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CHAPTER 5.12. SOUTHERN OCEAN OCTOPUSES.

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THE BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN

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5.12. Southern Ocean Octopuses

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1. Introduction

Only a limited subset of Octopodiformes are found in the Southern Ocean. Vampire squids, argonauts and octopuses of the genera *Bolitaena, Japatella, Amphitretus* and *Eledonella*, all of which are pelagic, are restricted to tropical and temperate waters of the world's oceans. The octopod species that are present display a limited range of life history patterns.

Finned or cirrate octopuses (Order Cirrata) generally live demersally or pelagically and swim using the paired fins that protrude laterally from the anterior mantle. They are potentially long lived and slow to reach maturity. Few details are known about their life cycle but, unlike many octopod species, cirrates are thought to release eggs singly rather than spawning and then brood large quantities of eggs (Collins & Villanueva 2006). The time from spawning to hatching is not known but may be considerable. This might allow time for planktonic dispersal but eggs have been found attached to substrata such as gorgonians so dispersal may actually be limited. This would likely impact biogeographic patterns.

The incirrate octopuses (Order Incirrata) found in the Southern Ocean are all benthic. Adult movement is likely limited during their lifetime since slow crawling is the primary ambulatory mode. Swimming is limited to short bursts (two to three jets) as an escape response. All known species of Southern Ocean incirrate octopuses have relatively large eggs compared to their body size. It is thought that these eggs are layed on a hard substrate, brooded by the female, and hatch into benthic juveniles. Hence dispersal is also limited. Limited dispersal coupled with the disturbance to their habitat caused during glacial maxima likely promoted speciation and probably explains the relatively high local diversity of octopus species in the Southern Ocean.

Generally, only the area around the Antarctic Peninsula has been well sampled for octopuses and, even here, highly distinctive species are known from only one or a few records. Although the Antarctic Peninsula region can appear as a Southern Ocean biodiversity hotspot in many groups, this may simply reflect increased sampling effort in this region (Griffiths *et al.* 2011). It is not clear whether the octopus fauna in this region is richer or just better known. Interestingly there is high regional abundance of octopuses around Elephant Island, the eastern most of the South Shetland Islands. This appears to be because of a permanent ecological shift following overfishing of fin-fish stocks in the 1980s (Vecchione *et al.* 2009 a). Records from east of the Weddell Sea clockwise around to Adélie Land are very few and almost nothing is known of the octopod fauna of this region.

Photo 1 *Cirroctopus* sp., north of Livingston Island (*Polarstern* ANT-XXIX/3, st. 244-2). Arm span: nearly 1 meter. Image: C. d´Udekem d´Acoz © RBINS.

2. Model organisms for understanding Southern Ocean evolution

The incirrate octopuses were one of the first invertebrate groups to be investigated using genetic techniques (e.g., Allcock *et al.* 1997). This early work provided evidence of restricted gene flow over short distances — between Shag Rocks and South Georgia — and indicated that benthic octopuses might be suitable for studying barriers to dispersal and speciation within the Southern Ocean. It was predicted that the benthic, depth-limited lifestyle and minimal dispersal (see above) would render Southern Ocean octopuses susceptible to speciation (Allcock *et al.* 1997). Morphological taxonomic work confirmed that there had been endemic radiation in at least one genus (Allcock 2005) but also indicated morphological similarity between endemic Southern Ocean shallow-water (shelf) species and species distributed globally in the deep sea. Subsequent molecular work confirmed that these deep-sea species had their origin in the Southern Ocean (Strugnell *et al.* 2008) as had previously been suggested for several groups of organisms based on morphology (e.g., Brandt 1992). For the first time, dated phylogenies linked evolutionary events in Southern Ocean invertebrate fauna to periods of major climate change (Strugnell *et al.* 2008). Not all the benthic octopods evolved in situ in the Southern Ocean however. Molecular evidence has also been presented to illustrate movement of octopods in to the Southern Ocean from the deep sea with accompanying polar emergence (Strugnell *et al.* 2011). Recently, focus has returned to population genetics studies (Strugnell *et al.* 2012) which are providing evidence of recent population expansion and helping explain how invertebrate fauna survived multiple glacial cycles (Allcock & Strugnell 2012).

3. Biogeography

The maps are compiled from records published in journals and books (below) as well as records compiled by the author from museum specimens and cruise data.

3.1. Cirrata

Finned octopods are found throughout the world's oceans at depths to nearly 7000 m. Four families are currently recognised (Cirroctopodidae, Cirroteuthidae, Grimpoteuthidae and Opisthoteuthidae). Three of these families are found in the Southern Ocean, with representatives of four genera (Collins & Rodhouse 2006). The cirrate fauna of the Southern Ocean is poorly known and taxonomic problems abound. Cirrates are usually caught in small numbers, although there have been occasional large catches, possibly associated with schooling activities (Vecchione *et al.* 1998). The small capture numbers coupled with their fragile nature (which means they often incur substantial damage in trawls) has not helped systematic progress. However there have been some recent advances and when the results of the CAML barcoding programme are fully synthesised some taxonomic issues at least are likely to be resolved.

Family Cirroteuthidae (Map 1). Two members of the family Cirroteuthidae are found in the Southern Ocean. Neither is endemic to the Antarctic region. *Stauroteuthis gilchristi* is known from off Capetown, South Africa and from South Georgia and is probably distributed throughout the South Atlantic in depths from 900 to 3000 m. A single specimen from the Ross Sea may also be referable to this species. *Cirrothauma magna* is known only from four specimens. It was originally described from between Crozet and Prince Edward Islands and has since been reported from the Atlantic Ocean (Guerra *et al.* 1998, Collins *et al.* 2001). Its true distribution will only become apparent after further captures. The four known specimens may comprise a species complex.

Family Cirroctopodidae (Map 1). It is not clear how many species of *Cirroctopus* occur in the Southern Ocean. There are three available names: *Cirroctopus glacialis* described from the Schollaert Channel, *Cirroctopus mawsoni* described from off Adélie Land, and *Cirroctopus antarctica* described from off Smith Island in the South Shetland Islands. We treat records from near the Antarctic Peninsula and Weddell Sea as *Cirroctopus glacialis* and assume that *C. antarctica* is synonymous with this. We treat specimens from the Ross Sea and nearby as *C. mawsoni*. This species may be the senior synonym of both *C. glacialis* and *C. antarctica*. Additional *Cirroctopus* specimens (not mapped) have been reported (as *C*. cf *mawsoni)* from off Enderby Land and near Prydz Bay in East Antarctica (O'Shea 1999). *Cirroctopus* specimens in the Southern Ocean occur in depths of 333–879 m. Sequencing of material from near the type localities is probably required to solve the nomenclature since morphological studies have not provided consensus.

