Antarctic. The areas with the highest known stylasterid diversity include the coral-fields of the Dumont d'Urville and Ross Seas, the Larsen B ice shelf in the Weddell Sea, Cape Horn, and Burdwood Bank. The *Errina* spp. assortment has been recorded at all these high diversity sites, except Cape Horn. Hence particular attention should be focused on *Errina* species fields to maintain biodiversity.

The Peninsula area of Antarctica, the Magellanic region and the Weddell Sea, are without a doubt the most heavily explored regions of Antarctica. Within this region the South Sandwich Islands stand out as no stylasterid records exist in this region, despite a number of voyages having explored the area. However, this 'heavy' exploration is extremely light in comparison to other oceans; new species, and range extensions continue to be recorded with every benthic sampling expedition. Antarctic populations, including corals, are often highly localised to the extent that when an area is surveyed multiple times with both video and sample collection, new species compositions can still be found within only a few meters either side of a highly sampled area (Bax pers. obs.). Therefore, although future expeditions, when possible, should be focused outside of the Antarctic Peninsula and the Scotia Arc areas, we are only just beginning to understand Southern Ocean stylasterid fauna, and no doubt new species and diverse habitat assemblages are yet to be discovered in all areas of Antarctica**.**

Acknowledgments

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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.

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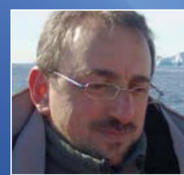

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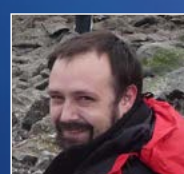

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