Census of Antarctic Marine Life
SCAR-Marine Biodiversity Information Network

BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN

CHAPTER 5.21. DECAPODA: CRABS AND LOBSTERS.

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THE BIOGEOGRAPHIC ATLAS OF THE SOUTHERN OCEAN

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5.21. Decapoda: Crabs & Lobsters

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1. Introduction

Crabs and lobsters (Brachyura, Anomura and Nephropidae) are reptant decapod crustaceans and form a relatively unknown and understudied component of the Southern Ocean benthos. Recent records show that 22 species of crabs and lobsters have been reported from the Southern Ocean with 12 species found south of 60°S. All records are restricted to waters warmer than 0°C, with their Antarctic distribution limited to the areas of seafloor dominated by Circumpolar Deep Water (CDW) (Map 1). This cold temperature restricted distribution has previously been explained by problems with haemolymph Mg^{2+} regulation at cold temperatures by the reptant decapods (Frederich *et al.* 2000). The most widely reported and abundant group of crabs or lobsters from the Southern Ocean are the Lithodidae (stone or king crabs). In recent years, the 'crab invasion' story has become a metaphor for climate change in the Antarctic marine realm, both in scientific literature and the media.

The available decapod fossil record reveals large gaps in knowledge during part of the Cretaceous due to a lack of suitable marine deposits in Antarctica. There are many controls on the preservation of decapods which make interpreting their evolutionary history difficult and a large percentage (99.7%) of the Antarctic continent is covered by snow and ice (Convey *et al.* 2008), restricting the exposure area in which fossils can be found, and resulting in an intermittent record. The Late Cretaceous through to the end of the Eocene shows the highest diversity at family level and most fossil records across all infraorders (Feldman *et al.* 1993, Feldman & Schweitzer 2006, Griffiths *et al.* 2013). Although there are marine fossil sites for the Oligocene through to the Pleistocene they are generally made up of drill holes or short stratigraphic sequences. Only two families from the decapod fossil record exist south of 60°S at the present day, the Nephropidae and the Galatheidae (Griffiths *et al*. 2013). Both are known from single living records found in deep water. The global fossil history of Lithodidae is extremely poor, consisting of only two occurrences, one from the Middle Miocene of New Zealand and a broken claw from the Miocene of Japan (Feldmann 1998, Karasawa & Ohara 2012).

The earliest records of Recent Southern Ocean crab and lobster species date back to the *Challenger* expedition with records of *Lithodes murrayi* and *Paralomis aculeata* from the Prince Edward Islands in 1873 (Henderson 1888). The first record of a crab in Antarctica (south of 60°S) is of a single record of the brachyuran crab *Halicarcinus planatus* from shores of the South Orkney Islands in 1903 (Stebbing 1914). Records of Antarctic Lithodidae date back to an individual of *Paralomis birsteini* collected by the RV *Eltanin* in 1958 from near Scott Island, north of the Ross Sea (Ahyong 2010) and they were not recorded again until 1994 near Peter I Island (Klages *et al.* 1995). There are a total of nine encounters with Lithodidae recorded from the slope/shelf of Antarctica with the earliest dating back to 1998 (Arana & Retamal 1999). García Raso *et al.* (2005) suggested that many of the observed distribution patterns of Antarctic lithodids were an artefact of limited sampling rather than representing true distributions. The most recent Southern Ocean species to be described is the lobster *Thymops takedai* (Ahyong *et al.*, 2012) from the South Georgia region. Earlier studies on the biogeography of the SO concentrated on the decapods as a whole (Zarenkov 1968, Gorny 1999, Boschi & Gavio 2005), and as such are dominated by data for the shrimps or groups not found in Antarctic waters and predate most records of crabs south of 60°S. Spiridonov *et al*. (2006), were among the first to discuss the biogeography of the SO lithodids, concluding that that there is not a single, homogeneous, Antarctic/sub-Antarctic lithodid fauna, but the species assemblages change from west to east. Hall & Thatje (2011) examined the link between the biogeography of the Lithodidae and seafloor temperature and were the first to quantify the known temperature limits of the SO lithodids, giving examples of cold tolerant and cold intolerant species from the three genera present in the region.

Photo 1 *Paralomis stevensi* Ahyong & Dawson, 2006, Ross Sea. Image © S. Ahyong.

The first crabs to be labelled as 'invasive' in Antarctic waters were two individuals of *Hyas araneus* found at the South Shetland Islands (Tavares & De Melo 2004). Tavares and De Melo (2004) postulated that these brachyuran crabs, usually found in the North Atlantic and Arctic Oceans, entered the Antarctic either on ships' sea-chests or through ballast water. The first study to suggest that lithodids were potentially 'recolonising' or 'invading' the Antarctic shelf as result of climate change was Thatje *et al.* (2005). This was also the first study to suggest that adult lithodid crabs crossing the deep sea was the most likely route for any invasion, although others had suggested a longer scale recolonisation of the Antarctic through the deep sea by the eurybathic genus *Neolithodes* from regions further north (Macpherson 2004).

2. Distribution patterns

To date 22 species of crabs and lobsters are recorded from the SO. The known distributions of all Recent Lithodidae in the SO are constrained by temperature with no records from areas where water temperatures are lower than 0°C (Map 1).