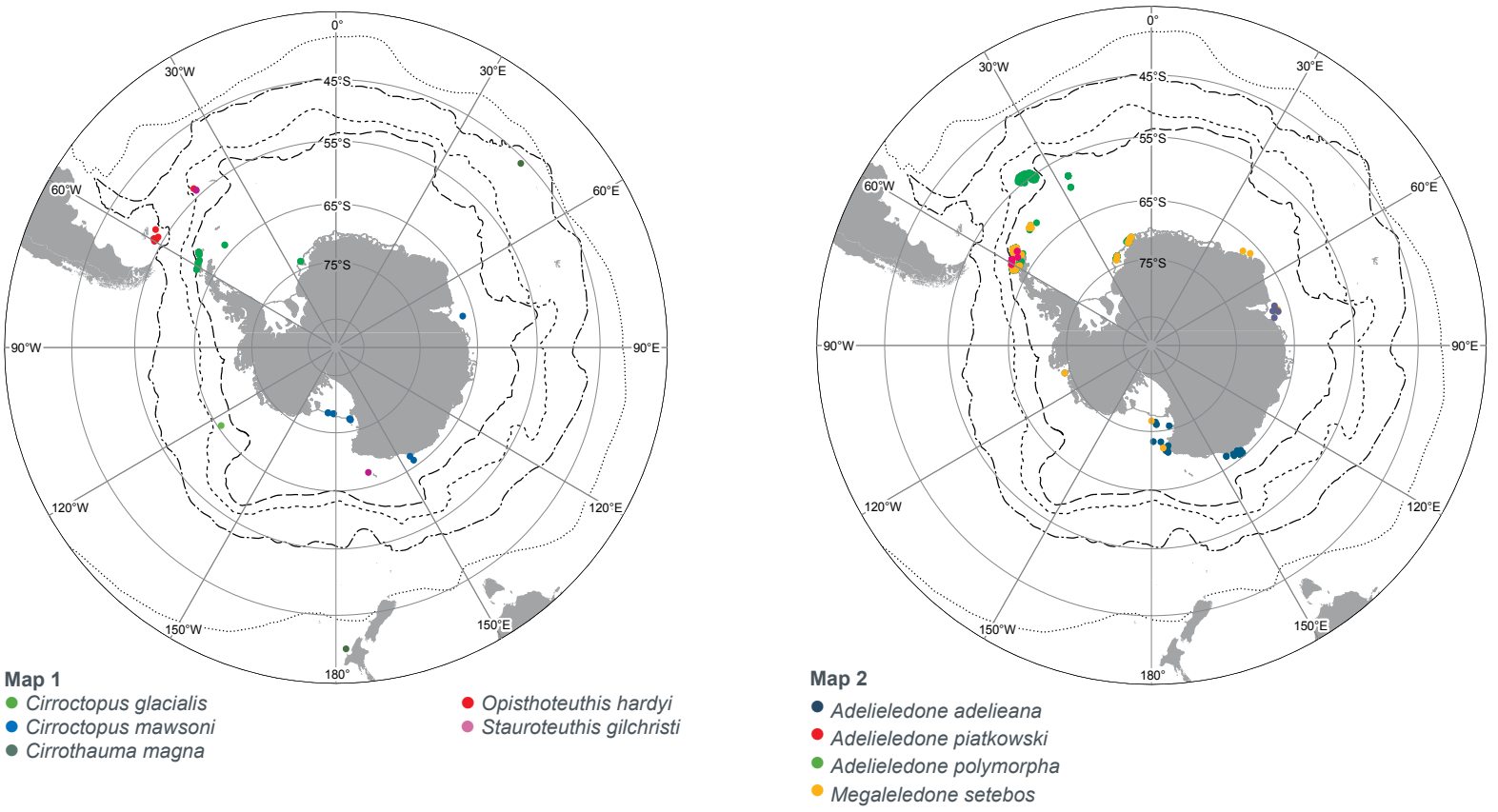
Family Opisthoteuthidae (Map 1). One species of the genus *Opisthoteuthis* is known from the Southern Ocean. *Opisthoteuthis hardyi* was originally described from South Georgia at depths of 800–1000 m, but the distribution of this demersal species is now known to cross the Polar Front to the Falkland Islands where it has been captured between about 600 and 1400 m depth (Collins *et al.* 2010).

3.2. Incirrata

3.2.1. Southern Ocean endemic genera

There are three, well-established endemic genera of incirrate octopuses in the Southern Ocean: *Adelieledone*, *Megaleledone* and *Pareledone*. The species of all three genera are mainly found on the shelf although in a few cases the distribution may extend to the upper slope.

Megaleledone (Map 2). This monotypic genus contains the single species *M. setebos* which has a circum-Antarctic distribution. Its range does not extend to South Georgia. It is found from shallow waters <50 m depth to below 800 m.



Octopods Maps 1–2 Map 1. *Cirroctopus glacialis, Cirroctopus mawsoni, Cirrothauma magna, Opisthoteuthis hardyi, Stauroteuthis gilchristi.* Map 2. *Adelieledone adelieana, Adelieledone piatkowski, Adelieledone polymorpha, Megaleledone setebos.*

Adelieledone (Map 2). Three species of *Adelieledone* have been described: *A. adelieana*, *A. polymorpha* and *A. piatkowski*. *A. adelieana* is distributed in East Antarctica in depths from 139 m to 680 m. *Adelieledone polymorpha* is distributed in West Antarctica. This species occurs around South Georgia in depths from 102 m to 364 m but has been taken in water as deep as 804 m around the South Shetland Islands. Molecular work may reveal that *A. polymorpha* and *A. adelieana* are conspecific since a continuum of morphological variation is seen throughout the range of these species. *Adelieledone piatkowski* is known only from the islands around the Antarctic Peninsula in depths from 612 m to 1510 m.

Pareledone (Map 3–7). This is the most speciose cephalopod genus in the Southern Ocean. Thirteen species are currently considered valid. One species, *Pareledone turqueti*, differs from other species by its lack of papillae. This species was thought to be restricted to West Antarctica, but recent molecular work has shown that this species is actually circum-Antarctic (Strugnell *et al.* 2012). Previously, records from East Antarctica have been referred to the name *P. harrissoni.* This now appears to be a junior synonym of *P. turqueti.* Twelve species of *Pareledone* with extensive papillae covering their dorsal and sometimes ventral surfaces are currently considered valid. Some species have limited depth distributions. This factor probably combines with their reproductive mode — their eggs hatch as benthic crawl-away young that spend no time in the plankton — to limit their geographic ranges, although at least two species have circum-Antarctic distributions. Unfortunately few areas have been well sampled so the true distribution of these species is mostly unknown.

3.2.2. Genera with a wider global distribution

Enteroctopus (Map 8). The genus *Enteroctopus* does not extend south of the Polar Front: it is restricted to temperate waters in the northern and southern hemisphere. However, the distribution of one species, *Enteroctopus megalocyathus,* extends from the Argentinian coast as far south as the Falkland Islands.

