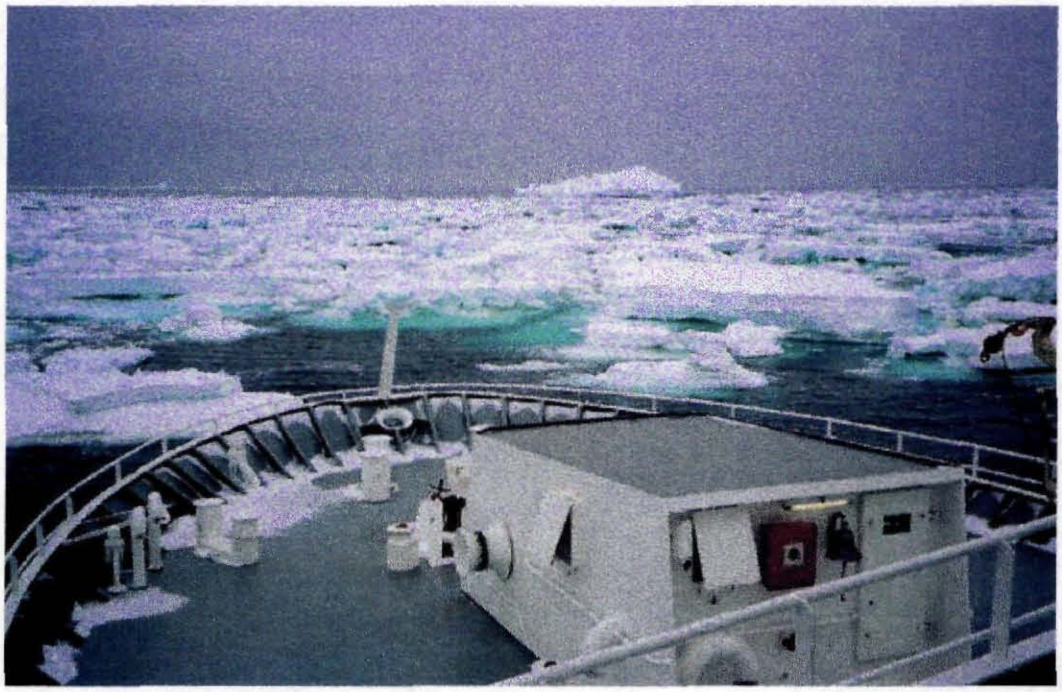
NOR-00228

A review of the current knowledge describing the biodiversity of the Ross Sea region



Janet Bradford-Grieve and Graham Fenwick

Final Research Report for
Ministry of Fisheries Research Project ZBD2000/01
Objective 1 (*in part*)

National Institute of Water and Atmospheric Research

December 2001

Final Research Report

Report Title: A review of the current knowledge describing the biodiversity of the Ross Sea region

Authors: Janet Bradford-Grieve and Graham Fenwick

1. **Date:** 30 December 2001

2. **Contractor:** National Institute of Water and Atmospheric Research Limited

3. **Project Title:** A review of the current knowledge describing the biodiversity of the Ross Sea region

4. **Project Code:** ZBD2000/01

5. **Project Leader:** Janet Grieve

6. **Duration of Project:**

   Start date: 8 May 2001
   Completion date: 20 December 2001 (Ross Sea report)

7. Executive Summary

- This review of the Ross Sea biodiversity, based on published research and museum records, was facilitated by the development of two databases as tools for compiling this report. A literature database was created for the Biodiversity of the Ross Sea (BDORS) using the bibliographic package Endnote, and a relational database (BioRoss) was created in Microsoft Access for expedition station information.
- Historical collections of biota come from more than 31 collecting events and include about 1500 sampling stations. These collections span the period from 1839–1994.
- Biodiversity of the Ross Sea has been described from several large collections, the bulk of which appear to reside at the The Natural History Museum, London, Smithsonian Institution, Washington D.C., the National Institute of Water and Atmospheric Research (NIWA), and the Natural History Museum of Los Angeles County, Los Angeles.
- Some of this material has not been studied. In some cases, the identities of taxa have been published, other taxa have been identified, but not published (identifications are in institutional databases). Other taxa have only been sorted at a high level and have not as yet been worked on. In general, a good deal of the flora and fauna is known although scant attention has been paid to smaller organisms or the total biota in aggregate.

- Patterns of benthic biodiversity elucidated here from sparse sampling and usually incomplete analyses of the biota, now need to be re-assessed and refined. This could be done through an integrated research programme that includes systematic, wider-ranging investigations that takes into account at least latitude, depth, substrate type, disturbance (e.g., ice scouring), development of assemblages (communities) with time, and the overlying patterns of primary productivity.
- An essential aspect in understanding the resilience and vulnerability of Ross Sea biodiversity is knowledge of the rates of biological processes occurring there, the production/biomass and consumption/biomass characteristics of the biota, and knowledge of the standing stocks of functional groups of the biota. This aspect is beyond the scope of the present review, but should be considered carefully as an essential component of future research effort in the region.

8. Objectives

Objective 1. To review and document existing published and unpublished information describing the biodiversity of the Ross Sea region.

At the Ministry of Fisheries's request, NIWA submitted a separate report addressing biodiversity of Balleny Islands ahead of the main report.

9. Methods

As attached.

10. Results

As attached.

11. Conclusions

As attached.

12. Publications

Bradford-Grieve, J.; Fenwick, G. 2001: A review of the current knowledge describing the biodiversity of the Balleny Islands. Final research report for Ministry of Fisheries, Research Project ZBD2000/01 Objective 1 (in part), 38 pp, 13 Tables, 7 Figures.

13. Data Storage

The literature database (BDORS) and the relational database on the fauna and flora of the Ross Sea region (BioRoss) will be placed with the Ministry of Fisheries databases and if required, copies of each will be submitted on compact disk to the Ministry at the end of the project.

Contents

Pages

1. Introduction

This review of current knowledge which would contribute to a description of the biodiversity of the Ross Sea region is contracted by the Ministry of Fisheries and was prompted in part by the fact that the New Zealand Government's Environmental Strategy for the Ross Sea and State of the Environment Assessment for the Ross Sea Region encountered significant difficulties due to the widely scattered and apparently scant knowledge of the region's marine environment. This report represents the second part of Objective 1, on the Ross Sea, the first part being only about the Balleny Islands (Bradford-Grieve & Fenwick, 2001)

Before the funding that has been allocated for increasing knowledge of the region's biodiversity can be assigned, a review of available knowledge of the region was required to provide a single comprehensive reference on the biodiversity of the Ross Sea region. The report will be used to assist in planning future research, to identify and assess potential threats to biodiversity, and to form the basis on which to manage and monitor impacts on biodiversity to achieve the aims of the New Zealand Biodiversity Strategy.

In this summary we present a review of the information available that is relevant to assessing the biodiversity of the Ross Sea. At this stage the biodiversity information is essentially a catalogue of species, the data sources, the state of the samples or records and the spatial locations of original collections. Nevertheless, in order to be able to evaluate the biodiversity recorded in the Ross Sea, we need to use any information on the broad patterns of Antarctic marine biodiversity, the main drivers and key species of Antarctic marine ecosystems, and life histories strategies of Antarctic biota.

A summary of what is known about Antarctic biology and ecology was made by Knox (1994). In this book the complex interactions between organisms and their environment, for the Antarctic region as a whole, are evaluated and it is an excellent reference for those wishing to familiarise themselves with the breadth of work that has been carried out. In addition, the recently published *Ross Sea region 2001: A state of the environment report for the Ross Sea region of Antarctic* (Waterhouse, 2001) contains a good summary of information on the marine physical setting, biological biomass and processes, key features of Antarctic marine organisms, and assesses future information needs and human impacts. The current series of reports concentrates more on knowledge of the Ross Sea biodiversity, sources of biodiversity information and collections, and recommendations that flow from this information.

Two databases were developed in compiling this report. A literature database was created as part of Project ZBD2000/01 on the Biodiversity of the Ross Sea (BDORS), using the bibliographic package Endnote. This contains as many references as we could locate, given the resources, to the flora and fauna of the greater Ross Sea region (the marine environments within longitudes 160° E and 150° W, and shallower than 3000 m depth), including the Balleny Islands. Each reference is given a unique number.

In addition, a relational database (BioRoss) was created in Microsoft Access for expedition station information (Fig. 1.1). This database consists of several tables, including Expeditions, Locality, Station, and Repository. To this are linked other fields that contain more information, such as a numerical code for higher-order taxa

(Order NODC), Species Lot, Identification, Samples, Personnel, Sample Types, Gear Types, Habitat Types, and Data Entered (for tracking data entry). A link is made between BioRoss and the BDORS literature database through the identification field item "Reference" using the unique reference numbers assigned within BDORS. Together, the databases constitute a significant resource for researchers, providing a rapid means of reviewing biodiversity information that is otherwise widely scattered and often difficult to access.

Nevertheless, we cannot claim that BioRoss and BDORS is an exhaustive list of all literature, material, and species for the Ross Sea region. Close inspection will also reveal that a number of ambiguities in the data so far collected have not been resolved. Where a recent publication comprehensively collated records from a number of expeditions and previous researchers, it was usually deemed prudent to use these reviews, rather than re-collating all of the historical information anew within BioRoss. An example of this is Dell's (1990) monograph on molluscs. We believe that enough information has been entered for the reader to gain an overall view of the extent of exploration and knowledge of the flora and fauna. Sufficient additional information is given so that anyone wanting to locate further published information about samples and their location can find this relatively easily.

Additionally, few institutions holding collections of Antarctic biological samples have electronic catalogues of these, so that it is often difficult to identify and locate Ross Sea material within their holdings. The Smithsonian Institution is a notable exception. It has an excellent database for biota collected by the United States Antarctic Research Program (previously funded by the National Science Foundation), which is searchable via the web (http://www.nmnh.si.edu/iz/usap/). Repository information within the BioRoss database, although as yet incomplete, helps to make Ross Sea collections more accessible.