There are six species of Lithodidae found south of 60°S (Maps 2–7), representing 137 animals from 61 separate locations. Two species of lithodids have only ever been found south of 60°S, *N. yaldwyni* and *P. stevensi* (Maps 2 and 3). A single record of *Munidopsis albatrossae* exists from the slope of the Antarctic Peninsula in the Bellingshausen Sea (Map 7). The Brachyura are represented by three species south of 60°S. A single record of *H. planatus* is known from the South Orkney Islands (Stebbing 1914). Most records of this species come from South America and the sub-Antarctic (Map 8). Two further species of Brachyura have been recorded from the South Shetland Islands, *Rochinia gracilipes* (usually found in South American waters) and *Hyas araneus* (a North Atlantic species) (De Melo 1995,Tavares & De Melo 2004) (Map 8). None of these brachyuran species have been collected in the region since. Other species with records south of 60°S are an undescribed *Kiwa* sp. associated with warm temperatures prevailing at hydrothermal vents, and the lobster *Thymopsis nilenta* from the deep sea, but in both cases samples were taken from the Scotia Arc just south of 60°S, well away from the Antarctic Continental Shelf itself.

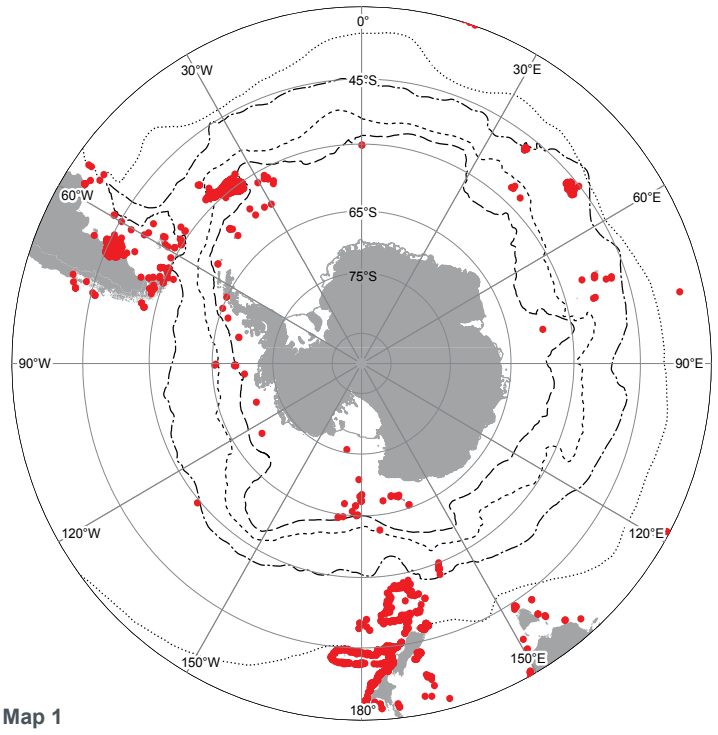
There are nine recorded encounters with lithodids (observations or specimens captured) on or near to the Antarctic shelf/slope (<50 km from the 1000 m bathymetric contour). These nine encounters represent 62 individuals from four species (44 *Neolithodes yaldwyni*, 16 *Paralomis birsteini*, 1 *Neolithodes capensis* and 1 *Paralomis stevensi*) (Map 2). These records range from 850 m to 1947 m deep and occur from the slope of the Ross Sea through to the North West end of the Antarctic Peninsula (64.9°S – 75.5°S & 178.7°W – 64.3°W). No records of lithodids exist for the Antarctic shelf/slope beyond the Ross, Amundsen, and Bellingshausen Seas.

Other SO species restricted to south of the Sub-Antarctic Front or near to the PF include five species of Lithodidae (*Lithodes macquariae*, *Paralomis anamerae, P. elongata, P. aculeata* and *Neolithodes duhameli*) (Maps 9–11), one species of Kiwaidae (Map 10) and two species of Nephropidae (*Thymopides grobovi* and *T. nilenta*) (Maps 11–12). A further two species of lobster, *Thymops takedai* and *T. birsteini* (Map 13), and two lithodids, *Paralomis formosa* (Map 14) and *P. spinosissima* (Map 15) have been found to span the Drake Passage with records in southern South America and South Georgia. None of the species of lobster (Nephropidae) are found near to the Antarctic shelf and at this stage can be considered to be mostly sub-Antarctic in distribution, although this may change with increased deep water sampling.