Muusoctopus (Map 8). Formerly known as *Benthoctopus*, this genus has representative species on either side of the Polar Front although no species has a distribution extending across the front. *Muusoctopus eureka, M. longibrachus* and *M. bizikovi* are all known from the Patagonian shelf with reported distributions that encompass the Falkland Islands. They do not occur south of the Polar Front. *Muusoctopus thielei* is known from around the Kerguelen Islands. Although the mean path of the Polar Front lies to the south of these islands, the front has been recorded to the north of them (Moore *et al.* 1999). *Muusoctopus levis* is known from the adjacent Heard and MacDonald Islands. Molecular work has confirmed the validity of these species (Strugnell *et al.* 2011). They appear to be sister taxa that diverged around 6 Ma. *Muusoctopus rigbyae* is reported from the Antarctic Peninsula and similar, but morphologically and genetically divergent specimens (not mapped), have been reported from the Weddell Sea, Amundsen Sea and Adélie Land. In a molecular analysis, these specimens all formed a monophyletic clade, but were estimated to have diverged around 5 Ma. This appears to be a species complex, and further work is required to elucidate the distributional extent of each species. Southern Ocean individuals appear to be found at shallower depths than their global counterparts. Interestingly, *Muusoctopus* appears to have invaded the Southern Ocean twice providing independent examples of polar emergence (Strugnell *et al.* 2011).

Graneledone (Map 9). This genus is distributed globally throughout the world's oceans and comprises nine species. Four species are reported from the Southern Ocean but only one is found in the high Antarctic. *Graneledone yamana* is reported from the continental slope off Argentina in depths from 90–1000 m as far south as Burdwood Bank while *G. macrotyla* is known from deeper waters off Burdwood Bank. *Graneledone gonzalezi* is known from shallower waters (circa 500 m depth) on the Kerguelen-Heard Plateau. *G. antarctica* appears to be circum-Antarctic and is reported from 1500 to 2300 m. It is thought that the genus *Graneledone* had its evolutionary origins in Antarctica (Strugnell *et al.* 2008).

Thaumeledone (Map 10). There are nomenclatural issues surrounding this genus and its species. A deep-water (circa 3000 m) circum-Antarctic species occurs in the Southern Ocean. It has mostly been treated under the name *T. brevis*, although the type locality of *T. brevis* is off Montevideo and it is unlikely that the distribution of this species extends to the Southern Ocean. Allcock *et al.* (2004) treated the circum-Antarctic species under the name *T. rotunda* based on the similarity of newly captured specimens to *Eledone rotunda*, known only from the holotype. Norman & Hochberg (2005) disagreed with this synonymy. The state of the type material makes the nomenclature difficult to resolve. Two other species of *Thaumeledone* occur south of the Polar Front. *Thaumeledone gunteri* is known from South Georgia in depths of 364–964 m. *Thaumeledone peninsulae* is known from off the South Shetland Islands and Powell Basin in depths of 377–1512 m. It is thought that this genus also had its evolutionary origins in Antarctica (Strugnell *et al.* 2008). No specimens of the genus have been reported north of Montevideo.

3.2.3. Other genera

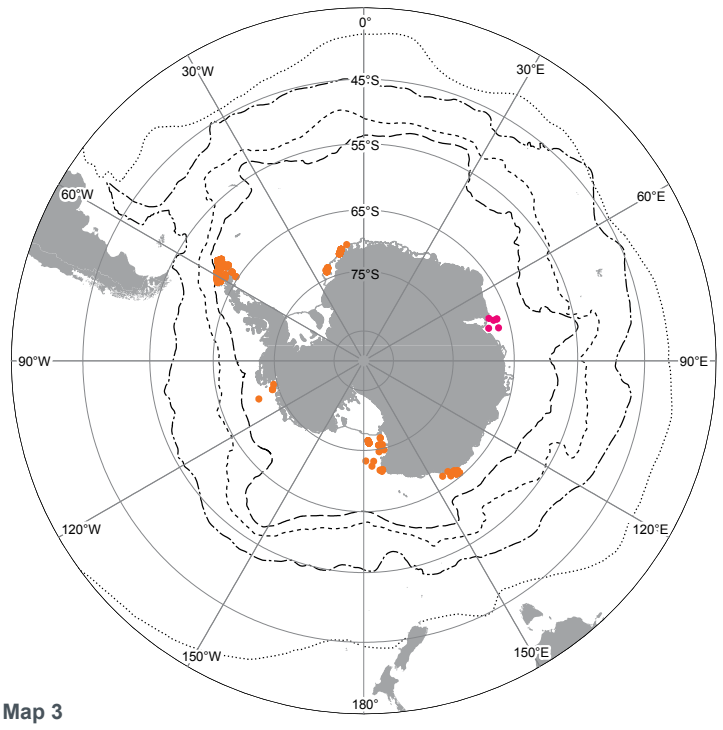
Two poorly-known Southern Ocean genera (Map 11) are currently monospecific but so few records exist it is not possible to categorise these genera as either endemic or deep-sea. *Bathypurpurata profunda* is a highly distinctive species known from a single specimen captured off Elephant Island. It is the only pygmy species reported from the Southern Ocean. The captured individual was a mature female with a dorsal mantle length of just 23 mm taken at a depth of around 500 m. *Praealtus paralbida* is known from a few specimens taken in deep water circa 3000 m off the Antarctic Peninsula. The similarity of this species to a specimen reported from East Antarctic as *Moschites albida* (Berry, 1917) has been noted (Allcock *et al.* 2004). These two names may refer to a single circum-Antarctic species but additional captures from East Antarctica are required to confirm this.

4. Published Records

Stauroteuthis gilchristi (Robson, 1924) (Map 1). Type locality: 2604 m depth southwest of Cape Town, South Africa. Type material: Holotype BMNH 1924.9.9.7. Other published Southern Ocean records: South Georgia (Collins & Henriques 2000).