1.1 History of biological investigation

Expeditions that entered the Ross Sea from the 18th century until 1956 have been summarised by Dater (1975). The first to come near was the 1838–1839 sealing and exploration of Captain John Balleny who discovered and chartered the Balleny Islands. In 1839–1843 Captain James Ross, RN, followed (Ross, 1847). This expedition included magnetic studies and other scientific investigations. The biological material collected on this expedition was in bad condition and much of it was lost although some material is deposited in the The Natural History Museum, London. In 1894–1895 the Norwegian Captain Leonard Kristensen, while investigating the whaling opportunities in Antarctic waters, landed at Cape Adare where lichens and seaweeds were collected (Borchgrevink 1895). In 1898–1900 C.E. Borchgrevink led a party that was the first to establish a base on the Antarctic continent. They made extensive collections of terrestrial and marine life (British Museum (Natural History), 1902).

The National Antarctic Expedition, led by Captain Robert F. Scott, RN, took place from 1901–1904. The three summers were devoted to extensive scientific investigations from the Camp established at Hutt Point (Scottish Geographical Magazine, 1905a). The results of this expedition were issued serial reports. The next expedition to enter the Ross Sea was that of the British Antarctic Expedition, led by Lt. Ernest Shackleton, RNR. This expedition established a camp at Cape Royds and biological studies were made principally of freshwater organisms (Murray, 1910) and scientific reports were publish serially from the *British Antarctic Expedition, 1907–1908.*

In 1910–1913 the Norwegian Roald Amundsen entered that Ross Sea (Amundsen, 1913) with the South Pole as his objective. The scientific objectives of this expedition were minimal. Simultaneously Captain Robert F. Scott, RNR, also set out for the South Pole. Although their goal was not attained the party that remained behind and the party on the *Terra Nova* contributed much material for the study of marine biology of the Ross Sea (Mountevans, 1913). Serial reports from this expedition are published from the *British ('Terra Nova') Antarctic Expedition, 1910.*

Sir Ernest Shackleton returned to the Antarctic with the British Imperial Trans-Antarctic Expedition in 1914–1916 (Shackleton, 1920). As part of this expedition in 1915 a party arrived at Cape Evans under the command of Captain A. Mackintosh. Some biological specimens were collected during the final period at Ross Island, but in general little scientific work was done.

The Discovery II investigations included the Ross Sea in the summer of 1928–29 where about 29 stations were occupied from the SS *C.A. Larsen* (Anon., 1931) and in 1936, 34 stations were sampled from *Discovery II.* The samples collected on this voyage appear be unreported in many of the resulting reports, the reason probably being that some reports were published before these samples were taken.

The United States second Byrd Antarctic Expedition took place in 1933–35 under the command of Rear Admiral Richard E. Byrd, USN (Ret.) (Poulter, 1939). Most of the research was terrestrial. A later expedition also entered the Ross Sea under his command in 1939–1941 but no biological work appeared to have been carried out. A later United States expedition was undertaken in 1947–1948 under the command of Commander Gerald L. Ketchum, USN, part of which entered the Ross Sea.

The International Geophysical Year and the Trans-Antarctic Expedition, 1955–1958 began a new era of marine exploration of the Ross Sea. The details of this work are reported by Bullivant (1967b). Two collections were made. One was made by the New Zealand Oceanographic Institute, and a second collection was made by the Trans-Antarctic Expedition personnel; many of the results of this work are published under the general title *Fauna of the Ross Sea.* At the same time, the Stanford University Marine Biology Program, led by John H. Dearborn, made comprehensive collections of marine invertebrates while studying the ecology of selected species during 25 months at McMurdo Sound (Dearborn, 1967). Material from this latter study appears to be deposited in the Natural History Museum of Los Angeles County, Los Angeles, U.S.A.

The Soviet Antarctic Expeditions of 1995–96 (12 stations) and 1957–58 (13 stations) sampled in the northern Ross Sea region. Some of the resulting information is published in the Biological Reports of the Soviet Antarctic Expedition (1955–1958) which is part of the series (*Issledovaniya fauny morei* – Studies of marine fauna) published by the Russian Academy of Sciences and available in English translation from the Israel Program for Scientific Translations. Publications on material from these expeditions have not been exhaustively searched out.

Marine Antarctic exploration was undertaken by the US National Science Foundation aboard the USNS *Eltanin* from 1962–1972. Of the 55 cruises undertaken, Cruises 27, 32, and 51 entered the Ross Sea to take biological oceanographic samples (El-Sayed, 1973) and study the systematics of the Antarctic fauna (Hedgpeth, 1973). Material from these samples has and is being widely reported, some of it published in the *Antarctic Research Series.*

Ross Ice Shelf Project (1976–1978) drilled a hole through 420 m of ice 450 km from the open sea at 82° 22.5'S, 168° 37.5'W (Clough & Hansen, 1979). There was 237 m of water beneath the ice. A principal reason for the project was to discover whether life was present so far from the open sea. Studies were also made of the ice shelf and the water column and sediments beneath.

In 1964 and 1965 there was a concentrated effort by New Zealand researchers on board the US Icebreaker *Glacier* in the vicinity of the Balleny Islands. Eight stations (D212–219) were sampled in March 1964. This expedition's results were reported in general terms by Hatherton et al. (1965). The following year, a more extensive exploration was made aboard the sample vessel and resulted in 51 benthic samples from 36 stations (January-February 1965) that represent selected material from United States Antarctic Research Program trawls. Some of this material has been reported in published papers (e.g., McKnight, 1976a, b; Dell, 1990), but most of the results are not reported in print.

In 1980–1981, the Tokyo University of Fisheries participated in the Biological Investigations of Marine Antarctic Ecosystems and Stocks (BIOMASS). This expedition was divided into several legs and the Fourth Leg occupied a few stations near Balleny Islands (65°S 160°05'E and 67°25'S 164°27'E, west of Sturge Island) beginning in late January and extending to early February (Murano & Inoue, 1982).

From 1987 to 1995, the Italian Ministry of the University and Scientific and Technological Research, National Scientific Commission for Antarctica, carried out research in the Ross Sea. It aimed at characterising the physical, chemical, and biological environment, the structure and functioning of the Antarctic ecosystem and the ecology of the Ross Sea marginal Ice Zone (Faranda et al., 2000).

In 1992, the R.V. *Akademik Ioffe* sampled near the Balleny Islands on the western part of a leg parallel to the Antarctic coast. This survey was part of the Russian contribution to the World Ocean Circulation Experiment. Up to 7 stations north of the Ross Sea are represented in this work.

1.2 Ross Sea Environment

1.2.1 Topography

The Ross Sea, as defined here, is a triangular body of water lying between Cape Colbeck and Victoria Land, Antarctica and extending out to the 3000 m isobath encompassing the volcanic outcropping of the Balleny Islands (Johnson et al., 1982) (Fig. 1.2.1.1). The Ross Sea is bounded, in the south, by the Antarctic continent, although the Ross Ice Shelf forms the southern boundary for the upper 200 ± m of water. Several small ice shelves, fed by the glaciers of Victoria Land, are present along its western boundary.

Kennett (1968) has described the main topographical features of the Ross Sea floor. Unlike most parts of the Antarctic, where the shelf is narrow, or absent, the Ross Sea has a wide but deep continental shelf. As is typical of the Antarctic shelf, the Ross Sea shelf break occurs at 800 m as a result of extensive carving action by outward-moving ice during the glacial maximum (Brodie, 1965). Shelf depths range from 100–1000 m, averaging 550 m. Two troughs deeper than 900 m occur immediately north of Ross Island. The most conspicuous feature of the Ross Sea floor is the relatively shallow ridge that runs north-west from Cape Colbeck to the Pennell Bank, where it broadens considerably and reaches a minimum depth of 100 m. Taylor (1930) suggests that this bank represents a vast terminal moraine formed by a grounded ice shelf during a former glacial period. From this shallow rise near the outer shelf the surface slopes gradually inland so that the rise forms a brim to the basin-like depression to the south and south-west. The inland slope of this basin takes the form of several fairly narrow channels deeper than 550 m that converge near the Ross Ice Shelf to form a broad basin.

1.2.2 Physical and Chemical Oceanography

Physical oceanographic conditions in the Ross Sea have been described by Countryman & Gsell (1966) and in various chapters of "Ross Sea Ecology" (Faranda et al., 2000). The Ross Sea is subject to annual climatic change. In winter there is continuous darkness and in summer continuous daylight and almost ice-free conditions. These conditions cause the physical regime to approach equilibrium in winter but to be unstable during summer.

Three water masses with definable characteristics are present in the Ross Sea in summer (Fig. 1.2.2.1):

1. *Antarctic Upper Water*, in which two types of water are distinguishable:
    - *Antarctic Surface Water* warmed by solar radiation and diluted by melt water. The degree of warming and dilution depends on proximity to the ice shelf, the presence of ice cover, and the time of year.
    - *Winter Water* found below Antarctic Surface Water, retains characteristics acquired during winter.
2. *Antarctic Circumpolar Water*, is a southward extension of the Deep Warm Water (Antarctic Deep Water) from 2000 m, which, as it moves over the Ross Sea shelf, is modified from above by mixing with Winter Water and from below by mixing with cold, saline Shelf Water. The amount and extent of Circumpolar Water in the Ross Sea varies from month to month and year to year. It is apparent the Antarctic Circumpolar Water mainly modifies the subsurface Winter Water.
3. *Shelf Water*, is the coldest, most saline, densest water mass of the Ross Sea. It is present mainly in the south-western part of the sea and is believed to originate during winter when the formation of sea ice increases salinity in the surface layers resulting in mixing. The occurrence of shelf water in all depressions, some close to the shelf edge, indicates that it probably spills over the slope in winter. It probably flows mainly northward between Pennell Bank and Victoria Land where two troughs, separated by a broad ridge, form a natural path for the outflow of Shelf Water. Jacobs et al. (1995) more recently discuss the role of the Ross Sea polynya in the formation of Shelf Water. The winter sea surface, forced by persistent southerly winds off the ice shelf east of Ross Island, is characterised by thinner ice and a constantly open-water area of 27 000 m^2. The

rapid growth and removal of sea ice, prior to spring, results in brine drainage into the polynya and the production of high-salinity Shelf Water. It mixes near the shelf break to form *Antarctic Bottom Water* and also transports biological material hundreds of kilometres beneath the Ross Ice Shelf to support life there (Bruchhausen et al. 1979). The Ross Sea is one of the major sources of *Antarctic Bottom Water* (Russo 2000 and references therein).