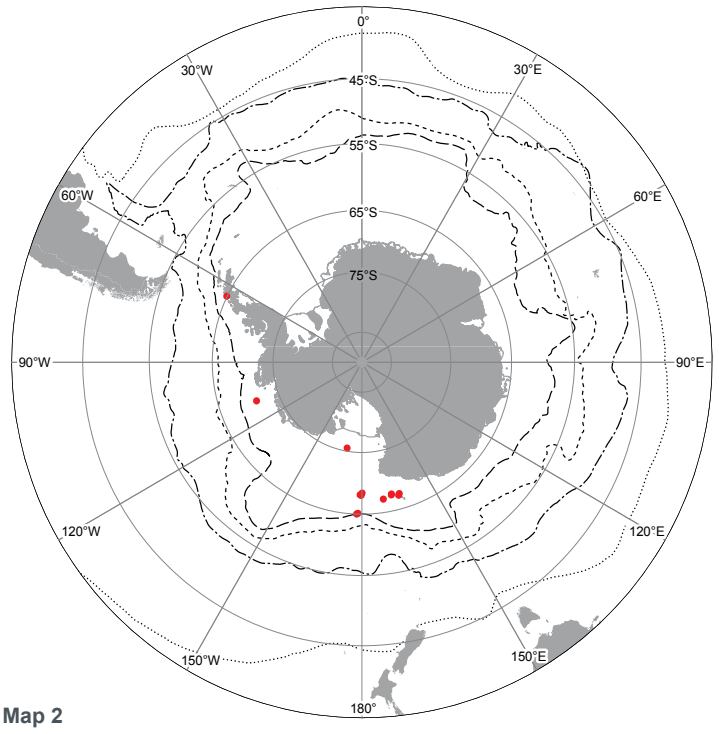
3. Depth distribution

The majority of species examined in this study (13 out of 21) can be considered to be highly eurybathic, with depth ranges exceeding 1000 m (Griffiths *et al.* 2013). None of the Brachyura displayed depth ranges greater than ~400 m. The species with the smallest depth ranges included those with only very few records e.g. newly discovered *Kiwa* sp., known from two locations in the Scotia Sea (Rogers *et al*. 2012), and *P. elongata,* which is also recorded from two locations near Bouvet Island. In general, the nephropid lobsters displayed wide depth ranges e.g. *T. nilenta* with a depth range of 2218 m. The lithodid genus *Paralomis* had the greatest number of species (5 species) with depth ranges wider than 1000 m. The widest depth range examined belonged to the lithodid *N. capensis* with a depth range of 2540 m (660–3200 m).

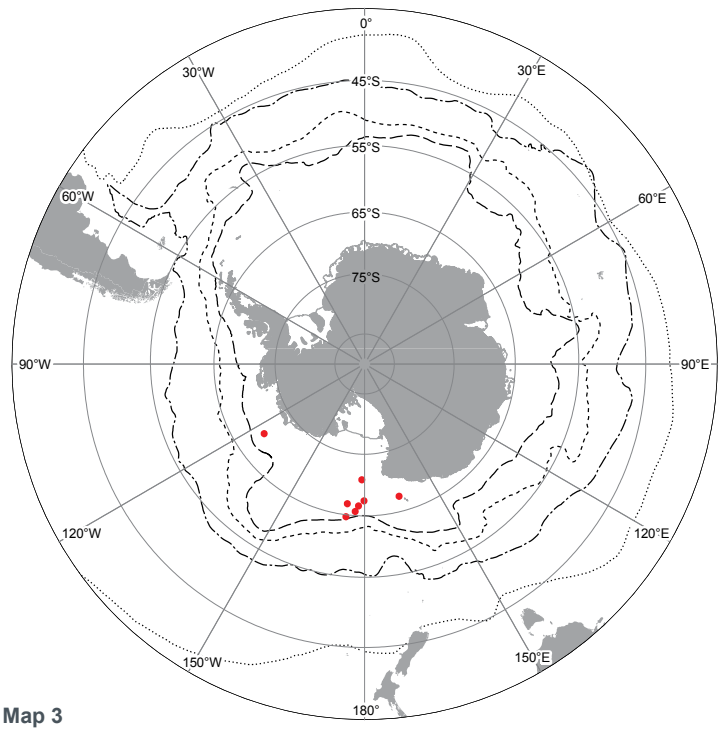
The depths of samples taken from Antarctic waters (south of 60°S) and from the slope/shelf of the Antarctic continent tended to sit within the normal depth range of the species (Griffiths *et al*. 2013). All Antarctic slope/shelf records, other than a single record for *P. birsteini* (1947 m), are within the standard deviation of each species' depth range. The only known record of *P. stevensi* from the Antarctic slope/shelf is lacking a depth record at its location (Ahyong, 2010), but bathymetric data suggest an approximate depth of 1000 m, making it the shallowest known record for this species. The single record of *M. albatrossae* is the only record of this species in the SO and is its shallowest record to date (1920 m).



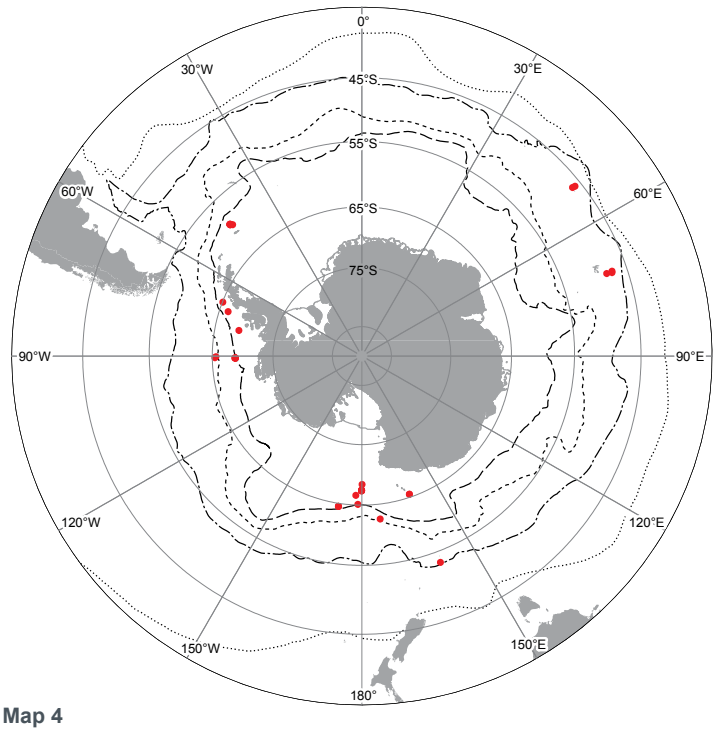
Map 1
● All records of crabs and lobsters