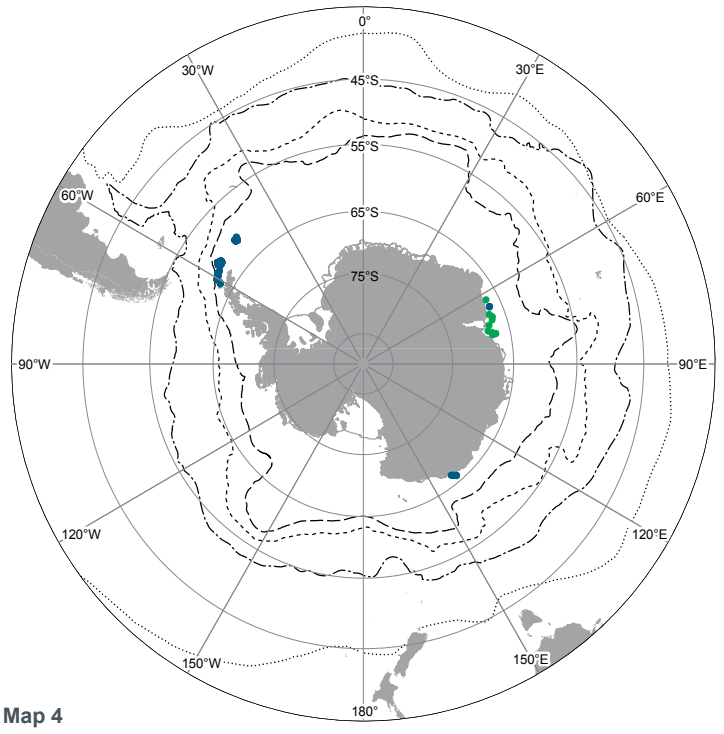
Cirrothauma magna (Hoyle, 1885) (Map 1). Type locality: 2557 m, South Indian Ocean, between Prince Edward and Crozet Islands (45°46'S, 45°31'E). Type material: Holotype BMNH 1890.1.24.1.

Cirroctopus glacialis (Robson, 1930) (Map 1). Type locality: Schollaert Channel (64°21'S, 62°58'W). Type material: Holotype BMNH Holotype 1951.4.26.1. Other published Southern Ocean records: King George Island and Elephant Island (Vecchione *et al.* 1998), Smith Island and Elephant Island (holotype and paratype of *Grimpoteuthis antarctica*