Countryman & Gsell (1966) leave unresolved the problem of whether Shelf Water controls the presence of Antarctic Circumpolar Water or vice versa. The shelf in the north-west slopes much more gradually seaward and is wider than in the east. Thus it is probable that the inflow of Antarctic Circumpolar Water is deflected southward by the topography, confining Shelf Water to the south-west. This conclusion has been reached also by Car (1967), who found that the summer 1° C isotherm follows the 1000 m isobath and that the core of Circumpolar Water in the Ross Sea centres on 174° W.

Dissolved inorganic nutrients in surface waters in the Ross Sea are influenced by Antarctic Circumpolar Deep Water and are therefore high in dissolved reactive silica (Catalano et al., 2000) and relatively high in trace metals in spring (November and December) (Sedwick et al., 1996). Nevertheless the Ross Sea can exhibit macronutrient exhaustion in certain inner parts in summer as well as trace metal exhaustion (Sedwick et al., 1996), especially at the ice edge (Catalano et al., 2000 and references therein).

The annual cycle of temperature at 3 m in McMurdo Sound in 1961 goes from a maximum of -1.57° C in January to -1.92° C in August (Littlepage, 1965). Salinity at 3 m was least in February (33.96) and greatest in July (34.78). Littlepage summarises conditions as being very stable through the year; there did not appear to be a seasonal cycle in the concentrations of dissolved reactive phosphorus and silica. He identifies a "winter" season that extends from April to December and a "summer" season that extends December to April. Summer water temperatures are generally above -1.8°C.

1.2.3 The Ross Ice Shelf

The southern Ross Sea is overlain by the world's largest floating ice sheet (see Knox 1994: 235). The Ross Ice Shelf may be regarded as a thick ice sheet floating everywhere except where it is grounded on Roosevelt Island (Markov et al., 1972). The thickness of the Ross Ice Shelf increases from 150–300 m at its outer edge to 600–800 m inland. The depths beneath range from 400–800 m.

In the south-west corner the McMurdo Ice Sheet is formed by the northward movement of the Ross Ice Shelf between Black Island and Brown Peninsula, by a distributory flow of ice between White Island and Ross Island and from the Koettlitz Glacier in the west (see summary by Knox et al., 1996). Ablation processes result in the McMurdo Ice Sheet being much thinner (30–40 m) immediately west of White Island compared with 140 m thick east of White Island (Swithinbank, 1968). The rise and fall of the tide produces a crack along at least the western side of the island.

Ross Sea tides are principally diurnal. Along the northern margin of the Ross Ice Shelf tidal range is 1–1.2 m and this range increases to 2 m in the southernmost part of the Ross Sea (Williams & Robinson, 1980).

1.2.4 Sedimentation of particulate matter to the sea floor

Sedimented material in the Ross Sea may originate from land-derived or marine biological sources. The Ross Sea has a broad continental shelf, relatively smooth gentle slopes, and a vast floating ice shelf. Glacial (land-derived) sedimentation occurs well inland of the ice shelf front (Anderson et al., 1979). Land-derived material and the sediment supply to the continental slope is primarily restricted to that carried by currents. Consequently surface sediments consist of current derived silts and clays that contain 9–44% ice-rafted detritus. Present glacial sedimentation on the continental shelf is minimal and siliceous muds and oozes are the most abundant surficial sediments (Anderson et al., 1982).

Data collected from moored sediment traps by Collier et al. (2000) shows that the vertical flux of particulate material in the southern Ross Sea is generally double that in the north. There is a significant increase in flux into the deep traps indicating that material is transported horizontally. Particles are primarily biogenic although lithogenic material can be over 30% of the flux in the near-bottom trap nearer to the ice shelf. Fluxes collected in traps were generally low. The export of organic matter to 200 m during the spring and summer was extremely low consistent with observations that the ongoing phytoplankton bloom was being stored or recycled in the upper water column. A major pulse of biogenic silica occurred in autumn just as the ice was reforming. This export event was correlated with lithogenous particles, excess iron (Fe) and early onset of katabatic winds suggesting this event might be related to Fe fertilisation of diatom production and export. The largest flux of organic matter was carried by the herbivorous pteropod mollusc *Limacina helicina* and was observed under the ice in late autumn after the diatom pulse; it is speculated that this event was related to the die-out of this population after suspended particulate organic matter had dropped to very low levels.

The above observations appear to differ from the work of Dunbar et al. (1998). They note that total particle flux and biogenic Si fluxes were highest during January and February in the south-western Ross Sea beneath a seasonally recurrent bloom of *Fragilariopsis curta.* They found that organic fluxes were highest in the central Ross Sea consistent with a surface water algal assemblage dominated by the prymnesiophyte *Phaeocystis.* Faecal pellets and large aggregates contributed between 4–70% of the vertical fluxes. Maximum particle fluxes occurred 2–10 weeks after surface waters became ice-free. They speculate that windiness and relative phasing of the annual cycles of ice cover and air temperature may be responsible for the development of different algal communities in the central versus the western Ross Sea.

2. Major Habitats

2.1 Sea ice, fast ice and marginal ice zone

Sea ice is an ephemeral habitat and coverage in the Ross Sea varies both with season and from year to year. At its maximum extent, the outer edge of sea ice usually reaches to approximately 65° S, most of which is annual sea ice, with a relatively small area (0.5–1.0 x 10^6 km^2) of perennial sea ice (Parkinson, 1998). Seasonal oscillations in satellite-derived estimates of ice cover over the 1978–1987 period were between 30 and 70% through the Ross Sea, (Gloerson & Mernicky, 1998). Overlain on the seasonal ice cycle these authors found a 4.2 yr component, possibly related to the El Niño Southern Oscillation. The Ross Sea has more complex ice dynamics than the other major seas of Antarctica, because of the presence of an extensive polynya that forms in spring off of the Ross Ice Shelf. This results in ice cover reductions occurring in spring/summer both from erosion at the northern limit and from the south.

Sea ice in the Ross sea comes in two basic types, fast ice (ice attached to land in a continuous, or near-continuous sheet) and pack ice. Pack ice is more physically dynamic than fast ice, both in its formation, and its evolution through time. Pack ice primarily forms through growth of frazil ice crystals, and rafting and ridging of pancake ice that forms from frazil ice growth. Subsequent growth of ice is by thickening by the formation of congelation ice on the underside of ice floes, that has characteristic vertically oriented columnar ice crystals (Gow et al., 1998). As snow load on the surface of the ice increases, the ice is displaced downwards and granular snow ice forms as seawater first infiltrates the snow layer and then freezes. This water-snow-ice complex becomes an important habitat for ice biota, particularly during spring as the water content increases. Pack ice in the Ross Sea in September-October 1994 was found by Jeffries & Adolphs (1997) to be composed of 30–40% snow ice, 20–40% frazil ice and 20–40% columnar congelation ice.

Fast ice contains similar layers of ice type, with an upper layer of granular ice formed from frazil ice or water-infiltrated snow, with a band of congelation ice that forms below this by vertical ice growth. The congelation ice again has vertically oriented crystals that enclose a series of brine pockets between the ice crystals. These brine pocket become important habitats for ice biota, and the salinity of the brine increases with decreasing ice temperature. Within McMurdo Sound, a third type of ice forms several months after the congelation ice begins forming. This ice is known as platelet ice, and the exact mechanisms underlying its formation are not fully understood. It appears that near-vertically oriented ice platelets grow into the water column from the underside of the ice when supercooled, slow moving water comes into contact with it. This super-cooled water is generally believed to come from adiabatically cooled, low-density water that flows northward from under the Ross Ice shelf (Gow et al., 1998). It is this dependence of platelet formation on ice shelf water that appears to restrict extensive platelet ice formation to the McMurdo Sound region. Platelets are rendered into platelet ice by the growth of congelation columnar crystals through the platelet matrix, while loose and partially attached platelets can continue to persist under the ice. The melting of the platelet ice results in a more honeycombed type structure for biota compared to the vertical crystals of pure congelation ice, and the accreting platelets themselves provide a complex under-ice habitat that is used by many organisms.

During ice melt and break-up, the Marginal Ice Zone (MIZ) becomes an important bridge between the ice community and the open-water plankton (Nuccio, 1999; Goffart et al., 2000). Ice melt reduces salinity and thus increases water column stability at the surface. In addition, melting of ice releases ice biota into the water column and these can seed microbial populations, resulting in ice-associated species entering the plankton (Sullivan et al., 1988. Crisafi et al., 1999; Saggiomo et al., 1999)

2.2 Water column

The open ocean habitat in the Ross Sea is an extension of the circumglobal pelagic habitat called the Austral Polar Province by Longhurst (1998) (Fig. 2.2.1). Longhurst concludes this province has weak, variable wind mixing of surface waters with brief shoaling of the mixed layer in the summer. The winter mixed layer, estimated from the temperature profile, may be as deep as 180 m and shallower than 80 m in summer, but has a maximum of 70 m and minimum of about 20 m when estimated from the density profile. The pycnocline is nearly always deeper than the photic zone except for perhaps in January and February. The photic zone is 20–30 m in summer and 60–80 m in autumn and spring. From March to beginning of September there is complete darkness. Primary production conforms closely to the irradiance cycle with relatively strong secondary chlorophyll accumulation in the austral autumn (March and April), when productivity is declining. This accumulation is probably due to the relaxation of grazing pressure. Open water blooms occur most often near the receding ice front because the freshwater released by melting sea ice induces stability in the water column that may extend many tens of kilometers beyond the ice edge.