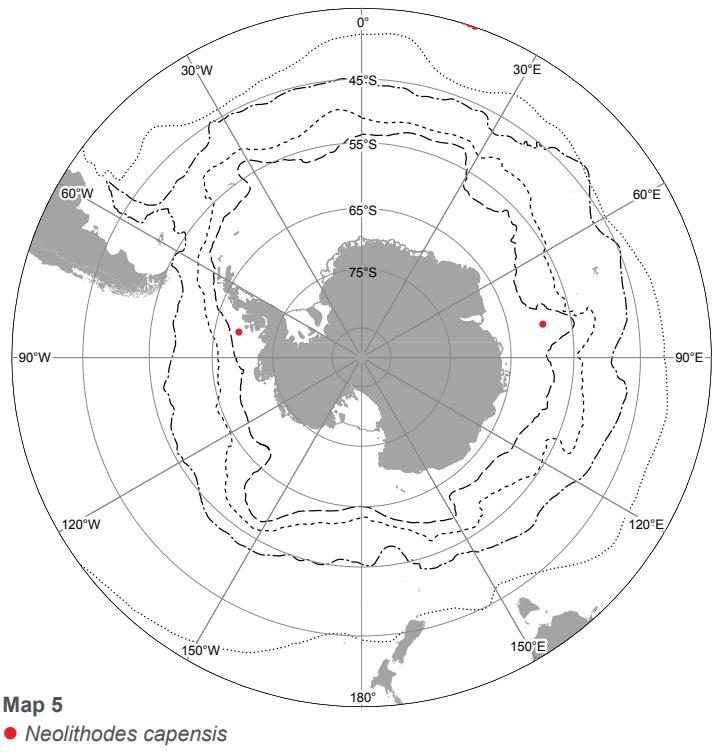
Map 2
● *Neolithodes yaldwyni*



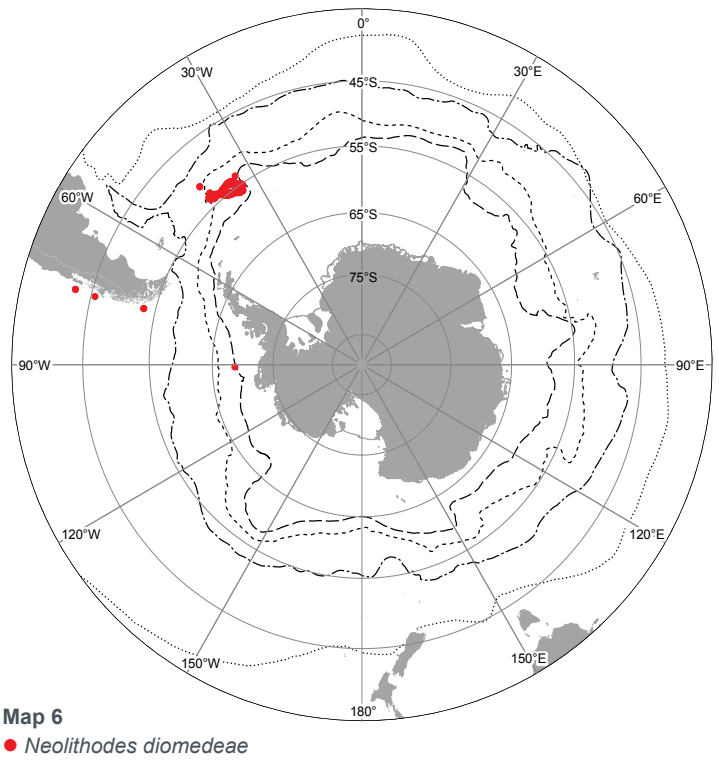
Map 3
● *Paralomis stevensi*



Map 4
● *Paralomis birsteini*

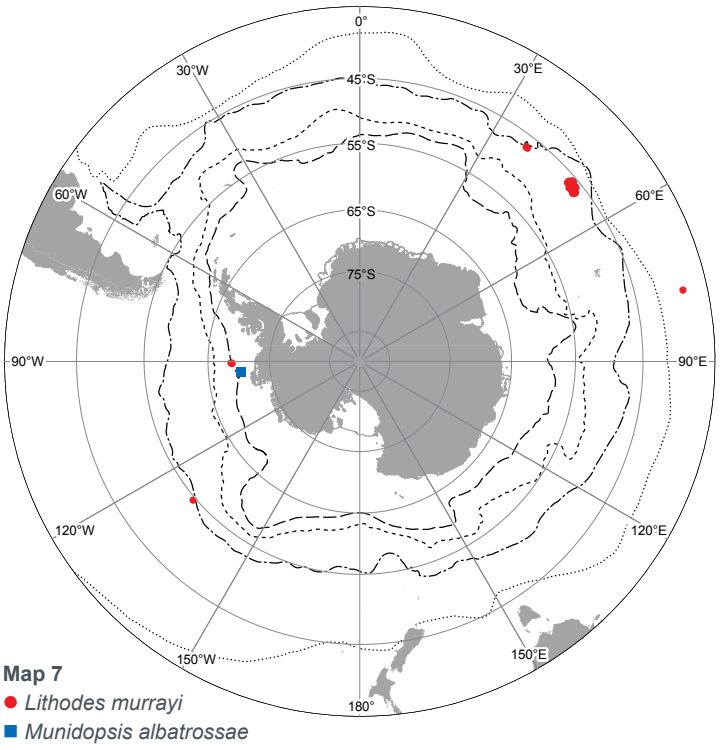


Map 5
● *Neolithodes capensis*

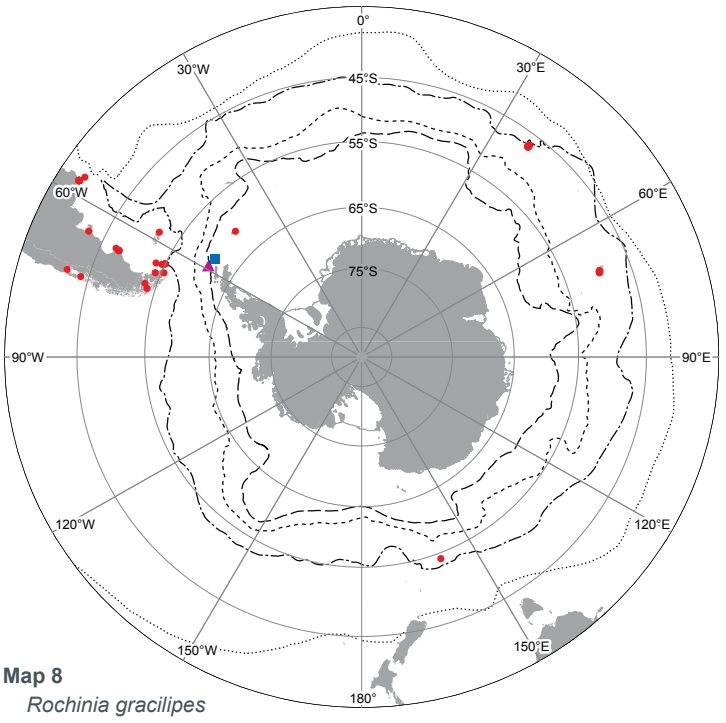


Map 6
● *Neolithodes diomedeae*

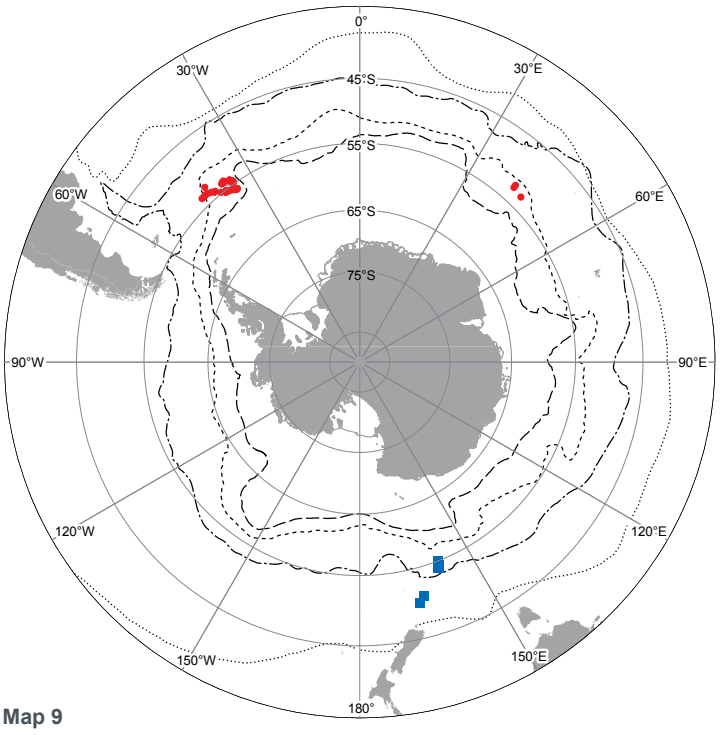
Decapoda Reptantia Maps 1–6 Map 1. All known records of Southern Ocean crabs and lobsters. Map 2. *Neolithodes yaldwyni* Ahyong & Dawson, 2006. Map 3. *Paralomis stevensi* Ahyong & Dawson, 2006. Map 4. *Paralomis birsteini* Macpherson, 1988. Map 5. *Neolithodes capensis* Stebbing, 1905. Map 6. *Neolithodes diomedeae* (Benedict, 1895).