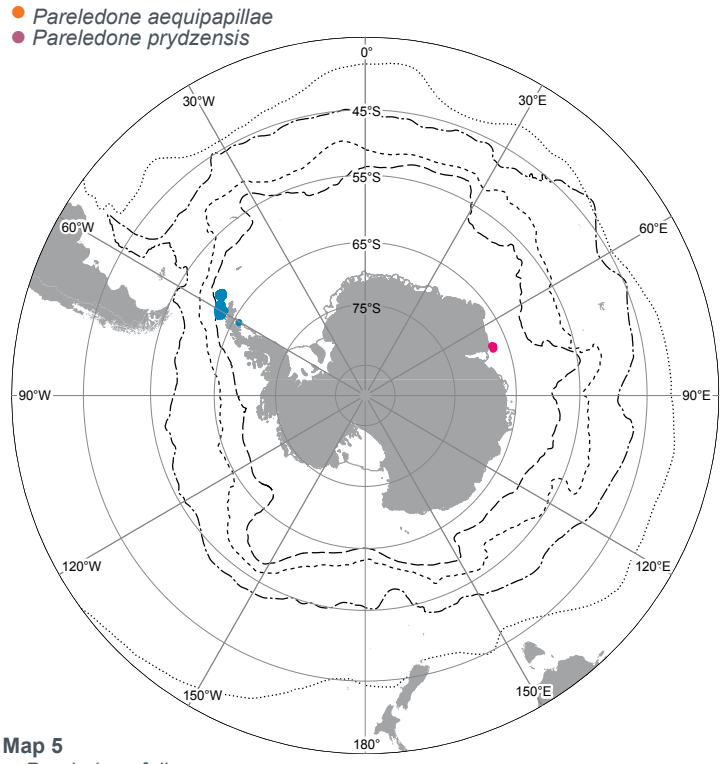
Map 3

- *Pareledone aequipapillae*
- *Pareledone prydzensis*



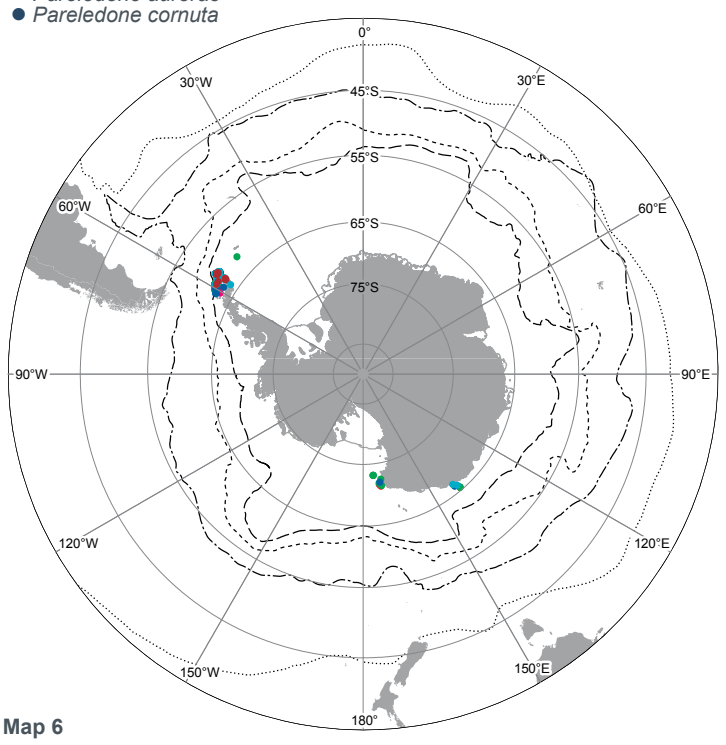
Map 4

- *Pareledone aurorae*
- *Pareledone cornuta*



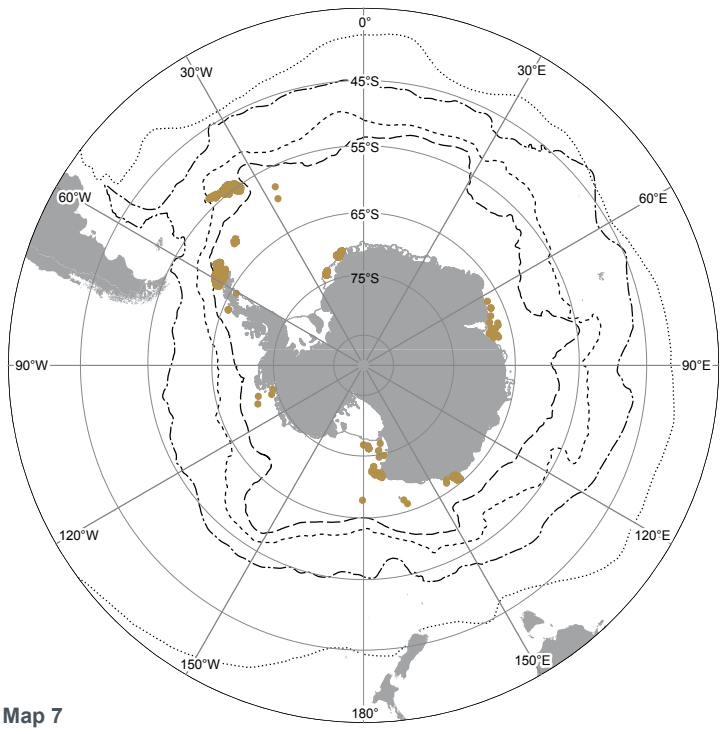
Map 5

- *Pareledone felix*
- *Pareledone framensis*



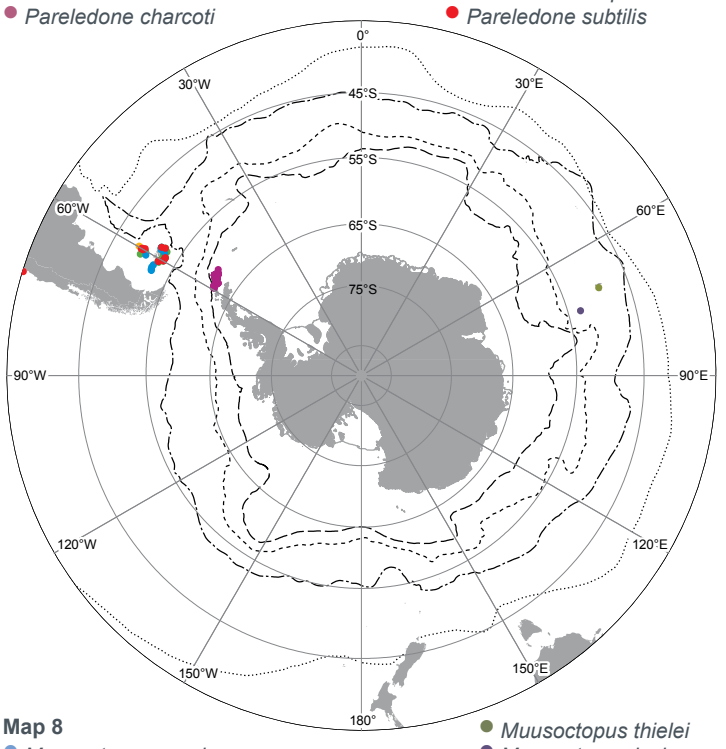
Map 6

- *Pareledone albimaculata*
- *Pareledone aurata*
- *Pareledone charcoti*
- *Pareledone panchroma*
- *Pareledone serperastrata*
- *Pareledone subtilis*



Map 7

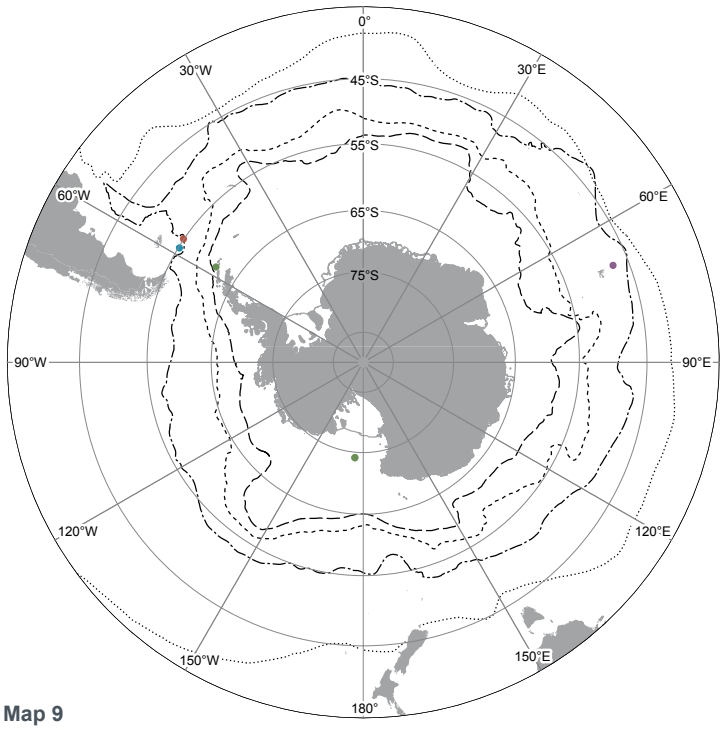
- *Pareledone turqueti*



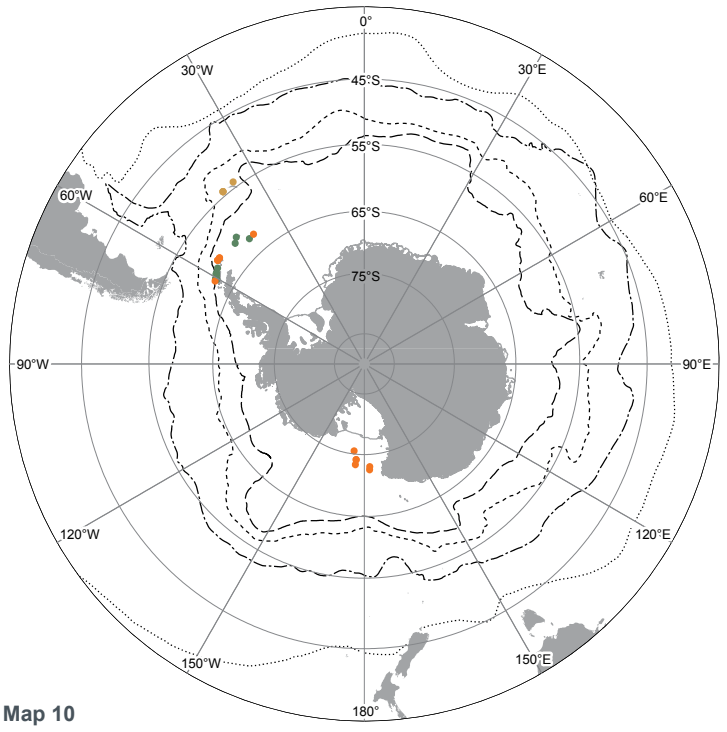
Map 8

- *Muusoctopus eureka*
- *Muusoctopus longibrachus*
- *Muusoctopus rigbyae*
- *Muusoctopus thielei*
- *Muusoctopus levis*
- *Muusoctopus bizikovi*
- *Enteroctopus megalocyathus*