The open ocean habitat is partitioned by pelagic animals into a surface epipelagic zone, a deep bathypelagic zone, and an intermediate mesopelagic zone. At lower latitudes epipelagic species live in the surface 200 m but can have ranges that extend to 500 m. Mesopelagic species live at intermediate depths and are only occasionally found above 500 m and extend deeper than 1000 m. Bathypelagic species usually are found below 1000 m. But in Antarctic waters, usually deep-living species are found nearer the surface and the epipelagic zone is used by only a few species exclusively as the most common species use the meso-and bathypelagic zones for part of their life history. Some species live in the water immediately adjacent to the seafloor, and in the case of the Antarctic, apparently immediately adjacent to the underside of ice.

The functional groups among the biota of the Antarctic include primary producers (phytoplankton), decomposers (e.g., bacteria), herbivores that cover a large range of sizes from unicellular Protozoa to large forms such as krill, carnivores that are not numerically plentiful but are represented by a diverse group of animals, and animals that feed on non-living organic particles (dead phytoplankton, zooplankton, and faecal pellets) that may be aggregated together into large particles.

The surface sunlit layers are the richest in living organisms and non-living organic particles. Surface waters are the origin of materials that sediment through the deeper parts of the water column to the sea floor. The further the sea floor is away from the surface the less the material reaches the sea floor because it is processed in the water column.

2.3 Sea floor

The nature of bottom sediments in Antarctica is principally driven by biogenic processes, oceanographic currents and mass flows because continental shelves are deep (mean depth 500 m), there are no rivers or melt-water runoff, and both pack ice and ice-covered shores restrict wave influence (Bullivant, 1967b). Thus, Antarctic benthic habitats are generally much more stable physically and have essentially no terrestrial inputs (Dayton 1990).

Surface sediments in Ross Sea do not differ greatly from place to place within broad depth zones, and sedimentation is dominated by production and settlement of biogenic material and resuspension by currents to about 500 m (Dunbar et al., 1989). Resuspension transports biogenic debris from shallower waters into the shelf basins (Dunbar et al., 1989), suggesting considerable benthic activity and interesting faunas within these deep basins (Dayton, 1990). Beaches and other shallow-water areas are not extensive and often are covered by permanent ice, so that sediment disturbance and transport by ice is much less than in Arctic areas, for example. In addition to being deep, the continental shelf includes troughs, some as deep as 1000 m. The continental slope extends to some 3000 m depth and the abyssal plain lies in 3700–5000 m of water (Knox & Lowry, 1977).

Ice disturbance is the dominant influence on benthic biotas to a depth of 33 m in McMurdo Sound (Dayton et al., 1969, 1970). Annual sea ice covers intertidal zones over winter and extends as deep as 4 m. The scouring effect of this sea ice keeps the intertidal clear of any macroscopic organisms and, less frequently, interferes with biota to depths of 15 m (Dayton et al., 1970). Below these depths, anchor-ice plays a significant disrupting role. Anchor-ice consists of aggregations of ice platelets (100–150 mm by 2–3 mm) up to 1–2 m in diameter and up to 0.7 m high (Dayton et al., 1969, 1970; Dayton, 1989). These aggregations entrap, but not necessarily kill, both sessile and motile benthic animals, including fish, urchins, asteroids, sponges and isopods. Eventually, these aggregations float free of the bottom, carrying with them any sessile organisms, and lie beneath the overlying sea ice. Anchor-ice disturbance in McMurdo Sound is greatest between 0–15m depth, forming a closed mat 150–400 mm thick, but mostly forming occasional clumps between 15 and 33 m depth (Dayton et al., 1969). Its lower limit in McMurdo Sound appears to be 33 m depth (Dayton et al., 1969, 1970). Within the Ross Sea, anchor-ice seems largely confined to McMurdo Sound (Gow et al., 1998; Cattaneo-Vietti et al., 2000a).

The hydrodynamically stable shallow water conditions, due to the limited wave action (Berkman et al. 1986; Shen & Squire 1998), plus the absence of terrestrial or riverine inputs, result in very heterogeneous bottoms close to shore. Small patches of cobbles, gravels, sands and bedrock outcrops frequently occur in close proximity to each other, along with larger erratic boulders. Miller & Pearse (1991: 38) vividly described such heterogeneity, notably at 12–20 m at Cape Evans: "the gently sloping bottom consists of bedrock, volcanic gravel, fist-sized cobble and widely scattered boulders, with pockets of sandy sediment". Bottoms predominantly of well-sorted fines appear confined to deep waters.

3. Geographic coverage of investigations in the Ross Sea region

To date we have identified about 1500 stations where the Ross Sea biota was sampled (Table 3.1). There is good coverage of the Ross Sea for both planktonic and benthic organisms (Fig. 3.1) with the eastern region less well sampled. The smaller sized benthos appears to have been neglected in the sampling strategies. Many of the expeditions resulted in special publications that make assessing the documented biodiversity relatively easy. Other expeditions or sampling occasions that did not have special publication arrangements are difficult to review as the literature is widely scattered in global publications.

4. Biodiversity in water column habitats

The Southern Ocean is one of the world's most discrete oceanic ecosystems (Fig. 4.1–4.3). The plankton of the Antarctic comprises not only true, indigenous Antarctic marine flora and fauna but also representatives of the world's deep planktonic fauna that is found nearer the sea surface at high latitudes. Many epipelagic to mesopelagic species are restricted to Antarctic habitats and within this fauna there is a small amount of endemism where species appear to be restricted to particulate parts of the Antarctic continent. Conditions of food scarcity favour specialised behaviour and adaptations to the strong seasonal pulse of primary productivity that is regionally high and usually extremely predictable (Dayton, 1990).

4.1 Microalgae

4.1.1 Water column

The open ocean flora (Table 4.1.1.1) has been described from a transect during the Transantarctic Expedition 1957 (Cassie 1963) and subsequent Italian work (e.g., Nuccio et al., 2000, Andreoli et al., 1995 and others). In addition, the diatom assemblages in surface sediments (Cunningham & Leventer, 1998) add further species to the modern flora probably because they represent the integration of what is happening over the whole year whereas most expeditions and sampling events can only operate in late spring and summer.

The taxonomy of several elements of the Ross Sea flora has not been worked out (as they have not been, in many cases, for the world's oceans). For example the picophytoplankton (Prochlorophyta and small Cyanobacteria), non-thecate dinoflagellates, and flagellates of various classes are not at all well known anywhere. The ease with which certain taxa can be identified is related to the method of preservation and availability of instruments such as electron microscopes. Particular care must be taken with preservation for identification of picophytoplankton, prymnesiophytes and non-thecate dinoflagellates. Other factors in the lack of identification to species may be lack of literature or expertise on particular groups. The generic identification of forms in Tables 4.1.1.1–4.1.1.3 may in fact not be correct.

Keeping this in mind, we are able to say that a number of the phytoplankton species recorded in the Ross Sea are apparently cosmopolitan in distribution (see asterisked species in Table 4.1.1.1) (see e.g., Hendy, 1964; Hasle et al., 1996) and species such as *Thalassiosira antarctica* are bipolar in distribution (Fryxell et al., 1981). Nevertheless there are thought to be distinctive Antarctic floristic zones (Zernova, 1993) and recent genetic work on Antarctic phytoplankton shows that populations found within the Antarctic circumpolar current are genetically distinct from others, suggesting the currents play an import part in determining population structure (Medlin et al., 2000).

The microalgal populations (Tables 4.1.1.1–4.1.1.3) must be interpreted in the light of the brief summary of current knowledge of factors affecting the makeup of phytoplankton populations that follows. For a more detailed account see Knox (1994: 245).

Goffart et al. (2000), Carrada et al. (2000) and Nuccio et al. (2000) identify three subsystems within the Ross Sea of relevance to the phytoplankton biota. These are the pack ice-covered waters, the marginal ice zone (MIZ), and the polynya. The first is dominated by picophytoplankton (up to 50% of chlorophyll *a* biomass), the second is dominated by microplankton (*Fragilariopsis, Nitzschia*), and the third by the aggregated form of *Phaeocyctis* cf. *antarctica* (see also Garrison et al., 1995). After the diatom bloom, the MIZ surface waters are populated by senescent *Fragilariopsis* cells with an underlying prevalence of *Phaeocystis* (Nuccio et al., 2000) in conditions where thermal stratification has replaced the haline stratification. The general growth of phytoplankton is determined by irradiance, temperature, water column stability brought about by melting of pack ice and warming of surface waters, and concentrations of macro- and micronutrients.

Subsequent to the spring bloom, phytoplankton biomass decreases, accompanied by nutrient depletion. Two weeks after the ice melt populations are characterised by a deep mixed layer, a deep euphotic zone and flagellate assemblage in growing phase and of low diversity in which *Phaeocystis* is increasing in surface waters. According to Arrigo et al. (1999), it is during this phase that the greatest draw down of CO_2 occurs; should the predicted climate warming increase surface stratification the capacity of the biological community to draw down CO_2 would be impacted. Carrada et al. (2000) and Nuccio et al. (2000) believe that the structure of the spring phytoplankton communities associated with the MIZ and the pack-covered water column were to a large extent the consequence of removal of the microphytoplankton by selective grazing by euphausiids, but nutrient depletion and loss of water column stability due to meteorological perturbations are also implicated. A second bloom develops (Nuccio et al., 2000) with a different composition from the first spring bloom when new nutrients become available and water column stability occurs.