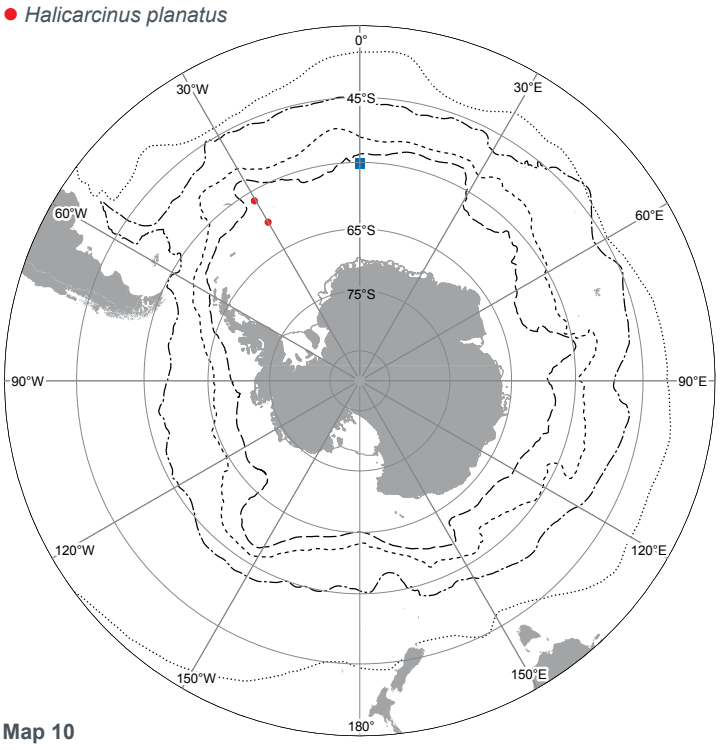
Map 7
- *Lithodes murrayi*
- *Munidopsis albatrossae*



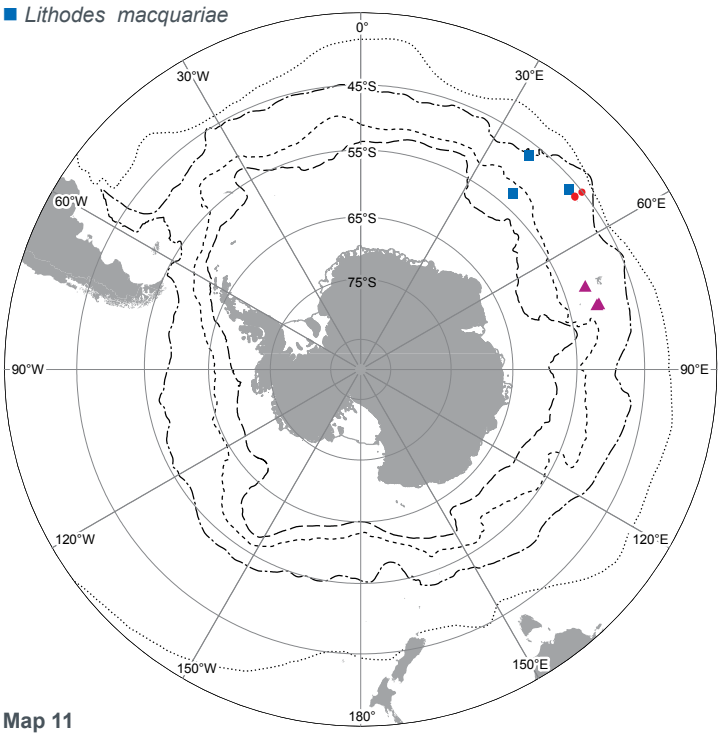
Map 8
- *Rochinia gracilipes*
- *Hyas araneus*
- *Halicarcinus planatus*



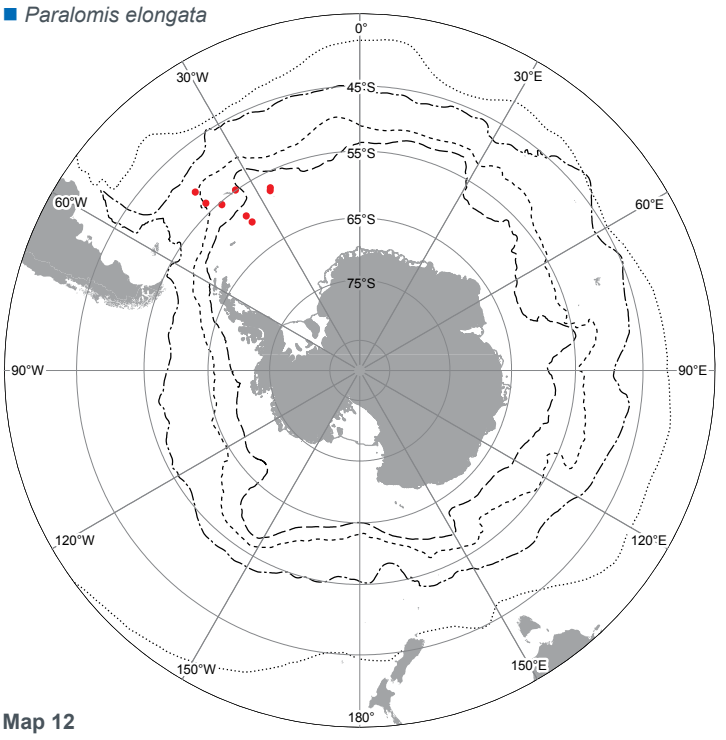
Map 9
- *Paralomis anamerae*
- *Lithodes macquariae*