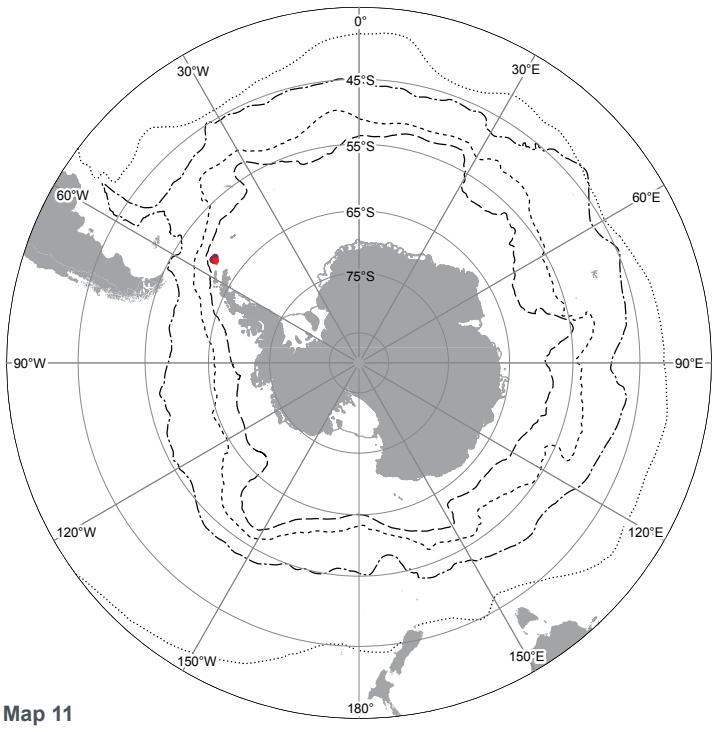
Octopods Maps 3–8 *Pareledone* spp Map 3. *Pareledone aequipapillae, Pareledone prydzensis.* Map 4. *Pareledone aurorae, Pareledone cornuta.* Map 5. *Pareledone felix, Pareledone framensis.* Map 6. *Pareledone albimaculata, Pareledone aurata, Pareledone charcoti, Pareledone panchroma, Pareledone serperastrata, Pareledone subtilis.* Map 7. *Pareledone turqueti.* Map 8. *Muusoctopus eureka, Muusoctopus longibrachus, Muusoctopus rigbyae, Muusoctopus thielei, Muusoctopus levis, Muusoctopus bizikovi, Enteroctopus megalocyathus.*



Map 9
- *Graneledone antarctica*
- *Graneledone gonzalezi*
- *Graneledone macrotyla*
- *Graneledone yamana*



Map 10
- *Thaumeledone rotunda*
- *Thaumeledone gunteri*
- *Thaumeledone peninsulae*



Map 11
- *Bathypurpurata profunda*
- *praealtus paralbida*

Octopods Maps 9–11 Map 9. *Graneledone antarctica, Graneledone gonzalezi, Graneledone macrotyla, Graneledone yamana.* Map 10. *Thaumeledone rotunda, Thaumeledone gunteri, Thaumeledone peninsulae.* Map 11. *Bathypurpurata profunda, Praealtus paralbida.*

Kubodera & Okutani 1986 - holotype NSMT 63958, 804 m, 62°59'S, 62°09'W).

Cirroctopus mawsoni (Berry, 1917) (Map 1). Type locality: 530–550 m, off Adélie Land (66°55'S, 145°21'E). Type material: Holotype AMS C40886.

Opisthoteuthis hardyi Villanueva, Collins, Sanchez & Voss, 2002 (Map 1). Type locality: 800–1000 m, near South Georgia Island (53°18'S, 42°12'W). Type material: Holotype NMSZ 1999158.088.

Megaleledone setebos (Robson, 1932) (Map 2). Type locality: in a rockpool, McMurdo Sound, off Cape Evans (77°40'S, 166°30'W). Type material: Holotype BMNH 1919.12.30.27. Other published Southern Ocean records: Ross Sea, Weddell Sea, South Orkney Islands, South Shetland Islands, Prydz Bay (Allcock *et al.* 2003a), East Antarctica (holotype of *Megaleledone senoi* Taki, 1961 - Holotype YTKC, 67°51.5'S, 33°13.5'E).

Adelieledone adelieana (Berry, 1917) (Map 2). Type locality: 450–549 m, off Adélie Land (66°55'S, 145°21'E). Type material: holotype. AMS C4088. Other published Southern Ocean records: Prydz Bay, off MacRobertson Land, off Enderby Land (Lu & Stranks 1994), off Dronning Maud Land (syntypes of *Pareledone umitakae* Taki, 1961 - syntypes YTKC, 67°51.5'S, 33°13.5'E).

Adelieledone piatkowski Allcock, Hochberg, Rodhouse & Thorpe, 2003 (Map 2). Type locality: 804–930 m, off the South Shetland Islands (61°58.5'S, 60°18.7'W). Type material: Holotype NMSZ 2000081.053.

Adelieledone polymorpha (Robson, 1930) (Map 2). Type locality: 120–204 m, mouth of Cumberland Bay, South Georgia. Type material: Syntypes BMNH 1951.4.26. Other published Southern Ocean records: South Georgia, South Orkney Islands, South Shetland Islands, Palmer Archipelago (Allcock *et al.* 2003b), Weddell Sea (Allcock *et al.* 2001).

Pareledone aequipapillae Allcock, 2005 (Map 3). Type locality: 278–343 m, Elephant Island (61°10'S, 54°34'W). Type material: Holotype NMSZ 2003152.002. Other published Southern Ocean records: South Shetland Islands, Larsen Ice Shelf, Adélie Land, Weddell Sea, Ross Sea, Amundsen Sea (Allcock *et al.* 2011).

Pareledone albimaculata Allcock, 2005 (Map 6). Type locality: 480 m, South Shetland Islands (61°19'S, 56°33'W). Type material: Holotype BMNH 1996192. Other published Southern Ocean records: Larsen Ice Shelf (Allcock *et al.* 2011).

Pareledone aurata Allcock, 2005 (Map 6). Type locality: 264–270 m, Elephant Island (61°21'S, 55°14'W). Type material: Holotype NMSZ 2003152.001. Other published Southern Ocean records: South Shetland Islands (Allcock *et al.* 2011).

Pareledone aurorae (Berry, 1917) (Map 4). Type locality: 220 m, off Queen Mary Land (66°08'S, 94°17'E). Type material: Holotype AMS C40891. Other published Southern Ocean records: off MacRobertson Land, off Enderby Land, Prydz Bay (Lu & Stranks 1994)

Pareledone charcoti (Joubin, 1905) (Map 6). Type locality: Shore, Wandel Island (Booth Island), Antarctic Peninsula (65°05'S, 64°W). Type material:

Lectotype MNHN 5.7.1095. Other published Southern Ocean records: Antarctic Peninsula, South Shetland Islands (Allcock 2005).

Pareledone cornuta Allcock, 2005 (Map 4). Type locality: 169–175 m, South Shetland Islands (61°10'S, 56°04'W). Type material: Holotype BMNH 1996196. Other published Southern Ocean records: South Orkney Islands, Adélie Land, Prydz Bay, Weddell Sea (Allcock *et al.* 2011).

Pareledone felix Allcock, Strugnell, Prodohl, Piatkowski & Vecchione, 2007 (Map 5). Type locality: 278–343 m, Elephant Island (61°10'S, 54°41'W). Type material: Holotype NMSZ 2002037.013. Other published Southern Ocean records: South Shetland Islands, Larsen Ice Shelf (Allcock *et al.* 2011).