Diatoms in bottom sediments (Leventer & Dunbar, 1996; Cunningham & Leventer, 1998) broaden out this picture to give a geographical component. The western part of the central Ross Sea is most closely associated with *Thalassiosira gracilis* (an open water species) and reflects the early seasonal pack ice break up during the last spring inception of the Ross Sea polynya. The diatom assemblage north of the Drygalski Ice Tongue, in the western Ross Sea, is most closely associated with *Fragilariopsis curta* (common in stratified ice edge zones), suggesting the water column seeding by species melting out of coastal sea ice is important in this area. The diatom assemblage south of the Drygalski Ice Tongue is most closely associated with resting spores of *Thalassiosira antarctica* (associated with coastal waters). Cunningham & Leventer (1998) speculated that sea ice conditions in this area support the autumnal bloom of *T. antarctica*, although the exact habitat of this species requires further research.

Much of the above analysis draws conclusion by inference and many of the details of life history strategies, the interaction of phytoplankton with their physical environment, and the impact of grazing on populations has yet to be worked out.

4.1.2 Fast ice (tide crack)

The only description of this type of habitat was made from work carried out by the University of Canterbury in 1976–77. The unicellular algae that live in the tide-crack west of White Island (Table 4.1.1.2) were recorded by Rawlence et al. (1987). They found that during late November *Pyramimonas* sp. dominated whereas from early December until late January diatoms dominated.

4.1.3 Sea Ice

Early studies of the ice-associated algae of McMurdo Sound, close to Cape Armitage, identified the following list of diatoms as numerically dominant (Bunt & Wood, 1963): *Amphiprora kjellmanii,* (now *Entomoneis*), *Amphiprora oestrupii,* (now *Entomoneis*), *Biddulphia weissflogii* (now *Odontella?*), *Coscinodiscus subtilis* (now *Actinocyclus*), *Eucampia balaustium, Fragilaria linearis, Nitzschia martiana, Nitzschia seriata, Pleurosigma antarcticum, Rhizosolenia alata, Rhizosolenia rostrata.*

Palmisano and Sullivan (1983), as part of a long-term research campaign directed at sea ice communties in McMurdo Sound, provide some taxonomic information on diatoms. However, the focus of their work was more process-oriented, and as such complete species lists are not available. They reported an *Amphiprora* sp. (now likely to be *Entomoneis*) and *Nitzschia stellata* Manguin as dominant phototrophs on the eastern side of the Sound, and an unidentified tube-dwelling diatom on the Western side, at New Harbour. No explanation for this spatial difference was proposed. *Entomoneis* has proven to be a common diatom in sea ice communities, presumably, in part, because it is tolerant of high salinity and low temperature. It is interesting to note that this same genus has been reported from the higher salinity regions of intertidal lagoon systems that develop at Bratina Island (Hawes et al., 1997). There is little doubt that high salinity/low temperature combinations prevail in sea ice habitats during winter and spring.

More recently, Moro et al. (2000) carried out a detailed study of ice algae in Wood Bay (74° 22'12"S, 165° 24' 06" E), some distance north of McMurdo Sound. They tabulated fifty diatoms, one xanthophyte, one dictyotchophyte, 12 dinoflagellates, the common Antarctic haptophyte *Phaeocystis* and two prasinophytes (Table 4.1.1.3). They identified that all of the common sea-ice taxa were also present in the water column, and in the ice during the ice formation process. The only taxa found in ice, but not in the water column, or in newly forming ice but not in late season ice, were exceedingly rare. The species generally reported as common at McMurdo Sound (diatoms *Entomoneis* sp. and *Nitzschia stellata;* Gymnodinoid dinoflagellates (Stoecker et al., 1992)) were also found at Wood Bay.

The ability of resting cysts to overwinter in the upper sea-ice in extreme conditions has been studied by (Stoecker et al., 1997). They showed that high densities of physiologically active cryo- and halo-tolerant algae can occur in the upper land-fast sea-ice under extreme conditions of temperature and salinity. Species occurring in the Ross Sea and Antarctic in general have therefore been selected for this capacity to survive in such an environment.

4.2 Bacteria

4.2.1 Water Column

Bacteria have been studied in the Ross Sea only as biomass (e.g. Fabiano et al., 1995; Maugeri et al., 1996; Carlson et al., 1999; Ducklow et al., 1999; Ducklow, 1999; Vanucci & Bruni, 1999; Crisafi et al., 2000). Bacterial biomass ranged from 0.152–1.278 mg C m^{-3} with higher depth integrated concentrations in the ice-covered zone compared with the ice-free zone. Intermediate concentrations were found in the MIZ (Crisafi et al., 2000).

Bacteria are very important in the Ross Sea system because they are part of the food source of microzooplankton, they mop up dissolved organic matter, and recycle nutrients. Recently new groups of bacteria and archaea have been identified from ribosomal RNA (Lopez-Garcia, 2001).

4.2.2 Sea Ice

Planktonic bacteria are frozen into ice during its formation and appear to persist throughout the ice cycle. There appear, however, to have been no studies of the diversity of bacteria, either in a taxonomic or functional context. Sullivan and Palmisano (1984) provide the best information on bacterial diversity, and this only from a few cores from McMurdo Sound. They described an abundant bacterial flora, containing both free-living and attached forms in the lower 20 cm of platelet ice. Free-living bacteria included short (<0.5 μm) and long (0.5–1.0 μm) rods. Epibacteria were particularly associated with the diatom *Entomoneis (Amphiprora* in the original text) and included cocci, rods, straight and branching filaments, fusiform and prosthecate forms. As far as we are aware, the functional groupings of bacteria in sea ice have not been assessed.

4.3 Microzooplankton and sea ice Protozoa

4.3.1 Water column

The microzooplankton is composed mainly of protozoan ciliates and heterotrophic flagellates, and the developmental stages of large zooplankton. Previous Antarctic records contain mainly oligotrich and tintinnid and other ciliates, Radiolaria, and Foraminifera (Table 4.3.1.1). Recent work has shown that very small eukaryotes contain two new groups related to dinoflagellates identified from ribosomal RNA (Lopez-Garcia et al., 2001).

A number of microzooplankton taxonomic groups appear not to have been recorded living in the Ross Sea or be well known. Among these are: Radiolaria, Acantharia, and athecate ciliates although Radiolaria have been recorded in the Ross Sea from sea floor cores (Hays, 1965) and from sediments near the Balleny Islands (Petrushevskaya, 1968).

Three species of planktonic forams, *Globigerina bulloides, Globoquadrina conglomerata* and *Neoglobigerina pachyderma* were recorded from the Ross Sea area (Pflum 1966). The numbers of planktonic forms were low in the shelf area, increasing in samples from relatively deep water. Pflum (1966) speculates that

Neogloboquadrina pachyderma may be the only planktonic species present and the remaining two 'species' may simply be its juvenile forms. Temperature and salinity in the surface waters is essentially uniform and so unlikely to control the distribution of this fauna. Differences in reproduction and population composition near the ice shelf appears to be a consequence of freshwater input from melting ice and may be related to the resulting growth of microalgae. Greater concentrations of planktonic forams are recorded in the eastern Ross Sea where there is not an extensive ice shelf as opposed to southern Ross Sea in front of the Ross Ice Shelf. Planktonic forams were also observed by Kennett (1968) and Heron-Allen & Earland (1922) during the Terra Nova expedition, and more recently by Ward (1984) and Asioli & Langone (1997) resulting in 10 probable species of planktonic forams being recorded in the fauna of the Ross Sea region (Table 4.3.1.1).

Microzoplankton species observed by Monti & Urmani (2000) were typical of Antarctic waters. Heterotrophic dinoflagellates were very abundant in upper water layers and were made up of the genera *Protoperidinium* and *Gyrodinium.* Micrometazoans were more numerous than ciliates at most stations. Foraminifera and Radiolaria increased in bottom layers. A decreasing gradient in both abundance and species diversity was observed from the polynya to the northernmost stations still covered by ice, as well as from the surface to the bottom. Animals in this size class of organisms are part of the "microbial loop". They feed almost exclusively on the small fraction of primary producers such as cyanobacteria, nanoflagellates, and bacteria. Several studies have indicated that the microbial loop becomes more important after the spring diatom bloom, presumably because of the particulate and dissolved organic matter produced earlier in the season. Consequently microzooplankton populations reach their maximum development during the period of microbial loop increase at the end of summer (Monti & Umani, 2000, and references therein).

Two sediment traps deployed in western Ross Sea during December 1994 collected a planktonic foraminiferal assemblage comprising just one species, sinistral coiling *Neogloboquadrina pachyderma.* Two morphs of this species were collected by Asioli and Langone (1997); a thin walled juvenile stage from the uppermost levels of the water column, and a heavily encrusted, seemingly adult stage, from depth. No relationship emerged between foraminiferal distribution and the physical parameters of the water column or biogenic fluxes. However, incursions of the more northerly located, relatively warmer, Circumpolar Deep Water did introduce dextral coiling specimens.

4.3.2 Sea Ice

Stoecker et al. (1993), reported on Protozoa in multi-year fast and annual sea ice in McMurdo Sound. Samples were collected from ice-edge sites between Cape Royds and Cape Bird, and at a fast-ice site at Cape Armitage. They identified a number of heterotrophic Protozoa, many of which could not be identified beyond genus level (Table 4.3.2.1)

The foram *Neogloboquadrina pachyderma* has been confirmed by Dieckmann et al. (1991) to be capable of living in ice interstices, and the number of forams found in new sea ice is much higher than in the underlying water column. While most records of this occurrence are from the Weddell Sea the abundant occurrence of small

Neogloboquadrina pachyderma in annual sea ice has also been recorded in the Ross Sea (unpublished work of Lipps & Bradshaw in Lipps et al., 1979).

4.4 Zooplankton and sea ice metazons

4.4.1 Water column

Arriving at a reliable faunal list for the zooplankton has been difficult because, with time, increasing knowledge of the diversity in each group has lead to reviews of the taxonomic arrangement of many species and those identifying organisms have not always been experts. In addition, a number of larval forms of benthic species, that are temporarily in the zooplankton, have not been identified to species because to the often long larval life and the difficulties of working in the Antarctic. Only a few groups have been examined here to bring the taxonomy up-to-date (Copepoda, Euphausiacea, Chaetognatha).