Map 10
- *Kiwa* sp.
- *Paralomis elongata*

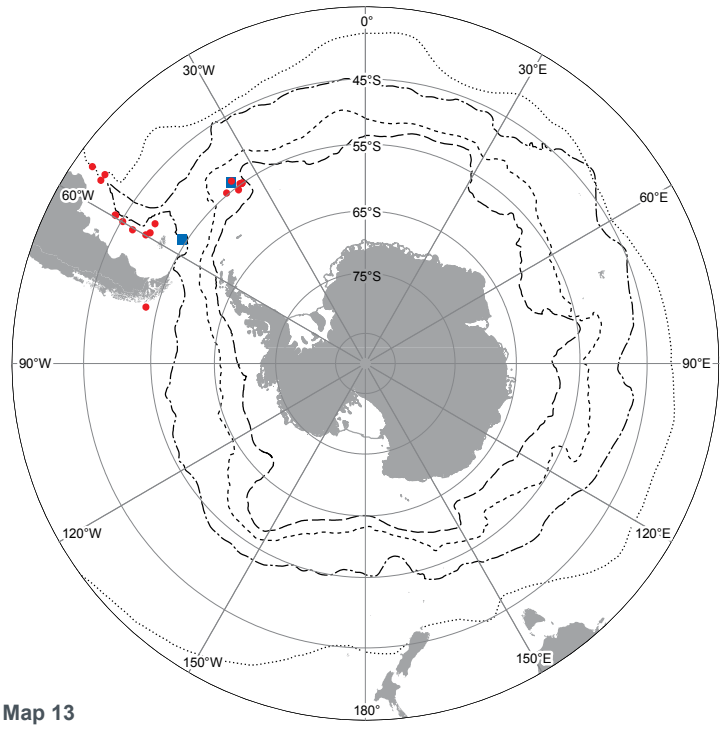


Map 11
- *Neolithodes duhameli*
- *Paralomis aculeata*
- *Thymopides grobovi*

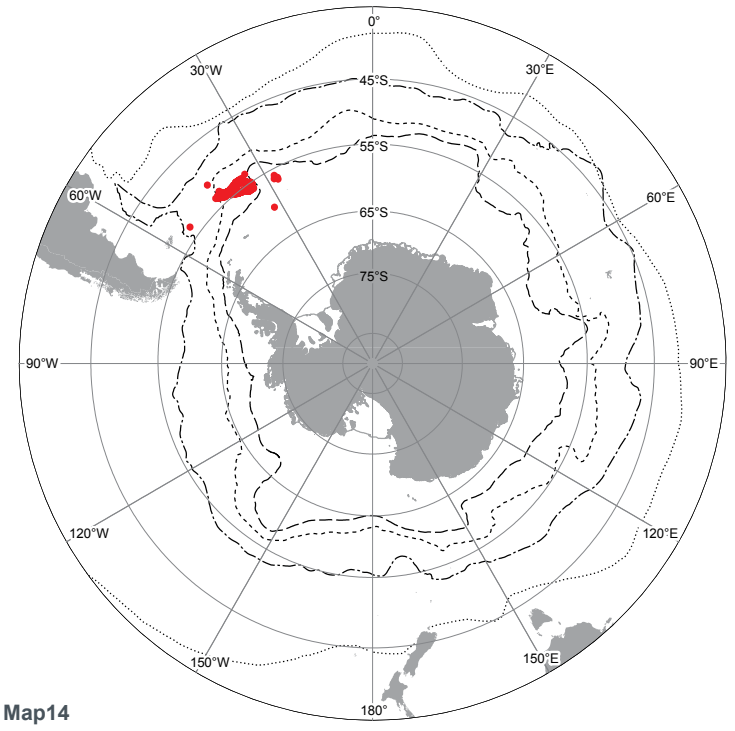


Map 12
- *Thymopsis nilenta*

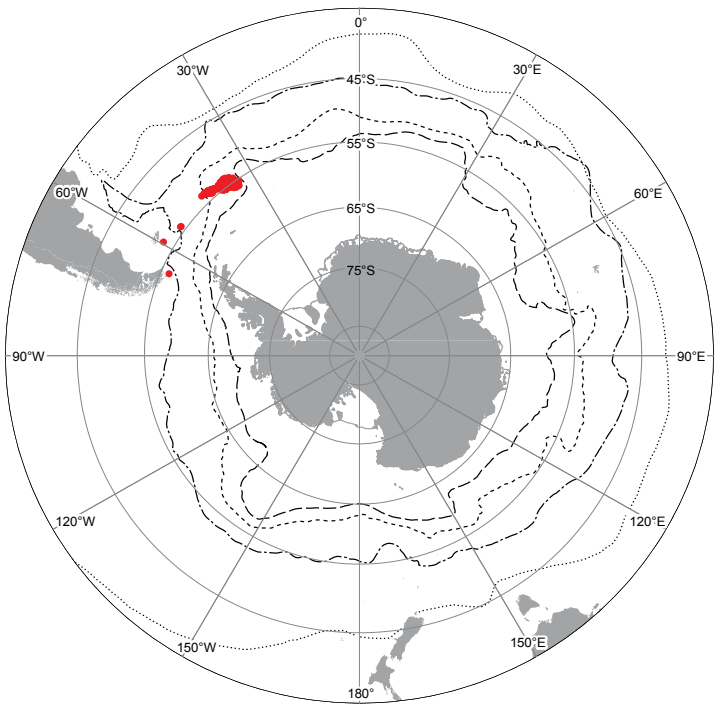
Decapoda Reptantia Maps 7–12 Map 7. *Lithodes murrayi* Henderson, 1888 and *Munidopsis albatrossae* Pequegnat & Pequegnat, 1973. Map 8. *Rochinia gracilipes* A. Milne-Edwards, 1875, *Hyas araneus* (Linnaeus, 1758) and *Halicarcinus planatus* (Fabricius, 1775). Map 9. *Paralomis anamerae* Macpherson, 1988 and *Lithodes macquariae* Ahyong, 2010. Map 10. *Paralomis elongata* Spiridonov, Türkay, Arntz & Thatje, 2006. Map 11. *Neolithodes duhameli* Macpherson, 2004, *Paralomis aculeata* Henderson, 1888 and *Thymopides grobovi* (Burukovsky & Averin, 1976). Map 12. *Thymopsis nilenta* Holthuis, 1974.



Map 13
- *Thymops birsteini*
- *Thymops takedai*



Map14
- *Paralomis formosa*



Map 15
- *Paralomis spinosissima*

Decapoda Reptantia Maps 13–15 Map 13. *Thymops birsteini* (Zarenkov & Semenov, 1972) and *Thymops takedai* Ahyong, Webber & Chan, 2012. Map 14. *Paralomis formosa* Henderson, 1888. Map 15. *Paralomis spinosissima* Birstein & Vinogradov, 1972.

The deepest records from Antarctic waters belonged to the *Kiwa* sp. (2400 m), with *T. nilenta* second deepest at 2068 m. All other Antarctic records are from depths shallower than 2000 m. The brachyurans found south of 60°S have all been found shallower than 100 m.

4. Biogeographic patterns

Since the Lithodidae had far more records available for analysis and a wider latitudinal range than other taxa, Griffiths *et al*. (2013) performed a biogeographic analysis of only this family. Seafloor water temperature appears to be a major determining factor in the geographic distribution of lithodid crabs in Antarctica as distributions are likely affected by physiological constraints. Six distinct geographic groupings were evident, which may mirror postulated multiple deep-sea radiations of this group outside the North Pacific (Hall & Thatje 2009). The biogeography of the SO lithodids appears to be driven by a combination of seafloor temperature and oceanographic fronts. The most southerly grouping was made up of the continental margin regions south of the Southern Antarctic Circumpolar Current Front (SACCF), the West Antarctic slope/shelf and the Balleny Islands. The waters north of the SACCF but south of the Sub-Antarctic Front included four of the biogeographic groupings. The smallest grouping was that of the Bouvet