Pareledone framensis Lu & Stranks, 1994 (Map 5). Type locality: 145–150 m, Fram Bank, off MacRobertson Land (67°29'S, 68°50'E). Type material: Holotype NMV F65665.

Pareledone panchroma Allcock, 2005 (Map 6). Type locality: 804–930 m, South Shetland Islands (61°59'S, 60°19'W). Type material: Holotype NMSZ 2003152.005. Other published Southern Ocean records: South Shetland Islands, South Orkney Islands, Adélie Land, Ross Sea (Allcock *et al.* 2011).

Pareledone prydzensis Lu & Stranks, 1994 (Map 3). Type locality: 526–532 m, Prydz Bay (66°48'S, 72°33'E). Type material: Holotype NMV F65666. Other published Southern Ocean records: ?Weddell Sea, ?Ross Sea, ?Adélie Land (Allcock *et al.* 2011).

Pareledone serperastrata Allcock, 2005 (Map 6). Type locality: 123–159 m, South Shetland Islands (61°01'S, 55°46'W). Type material: Holotype NMSZ 2003152.003.

Pareledone subtilis Allcock, 2005 (Map 6). Type locality: 308–399 m, Elephant Island (61°04'S, 54°36'W). Type material: Holotype NMSZ 2003152.004. Other published Southern Ocean records: South Shetland Islands (Allcock *et al.* 2011).

Pareledone turqueti (Joubin, 1905) (Map 7). Type locality: Shore, Wandel Island (Booth Island), Antarctic Peninsula (65°05'S, 64°W). Type material: Lectotype MNHN 5.7.1089. Other published Southern Ocean records: South Shetland Islands, South Orkney Islands, South Georgia, South Sandwich Islands, Prydz Bay, Adélie Land, Ross Sea, Amundsen Sea (Strugnell *et al.* 2012), East Antarctica (holotype of *Pareledone harrissoni* (Berry, 1917) — holotype AMS C40892, 65°06'S, 96°13'E).

Enteroctopus megalocyathus (Gould, 1852) (Map 8). Type locality: Orange Harbour, Tierra del Fuego. Type material: believed lost.

Muusoctopus eureka (Robson, 1929) (Map 8). Type Locality: shore, Falkland Islands (51°49'S, 57°51'W). Type material: Lectotype NMSZ 1921.143.558a.

Muusoctopus longibrachus Ibañez, Sepulveda & Chong, 2006 (Map 8). Type locality: Constitución coast, Chile at 35°10'S 72°55'W. Type material: Holotype MNHN (Chile) 3000123.

Muusoctopus bizikovi Gleadall, Guerrero-Kommritz, Hochberg & Laptikhovsky, 2010 (Map 8). Type locality: 467–478 m, north of West Falkland Island (48°43.6'S, 59°48'W). Type material: Holotype BMNH 20090279.

Muusoctopus thielei (Robson, 1932) (Map 8). Type locality: Bassin de la Gazelle (49°18.5'S, 69°41'E). Type material: Holotype ZMB.

Muusoctopus levis (Hoyle, 1885) (Map 8). Type locality: 137 m, off Heard Island (52°59'S, 73°33'E). Type material: Holotype BMNH 1889.4.24.43.

Muusoctopus rigbyae Vecchione, Allcock, Piatkowski & Strugnell, 2009 (Map 8). Type locality: 394–412 m, off Elephant Island (61°13.8'S, 56°25.8'W). Type material: Holotype USNM 1117765. Other published Southern Ocean Records: throughout South Shetland Islands (Vecchione *et al.* 2009 b).

Graneledone antarctica Voss, 1976 (Map 9). Type locality: 2341 m, Ross Sea (74°09'S, 175°09'W). Type material: Holotype USNM 729679. Other published Southern Ocean records: Antarctic Peninsula (Vecchione *et al.* 2005).

Graneledone gonzalezi Guerra, Gonzalez & Cherel, 2000 (Map 9). Type locality: 504 m, Kerguelen Plateau (47°15'S, 69°14'E). Type material: Holotype MNHN 3470.

Graneledone macrotyla Voss, 1976 (Map 9). Type locality: 1647–2044 m, southern slope of Burdwood Bank (54°43'S, 55°30'W). Type material: Holotype USNM 729678.

Graneledone yamana Kommritz, 2000 (Map 9). Type locality: 584–506 m, southern slope of Burdwood Bank (54°56'S, 58°05'W). Type material: Holotype ZMH 2781.

Thaumeledone rotunda (Hoyle, 1885) (Map 10). Type locality: 3500 m, East Antarctica (53°55'S, 108°35'E). Type material BMNH 1890.1.24.6. Other published Southern Ocean records: off Antarctic Peninsula, probably circum-Antarctic (Allcock *et al.* 2004).

Thaumeledone gunteri Robson, 1930 (Map 10). Type locality: 401–411 m, South Georgia (53°48.5'S, 35°57'W. Type material: BMNH 1951.4.26.50.

Thaumeledone peninsulae Allcock, Collins, Piatkowski & Vecchione, 2004 (Map 10). Type locality: 804–930 m, off South Shetland Islands (61°59'S, 60°19'W). Type material: Holotype NMSZ 2000081.057. Other published Southern Ocean records: Powell Basin (Allcock *et al.* 2004).

Bathypurpurata profunda Vecchione, Allcock & Piatkowski, 2005 (Map 11). Type locality: 509–565 m, off Elephant Island (61°02'S, 54°49'W). Type material: Holotype USNM 1020572.

Praealtus paralbida Allcock, Collins, Piatkowski & Vecchione, 2004 (Map 11). Type locality: 2896 m, off the Antarctic Peninsula (60°39'S, 53°58'W). Type material: Holotype NMSZ 2002038.002. Other published Southern Ocean records: ?off Wilkes Land (holotype of *Moschites albida* Berry 1917 – holotype AMS C40888, 3100 m, 64°34'S, 127°17'E).

Repository Abbreviations:

AMS – Australian Museum, Sydney; BMNH – Natural History Museum, London; MNHN – Museum National d'Histoire Naturelle, Paris; MNHN (Chile) – Chilean National Museum of Natural History; NMSZ – National Museums of Scotland, Edinburgh; NMV – Museum Victoria, Melbourne; NSMT – National Science Museum, Tokyo; USNM – Smithsonian Institution, Washington; YTKC – Private collection of the late Dr. Iwao Taki; ZMB – Zoologisches Museum, Berlin; ZMH – Zoologisches Museum, Hamburg.

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References

Allcock, A.L., 2005. On the confusion surrounding *Pareledone charcoti* (Joubin, 1905) (Cephalopoda: Octopodidae): endemic radiation in the Southern Ocean. *Zoological Journal of the Linnean Society*, **143**, 75–108.