A number of taxonomic groups appear unrecorded from the Ross Sea plankton, although published records imply that they should be there and there are unconfirmed casual observations of others (Table 4.4.1.1). Among these are Ctenophora (comb jellies), pelagic Nemertea (unsegmented, pelagic worms), Heteropoda (pelagic prosobranch gastropod molluscs), Cephalopoda (early developmental stages of squid and octopus), Branchiopoda (coastal Crustacea), Appendicularia (Urochordata). These organisms are not recorded for a variety of reasons. Members of these groups may be absent from waters near Antarctica, they may be very sparsely distributed, they may be difficult to preserve well, or they may be the unidentified meroplanktonic larval stages of benthic animals. Further, there may have been no specialists available to identify them in collections.

The biogeography of the pelagic fauna of the Ross Sea can be analysed from what is known about Copepoda, Euphausiacea, and Chaetognatha that are amongst the best known taxa. The factors that influence the degree of tightness with which the fauna is associated with the Antarctic continent depends on the bathymetric distribution of each species and the extent to which a species has been isolated and thus had an opportunity to speciate. The question of whether there is a true neritic fauna in Antarctic waters is also relevant to this question.

4.4.1.1 Horizontal and vertical distribution

Copepoda
There are very few entirely epipelagic (living in the surface 200–500 m) mesozooplankton species in Antarctic waters. Examples amongst the Copepoda are small species such as: *Ctenocalanus citer, Racovitzanus antarcticus, Scolecithricella glacialis, Oithona frigida,* and *O. similis.*

Other copepod species are very common in near the surface waters south of the Antarctic Convergence in summer: *Calanoides acutus, Calanus propinquus, Rhincalanus gigas* and *Metridia gerlachei.* Of these *C. acutus* and *R. gigas* perform seasonal vertical migrations (Vervoort, 1965). Thus these species drift north in the summer and appear to return south in Deep Warm Water in winter. In Antarctic surface waters developmental stages predominate. Most males have apparently died out implying a very short breeding season. It appears that copepodites descend in the

Deep Warm Water at the onset of winter and remain there until spring. They then ascend, moult to the adult stage and breed, although it is not know at which depth they copulate (Vervoort, 1965). *Metridia gerlachei*, on the other hand, appears to spawn at the end of summer.

Recent work and summaries of previous studies have led Atkinson (1998) to categorise the spectrum of adaptations copepods make to the Southern Ocean environment. He believes there are three broad life cycle types:

- Species that are herbivorous in summer, have a short reproductive period and winter diapause at depth (*Calanoides acutus* and possibly *Ctenocalanus citer*)
- Species that are predominantly omnivorous / detritivorous feeders that have an extended period of feeding, growth and reproduction but less reliance on diapause at depth (*Metridia gerlachei, Calanus propinquus, Microcalanus pygmaeus, Oithona similis* and possibly *Oithona frigida* and *Oncaea curvata*).
- Species that overwinter and feed within the sea ice as early nauplii or copepodids (*Stephos longipes* and *Paralabidocera antarctica*).
-

He considers *Rhincalanus gigas* to have a life cycle intermediate between the first two.

Most Antarctic copepods have a long (1 year, or even 2 year in the case of *R. gigas*) life cycle unlike temperature and tropical species (Schnack-Schiel in press). She has shown that the storage of internal energy reserves is important for fueling reproductive processes before the onset of the spring bloom; only a small proportion of accumulated lipid stores appear to be utilised for overwintering.

Shallow–living species and those species that live in surface waters in summer and perform ontogenetic vertical migrations tend to be confined to the Antarctic waters, but many other species found in the Ross Sea are there because they are distributed at mesopelagic and bathypelagic depths over a large part of the world's oceans that outcrops in the Antarctic (Table 4.4.1.1). The bulk of the species caught in the Ross Sea are associated with Antarctic Deep (Circumpolar) Water (Vervoort, 1965). For example, a number of species (*Microcalanus pygmaeus, Spinocalanus abyssalis, S. magnus, Gaetanus tenuispinus, Metridia curticauda, Lucicutia ovalis, Heterostylites major*) are widespread at bathypelagic depths, several being recorded from Arctic waters (Bradford, 1971).

Chaetognatha

David (1965) summarised knowledge of the biogeography and life history of Chaetognatha (arrow worms). Three species are endemic to the Antarctic: *Pseudosagitta gazellae, Solidosagitta marri, Eukrohnia bathyantarctica. Pseudosagitta gazellae* migrates seasonally out of the surface 100 m in winter to about 100–250 m. The next spring they migrate back to the surface but when they reach their maximum length they sink to deeper layers, becoming sexually mature. At about 1000 m they shed their eggs that float to the surface and hatch at about 250 m to recommence the life cycle. *Solidosagitta marri* is found at about 250–500 m but also is found in the surface 100 m. This species is characteristic of Warm Deep Water.

Eukrohnia bathyantarctic is distributed from 1000–2400 m. *Pseudosagitta maxima* and *Eukrohnia hamata* have wider distributions than just the Antarctic.

Euphausiacea
Euphausia crystallorophias is dominant in Antarctic neritic seas where is occurs in similar abundances as does *E. superba* in more offshore areas. Of the euphausiids recorded in the Ross Sea, only *Euphausia crystallorophias* is found in the shallower parts of the sea (Brinton et al., 2000), especially where depths are < 300 m. A few specimens of *Euphausia triacantha* were collected from the northern part of the Ross Sea, but this vertically migrating species appears to be limited by colder deep waters over the Ross Sea continental shelf since it generally occurs in waters warmer than 2° C (Lomakina, 1978). Although *E. frigida* and *E. vallentini* are circumpolar species in the Antarctic, they probably do not penetrate into the Ross Sea. The temperature boundary of *E. frigida* is –0.7° C, but it does not occur in the pack ice zone (Lomakina, 1978). *Euphausia vallentini* has a temperature limit of 2° C (Lomakina, 1978) so it is unlikely to penetrate into the Ross Sea where even near surface waters are close to 0° C.

It appears that *E. crystallorophias* spawns in November to early December and completes its larval development under the sea ice during the Antarctic winter (Kirkwood, 1996). The mean time for the eggs of *E. crystallorophias* eggs to develop to furcilia stage VI was 236 days – this is twice the time that *E. superba* takes to develop. The reason for this may be the low temperatures or the low levels of food available.

Euphausia superba has a different life history strategy (Miller & Hampton, 1989). Females probably spawn between December and February over a wide range of depths. The eggs then sink and hatch at depth (probably about 850–1000 m). After hatching, larvae develop as they ascend the water column and arrive near the surface at the first calyptopis stage to feed about 30 days after spawning. Total development from egg to final larval stage takes about 130 days. Daly & Macaulay (1991) believe that the seasonal behaviour and distribution of *E. superba* is designed by the need to acquire food and avoid predators. Seasonal sea ice plays an integral role in the ecology of krill. Ice-edge blooms are an important and predictable food supply, particularly for reproducing adults and first-feeding larvae. Ice floes provide protection for larvae and juveniles, and sea ice biota, a widespread food source, are important to the survival of larvae during winter. The shortest possible life cycle of *E. superba* (egg to egg) is 700–820 days, assuming that growth periods are only for 4–6 months of the year (Ikeda, 1985). *Euphausia superba*'s life span is probably about 1466–2726 days; this prolonged life is presumed to provide for improved fecundity of female krill. The style of life history of *E. superba*, in which eggs sink to greater than 850 m, is probably the reason why this species is circumpolar in the Antarctic and is only found in the outer parts of the Ross Sea. *Thysanoessa macrura* is also circumpolar and extends into Antarctic coastal waters.

Large quantities of *Euphausia superba* have been recorded near the Balleny Islands and north of the Ross Sea (Fig. 4.1.1.1) (Timonin, 1987; Veronina & Maslennikov, 1993; Azzali & Kalinowski, 2000). In the vicinity of the Balleny Islands these large densities are possibly associated with one or more of the water types (the Antarctic Circumpolar Current, Offshore Antarctic Current, and the mixed waters from both in the Ross Gyre) present in the area. Veronina & Maslennikov (1993) interpreted the distribution of *E. superba* to have some relationship to the hydrography of the region, but the description of this relationship is not very clear in their paper, and the quoted supporting papers are not easy to obtain, and are in Russian.

In the north-western part of the Ross Sea concentrations of *Euphausia superba* had a mean biomass ranging from 33–250 t nm^{-2} (Azzali & Kalinowski, 2000). They found that *Euphausia superba* was concentrated over the continental shelf during spring, but by the beginning of summer the main part of krill biomass occurred on the continental slope. When the sea was covered with ice *Euphausia superba* was restricted in dense aggregations in the narrow ice-free regions. These regions were also where dense peaks of krill-consumer populations were found (minke whales, crabeater seals, Adélie penguins).

Ostracoda

Ostracod species of the Southern Ocean have similar life histories (Kock, 1992). The changing vertical distribution of these species of *Alacia* is interpreted as being related to the need for them to maintain themselves adjacent to the Antarctic continent. The adults occur near the surface in Antarctic Surface Water during early summer and therefore are advected off shore over deep water. Before hatching the eggs sink to depths of 400–500 m, where the early juvenile stages stay within the Circumpolar Deep Water that slowly moves them back over the shelf. During the winter the last two juvenile stages migrate back towards the surface ready to restart the cycle when they mature in spring.

Mesopelagic fish

Mesopelagic fishes have two types of distribution in the Ross Sea sector of the Antarctic. Eggs and larvae of notal Antarctic species (*Krefftichthys anderssoni, Protomyctophym bolini, Gymnoscopelus braueri*) are confined to the Antarctic Circumpolar Current (ACC) whereas those of Antarctic species (*Bathylagus antarcticus, Notolepis coatsi, Electrona antarctica*) are encountered both in the ACC and in higher latitudes (Efremenko, 1987). The notal Antarctic fishes are found to spawn in the northern part of the area surveyed at depths > 200 m and Antarctic fishes spawn in the Deep Warm water masses of high latitudes. However, it appears that colder temperatures of deeper water over the continental shelf in the Ross Sea limit the southern penetration of mesopelagic fishes (Dewhitt, 1970). Based on Voyage 27 of the USNS *Eltanin* the midwater fish species normally abundant in Antarctic waters undergo a major faunal transition at the continental shelf of the Ross Sea and are replaced by fishes of the family Notothenidae (99% of the fishes captured). Of these, by far the dominant midwater species is *Pleuragramma antarcticum*, so that the midwater fish fauna of the Ross Sea can genuinely be classified as depauperate.