Island region, which is comprised of a single geographic region with a single endemic species. The widest longitudinal range of any grouping is the southern Indian Ocean Islands, plateaus and Peter I Island group. The third grouping within the Antarctic Circumpolar Current (ACC) was that of Macquarie Island and the Scotia Arc (explained by low numbers of species). The fourth grouping to cross these frontal boundaries is the only one, which connects Antarctic waters to more temperate ones (South Georgia and South America). The fifth grouping is comprised of New Zealand and the sub-Antarctic islands of New Zealand, including 13 species not recorded in any of the other regions.

5. Invasion hypothesis

The relatively recent records of lithodid crabs living on the slopes of West Antarctica, the Ross Sea and in the overdeepend basins on the shelf, has led many to suggest that they are a new and expanding element of these marine communities. The World Conservation Union (IUCN) defines invasive species as “an alien species which becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity”. Many authors in the past have used the term invasive interchangeably with range extension or polar emergence. It is important to differentiate between introduced non-native species and native taxa, which are expanding or changing their bathymetric or geographic ranges due to the effect of climate change. Other than in the case of *Hyas araneus* (Tavares & De Melo, 2004), most authors who describe potential “invasion” of the high Antarctic shelf by lithodids are in fact referring to potential range extensions or the theory of polar emergence (Thatje *et al*. 2005, Aronson *et al*. 2011, Hall & Thatje 2011, Aronson *et al*., 2007, Thatje *et al*. 2008, García Raso *et al*. 2008, Hall & Thatje 2009, Belchier *et al*. 2012). However, virtually no scientific work using well-established suitable sampling methods has been conducted in these regions below 1000 m and, to date, no campaign has repeatedly targeted decapod distributions over time in a single geographic

region to assess any density or distributional changes. Griffiths *et al*. (2013) concluded that there is no current evidence for a modern-day 'crab invasion' and recommended an integrated research program of repeated, hypothesis testing sampling of lithodid distributions in Antarctic waters.

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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.

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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.