Allcock, A.L., Barratt, I., Eléaume, M., Linse, K., Norman, M.D., Smith, P.J., Steinke, D., Stevens, D.W., Strugnell, J.M., 2011. Cryptic speciation and the circumpolarity debate: a case study on endemic Southern Ocean octopuses using the COI barcode of life. *Deep Sea Research II: Topical Studies in Oceanography*, **58**, 242–249.

Allcock, A.L., Brierley, A.S., Thorpe, J.P., Rodhouse, P.G.K., 1997. Restricted geneflow and evolutionary divergence between geographically separated populations of the Antarctic octopus *Pareledone turqueti*. *Marine Biology*, **129**, 97–102.

Allcock, A.L., Collins, M.A., Piatkowski, U., Vecchione, M., 2004. *Thaumeledone* and other deep water octopodids from the Southern Ocean. *Deep Sea Research Part II: Topical Studies in Oceanography*, **51**, 1883–1901.

Allcock, A.L., Hochberg, F.G., Rodhouse, P.G.K., Thorpe, J.P., 2003 b. *Adelieledone*, a new genus of octopodid from the Southern Ocean. *Antarctic Science*, **15**, 415–424.

Allcock, A.L., Hochberg, F.G., Stranks, T.N., 2003 a. Re-evaluation of *Graneledone setebos* (Cephalopoda: Octopodidae) and placement in the genus *Megaleledone*. *Journal of the Marine Biological Association of the UK*, **83**, 319–328.

Allcock, A.L., Piatkowski, U., Rodhouse, P.G.K., Thorpe, J.P., 2001. A study on octopodids from the eastern Weddell Sea, Antarctica. *Polar Biology*, **24**, 832–838.

Allcock, A.L., Strugnell, J.M., 2012. Southern Ocean diversity: new paradigms from molecular ecology. *Trends in Ecology and Evolution*, **27**, 520-528.

Brandt, A., 1992. Origin of Antarctic Isopoda (Crustacea, Malacostraca). *Marine Biology*, **113**, 415–423.

Collins, M.A., Henriques, C., 2000. A revision of the family Stauroteuthidae (Octopoda: Cirrata) with redescriptions of *Stauroteuthis syrtensis* and *S. gilchristi*. *Journal of the Marine Biological Association of the UK*, **80**, 685–697.

Collins, M.A., Laptikhovsky, M.A., Strugnell, J.M., 2010. Expanded description of *Opisthoteuthis hardyi* based on new specimens from the Patagonian slope. *Journal of the Marine Biological Association of the UK*, **90**, 605–611.

Collins, M.A., O'Dea, M., Henriques, C., 2001. A large *Cirroteuthis magna* (Cephalopoda: Cirroctopoda) caught on the Cape Verde Terrace (North Atlantic). *Journal of the Marine Biological Association of the UK*, **81**, 357–358.

Collins, M.A., Rodhouse, P.G.K., 2006. Southern Ocean Cephalopods. *Advances in Marine Biology*, **50**, 191–265.

Collins, M.A., Villanueva, R., 2006. Taxonomy, ecology and behaviour of the cirrate octopods. *Oceanography and Marine Biology: An Annual Review*, **44**, 277–322.

Griffiths, H.J., Danis, B., Clarke, A., 2011. Quantifying Antarctic marine biodiversity: The SCAR-MarBIN data portal. *Deep Sea Research Part II: Topical Studies in Oceanography*, **58**, 18–29.

Guerra, A., Villanueva, R., Nesis, K.N., Bedoya, J., 1998. Redescription of the deep-sea cirrate octopod *Cirroteuthis magna* Hoyle, 1885, and considerations on the genus *Cirroteuthis* (Mollusca: Cephalopoda). *Bulletin of Marine Science*, **63**, 51–81.

Lu, C.C., Stranks, T.N., 1994. Synopsis of *Pareledone* and *Megaleledone* species, with description of two new species from East Antarctica (Cephalopoda: Octopodidae). *Memoirs of the National Museum of Victoria*, **54**, 221–242.

Moore, J.K., Abbott, M.R., Richman, J.G., 1999. Location and dynamics of the Antarctic Polar Front from satellite sea surface temperature data. *Journal of Geophysical Research*, **104**, 3059–3073.

Norman, M.D., Hochberg, F.G., 2005. The current state of octopus taxonomy. *Phuket Marine Biological Center Research Bulletin*, **66**, 127–154.

O'Shea, S., 1999. The Marine Fauna of New Zealand: Octopoda (Mollusca: Cephalopoda). *NIWA Biodiversity Memoir*, **112**, 1–280.

Strugnell, J., Cherel, Y., Cooke, I.R., Gleadall, I.G., Hochberg, F.G., Ibáñez, C.M., Jorgensen, E., Laptikhovsky, V.V., Linse, K., Norman, M., Vecchione, M., Voight, J.R., Allcock, A.L., 2011. The Southern Ocean: source and sink? *Deep Sea Research II: Topical Studies in Oceanography*, **58**, 196–204.

Strugnell, J.M., Rogers, A.D., Prodöhl, P.A., Collins, M.A., Allcock, A.L., 2008. The thermohaline expressway: Antarctica as a centre of origin for deep-sea octopuses. *Cladistics*, **24**, 853–860.

Strugnell, J.M., Watts, P.C., Smith, P.J., Allcock, A.L., 2012. Persistent genetic signatures of historic climatic events in an Antarctic octopus. *Molecular Ecology*, **21**, 2775–2787.

Vecchione, M., Allcock, A.L., Piatkowski, U., 2005. Unusual incirrate octopods from the South Shetland Islands, Antarctica, including *Bathypurpurata profunda*, a newly discovered genus and species of deepwater pygmy octopod (Cephalopoda). *Phuket Marine Biological Center Research Bulletin*, **66**, 109–115.

Vecchione, M., Allcock, L., Piatkowski, U., Jorgensen, E., Barratt, I., 2009a. Persistent elevated abundance of octopods in an overfished Antarctic area. In: Krupnik, I., Laing, M.A., Miller, S.E. (eds.). *Smithsonian at the Poles: Contributions to International Polar Year Science*. Washington: Smithsonian Institution Scholarly Press, 197–204.

Vecchione, M., Allcock, L., Piatkowski, U., Strugnell, J. 2009b. *Benthoctopus rigbyae*, n. sp., a new species of cephalopod (Octopoda; Incirrata) from near the Antarctic Peninsula. *Malacologia*, **51**, 13–28.

Vecchione, M., Piatkowski, U., Allcock, A.L., 1998. Biology of the cirrate octopod *Grimpoteuthis glacialis* (Cephalopoda: Opisthoteuthidae) in the South Shetland Islands, Antarctica. *South African Journal of Marine Science*, **20**, 421–428.

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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