4.4.1.2 Feeding

Very few members of the Ross Sea biota are obligate herbivores. An exception is *Euphausia superba* which feeds almost exclusively on phytoplankton during the austral summer (Miller & Hampton, 1989) although they are able to exploit other sources of food. Ingestion of animal material and cannibalism has been noted in captivity. Their capacity for omnivory is likely to be important during winter months.

Salpidae and Appendicularia are fine particle feeders that can feed on particles ranging from the size of bacteria to nanoplankton size. The numbers of species and their biomass in the Ross Sea is not known.

Very few copepods are obligate herbivores. Most species are omnivores, carnivores, or have a scavenging habit. Members of the Scolecitrichidae (*Amallothrix, Landrumius, Lophothrix, Mixtocalanus, Pseudoamallothrix, Racovitzanus, Scaphocalanus, Scolecithricella*), Phaennidae (*Xanthocalanus, Onchocalanus*), and Tharybidae (*Tharybis*) are considered to be well adapted to a scavenging habit as they have modified sensory setae on the terminal part of the maxilla. Members of the Aetideidae (*Chiridiella*), Euchaetidae (*Pareuchaeta*), Heterorhabdidae (*Heterorhabdus, Heterostylites*), and Augaptilidae (*Haloptilus, Euaugaptilus*) have mouthparts adapted for grasping prey.

Many other Antarctic groups of zooplankton are carnivorous or microcarnivores: Protozoa, Hydrozoa, Scyphozoa, Ctenophora, Chaetognatha, Nemertea, Polychaeta, Ostracoda (these appear to prefer dead material), Mysidacea (some are detrital feeders), Amphipoda (many are parasitic, commensal or scavengers), Decapoda (ominvorous during early life history), Pteropoda (some are omnivorous mucous feeders), Cephalopoda, fish larvae (some first feeding larvae are herbivorous).

4.4.2 Fast ice (tide crack)

The tide crack and an ice hole drilled nearby indicate that there are a restricted number of species that lives in this habitat (Table 4.4.2.1). Also some of them have only been recorded here (*Paralabidocera grandispina*) or also under the Ross Ice Shelf (*Tisbe prolata*) far from the open sea or found in the Antarctic zooplankton (*Pseudocyclopina belgicae*). For a more detailed discussion of this habitat see Knox (1994: 221).

Waghorn & Knox (1988) note that the three main copepod species found in the tide crack apparently have differing life history strategies. Although their life histories have only been partly observed it appears that *Paralabidocera grandispina* may overwinter as eggs and hatch in spring and complete their life history quickly during the spring-summer food maximum so that both the maturation of the gonads and development of the young are completed in one season. The occurrence of large numbers of young *Pseudocyclopina belgicae* in November suggests that this species lays large numbers of free eggs in early to mid November that develop rapidly during the spring-summer food maximum. This species may overwinter as late stage copepodites or adults. The summer population of *Tisbe prolata* was principally composed of females, large number of which were ovigerous although very few juvenile stages were found. It is possible that this species uses the spring-summer food maximum to induce gonad maturity with the eggs not hatching until late summer. It would then have to overwinter as juvenile or adult stages. Much remains to be worked out about the life histories and distributions of these species.

4.4.3 Under Ross Ice Shelf

The fauna found under the Ross Ice Shelf included animals that live in the water column well as those that are more generally linked with benthic environments (Lipps et al., 1979a) (Table 7). A sparse population of bacteria, microplankton and zooplankton was found in the water column 400 km from the Ice Shelf edge at densities that similar for the abyssal ocean (Azam et al. 1979). Sediment samples also contained metabolically active bacteria. In a following study (Horrigan, 1981) it was established that about 1.5 g m^{-2} y^{-1} of chemoautotrophic production by nitrifying bacteria was occurring and that this may be sufficient to support the observed macrofaunal population. In addition, brooding females of the amphipod *Orchomeme* were captured (Stockton, 1982) and adults and developmental stages of copepods (Bradford & Wells, 1983) were attracted to bait and are assumed to be at least facultative scavengers.

Elements of the Ross Sea water column fauna have very restricted distributions associated with permanent ice in the south-western Ross Sea. For example *Pareuchaeta erebi* is found mainly under the Ross Ice Shelf, whereas *P. tycodesma* and *P. similis* while more abundant close to the ice shelf, but also occur occasionally in modified Circumpolar Deep Water (Fontaine 1988) (Fig. 4.4.3.1).

4.4.4 Sea Ice

The Metazoa of sea ice communities has been less well studied than the algal flora. The origins of the ice fauna are better understood for Arctic regions than for Antarctic; here the distribution of organisms reflects the proximity to land, and the source of inocula (Carey, 1985). In shallow, coastal margin waters, less than 10 m deep, the Arctic ice fauna is primarily derived from the sediments, and comprises benthic groups such as nematodes and harpacticoid copepods. In coastal oceanic water the ice fauna is also primarily benthic, but mostly comprised of benthic gammarid amphipods and mysids. Offshore, in the deep fast ice community, the ice fauna is pelagic in origin, with a few exception.

Traditionally, and derived mainly from data from the Weddell and Davis Seas, the Antarctic in-ice (brine channel) community is made up of copepods (harpacticoid and calanoid) and amphipods (Bradford, 1978). Bradford (op cit) reported the copepods *Harpacticus furcifer* and *Idomene antarctica* from the McMurdo Sound region.

Studies of the metazoan fauna of sea-ice specific to the Ross Sea appear to be lacking. The closest information available comes from the Bellingshausen and Amundsen Seas, 80° to the east. There, Schnack-Schiel et al. (1998) described the copepod fauna of multi-year ice floes and also commented that only copepods and nematodes were found in the sea ice fauna. They recognised six copepod taxa (Table 4.4.4.1), of which the normally benthic harpacticoid copepod *Drescheriella glacialis* and the calanoid copepod *Stephos longipes*, in a genus normally considered to be benthopelagic, were most abundant. It is intriguing to consider how the benthic species remain such an important component of the oceanic pack ice. Of note was that all instars of *D. glacialis* were found in the ice, suggesting that this species may complete its entire life cycle in the ice, and provide colonists in the upper water column to seed newly forming ice in autumn. This appears to be a successful strategy for this normally benthic species. In contrast, the pelagic *S. longipes* was only present as young stages, but clearly has a life history closely associated with the formation and melting of sea ice (Schnack-Schiel et al., 1995; Costanza et al., in press). *Harpacticus furcifer* was reported from McMurdo Sound (see above), and appears to be a widespread sea ice copepod.

5. Biodiversity of biota associated with the sea floor

The Southern Ocean is one of the world's most discrete oceanic ecosystems (Fig. 4.1–4.3); within the Antarctic Convergence, the physical and chemical parameters are more stable and uniform than they are around any other continent (Picken, 1985; Dayton, 1990). Consequently, the benthos of Antarctica is one of the most discrete and self-contained biological regions in the world, comprising only true, indigenous Antarctic marine flora and fauna. South of the Antarctic Convergence, the benthic fauna includes a high proportion of endemic species, which have radiated from a relatively small number of families and genera (Knox & Lowry, 1977; Dayton, 1990). Picken (1985) believed that speciation rates in Antarctica are enhanced by the prevalence of non-pelagic reproduction, but questioned the notion that oligotrophic conditions in the deep sea and some coastal situations contributed to this. Conditions of food scarcity presumably favour specialised diets and feeding mechanisms, but the high incidence of facultative scavenging and necrophagy among some Antarctic benthic taxa seems contradictory (Picken, 1985). In other regions, however, the Antarctic seas are among the most productive habitats in the world and, although there is a strong seasonal pulse, biological productivity is high and usually extremely predictable (Dayton, 1990).

Generally, the Antarctic continental shelf is narrow and deep, with the outer edge of the shelf at 400–800 m depth. There are no obvious barriers between habitats, so that most benthic habitats are inhabited by many of the same species, often in different proportions (Dayton, 1990). Thus, the principal factors determining the composition of Ross Sea and Antarctic benthos are substratum type, depth, annual ice scour and organic input (Picken, 1985), factors that are mediated primarily through the annual ice cycle.

Ice is a key factor for the benthos within the Ross Sea because its break-up influences algal growth and the onset and duration of phytoplankton blooms (Dayton, 1990). Ice also is a major disturbance factor through anchor-ice formation and subsequent rafting, and through scour and disturbance by sea ice and icebergs (Picken, 1985). It also influences salinity and water temperature (Knox, 1994), although the consequences of these effects are less obvious. Melting ice provides a continuous supply of coarse terrigenous material that is easily used as a substrate. Hence, epifauna dominates much of the Antarctic benthos (Knox & Lowry, 1977).

Ice also serves to reduce disturbance through its dampening effects on waves on Antarctic shores (Shen & Squire, 1998), notably within McMurdo Sound (Berkman et al., 1986; Miller & Pearse, 1991). Because of this, there is very little sorting and re-working of sediments, even in shallow waters close to Ross Sea shores. Sediment re-suspension by wave action, and subsequent re-deposition, is confined to brief periods when the coastal sea ice is absent, principally March-April in McMurdo Sound, but may occur at other times if severe winds cause unseasonal break out of the sea ice (Berkman et al., 1986). There are two consequences of this for benthos. First, bottom sediments in shallow waters are usually very poorly sorted and quite heterogeneous over small spatial scales (e.g., Dayton, 1990; Cattaneo-Vietti et al., 2000a), with the result that finer sediments are rare in shallower waters and the infauna is depauperate (Knox & Lowry, 1977). Second, rich epifaunal communities develop immediately below the depths of annual disturbance by ice scour, with the gross morphologies and behaviours of many shallow benthic animals more akin to those expected of deeper habitats at temperate latitudes. Obviously, ice and its effects vary with latitude, water depth and the physical geography of benthic habitats (Picken, 1985).

The composition of most benthic communities reflects their biogeographic histories and the physical stresses delimiting species' general patterns of distribution and abundance (Knox & Lowry, 1977). Thus, historical and physical factors determine benthic community composition, whilst the availability of organic matter and biotic interactions determine the relative abundances and biomasses of the species populations (Dayton, 1990). The supply of organic matter is usually a function of water column productivity, depth, and the intervening transport processes. Thus, the benthos at any one location is determined by the region's biogeographic relationships and history, the nature, predictability, abundance and utilization of organic inputs, as well as the extent to which abiotic disturbance and biotic factors influence recruitment, age-specific mortality and fecundity.

5.1 Shallow coastal habitats

5.1.1 Supralittoral

A brown band of mainly marine diatoms (two species) forms a supralittoral (epilittoral) zone on Ross Sea shores (Zaneveld, 1966b). This zone is readily apparent on ice-covered cliffs, extending up to 80 m above sea level within the influence of salt spray (Zaneveld, 1966b). The chlorophyte alga *Prasiola crispa* is the commonest species on ice-covered rocks, whereas, *Ulothrix flacca* seems confined to sites where dirt and guano accumulate (Zaneveld 1966b, 1968).

At Terra Nova Bay, the supralittoral was regarded as azoic, as a result of harsh physical conditions (Cattaneo-Vietti et al., 2000a). However, ephemeral communities, characterised by cyanobacteria and pennate diatoms, develop seasonally within small, supralittoral pools enriched by bird guano on rocky shores at Terra Nova Bay (Cattaneo-Vietti et al., 2000a). Similar supralittoral lagoons also occur further south in McMurdo Sound and have been studied by Downes et al. (2000).

5.1.2 Intertidal

Intertidal biotas are generally non-existent on Ross Sea and Antarctic shores (Zaneveld, 1966b; Picken, 1985), although some encrusting algae may occur in crevices on rocky shores at lower latitudes, as on part of the Antarctic Peninsula (Picken, 1985). From his wide-ranging survey, Zaneveld (1966b, 1968) believed that macroalgal growth was absent from Ross Sea intertidal zones, but that extreme high water springs and extreme low water springs levels were characterised by a brown, diatomaceous layer.

At Terra Nova Bay, ice abrasion excludes macroalgae, but allows the development of cyanobacteria and diatoms (e.g., *Achnanthes* spp., *Triceratium* sp., *Fragilaria* spp., *Nitzschia* spp., *Navicula* spp.) on open rock surfaces (Gambi & Mazzella, 1991; Cattaneo-Vietti, 2000a). Macroalgae (notably *Prasiola crispa* and *Urospora penicilliformis*, may occur on very protected rocky shores at Terra Nova Bay (Cattaneo-Vietti et al., 2000a). There are no reports of intertidal biotas within the McMurdo Sound area.

5.1.3 Sublittoral (0–30 m depth)

Zonation patterns have been described by various workers in the Ross Sea for the total macrobenthos or components of it on hard or cobble substrates in McMurdo Sound and at Terra Nova Bay. The general zonation pattern on Ross Sea shores reflects a gradient in the frequency and severity of scouring by ice and removal by anchor-ice described by Hedgpeth (1971) for Antarctica as a whole (Dayton, 1989, 1990; Knox, 1994). More detailed investigations of zonation and ecological interactions between species lead Dayton et al. (1970) to conclude that physical disturbance by ice scour and anchor-ice establish the zonation of shallow benthos in McMurdo Sound, whilst biological interactions are more important at greater depths.

Benthic primary production obviously plays an important role in benthos zonation patterns on both hard and soft bottoms in Antarctica, although the functional relationship between fauna and flora requires further attention. Microalgae thrive on both hard and soft bottoms within the Ross Sea to depths of at least 42 m in McMurdo Sound. Standing stocks of microalgae on sponge spicule bottoms in McMurdo Sound during summer may reach extremely high levels (up to 960 ± 220 mg chl *a* m^{-2}), although there is wide variation from place to place, especially between the sides of the Sound (Dayton et al., 1986). These differences were attributed to differences in light penetration due to water depth and ice conditions. For example, the standing stock of microalgae on a spicule mat bottom at 6 m depth near Cape Armitage increased by 27% over about two weeks after removal of snow from sea ice (Dayton et al., 1986). Substrate was another major cause of differences in standing stock; most of the very high standing stock values were from spicule mat bottoms. These sponge spicules provide a very complex habitat structure with enormous surface areas for benthic diatom attachment, layers of interstices to catch and retain ice algae and phytoplankton settling out of the water column, and a matrix affording protection from grazers (Dayton et al., 1986). In addition, Palmisano et al. (1985) demonstrated that these benthic diatoms are highly shade adapted, and there are suggestions that these diatoms utilize light that is actually transmitted along the individual spicules comprising these mats (Cattaneo-Vietti, 2000b).

5.1.3.1 Hard bottoms: McMurdo Sound

Few organisms inhabit Dearborn's (1965, reported in Dayton et al., 1970) shallow **Zone 1** at 0–15 m depth, the limit of ice scour. Within McMurdo Sound, this zone is conspicuously barren, and comprises a pebble slope at Cape Armitage or pebbles and volcanic debris at Hut Point (Dayton et al., 1970). Locally, macroalgae penetrate this upper sublittoral zone to depths as shallow as 3 m (Zaneveld, 1966b). In McMurdo Sound and at Cape Crozier, these shallow-living species include *Iridaea cordata*, *Phyllophora antarctica*, *Hildenbrandia lecannellieri* and *Monostroma hariotii*. *Monostroma*, the only green alga found in McMurdo Sound, never forms beds. It attaches to empty shells scattered over sandy bottoms where there is little or no ice cover (Zaneveld, 1966b).

During summer, dense diatom populations develop quickly on rocky bottoms in McMurdo Sound (and elsewhere, presumably), attracting large populations of the seastar *Odontaster validus* and the echinoid *Sterechinus neumayeri*, as well as the giant nemertean *Parborlasia corrugatus*, the large isopod *Glyptonotus antarcticus* and pycnogonids (Dayton et al., 1970; Dayton, 1990). A few fish also inhabit this zone. A similar biota exists at Cape Bird, located on the north-western corner of Ross Island. There, the bottom comprises predominantly well-sorted olivine basalt gravel sloping gently to about 15 m depth (Sagar, 1976). A rich diatom flora develops on these gravels over summer months and the associated fauna is dominated by the amphipod *Paramoera walkeri*. Other animals present include the lysianassid amphipod *Orchomenella pinguides*, polychaetes, gastropods and copepods (Sagar, 1976).

Stable rocky bottoms within the 0–15 m depth range of Dearborn's (1965) Zone 1 in McMurdo Sound and at Terra Nova Bay are often dominated by macroalgae (Zaneveld, 1966a, b; Miller & Pearse, 1991; Gambi et al., 1994, 2000; Cattaneo-Vietti, 2000a). These algae exhibit pronounced depth zonation patterns within this depth zone and support rich epifaunas of amphipods, isopods, molluscs, and fish (Picken, 1985). Macroalgal and epifaunal communities at Terra Nova Bay are discussed below.

Macroalgae may be locally abundant in the upper sublittoral of McMurdo Sound (Zaneveld, 1966b; Miller & Pearse, 1991). For example, at Cape Evans, the red seaweed, *Iridaea cordata*, forms thick growths on scattered rocky outcrops and boulders at 3.5 m depth (Miller & Pearse, 1991) and grows in extensive beds just east of Cape Royds (Zaneveld, 1966b; Miller & Pearse, 1991). Apparently, the attached alga lives within anchor-ice for part of the winter (Miller & Pearse, 1991). Fine gravels and sediments between these outcrops are covered by a heavy flocculent layer of benthic diatoms. A fauna is also present here. Asteroids (*Odontaster validus*), urchins (*Sterechinus neumayeri*), gastropods (*Neobuccinum eatoni*) and a fish (*Trematomus bernacchii*) are common on rock and sediments (Miller & Pearse, 1991). Littorine and rissoiform gastropods live on the seaweed itself also.

Another red macroalga, *Phyllophora antarctica*, occurs slightly deeper, largely replacing *Iridaea* by about 10–12 m depth. At Cape Evans, an unstable cobble slope at 4–12 m depth was bereft of algae and separated a distinct *Iridaea* zone from a *Phyllophora* zone (Miller & Pearse, 1991). The burrowing bivalve *Laternula elliptica* and an anemone (*Edwardsia intermedia*) were the only organisms found on this slope. Bedrock, boulders, cobbles and gravel patches interspersed with sandy sediment between 12–20 m depth were encrusted with *Phyllophora antarctica* and sessile invertebrates. The fauna here includes all species found at shallower depths, as well as encrusting Bryozoa, foraminiferans, two asteroids (*Diplasterias brucei*, *Perknaster fuscus antarcticus*), a heart urchin (*Abatus shackletoni*), a nemertean (*Parborlasia corrugatus*), the soft coral *Alcyonium paessleri*, a gastropod, *Amauropsis grisea*, and a bivalve (*Yoldia eightsi*) (Miller & Pearse, 1991). Both *Phyllophora* and *Leptophytum coulmanicum*, a crustose coralline alga found here, are encrusted with a bryozoan, a calcareous foraminiferan and diatoms.

The adjacent deeper **Zone 2** extends from 15 m to end sharply at 33 m depth, the limit of anchor-ice formation (Dayton et al., 1970). This zone experiences less frequent ice scour, but disturbance by anchor-ice formation and up-lift may be very profound (Dayton et al., 1969, 1970). Some species within Zone 2 at McMurdo Sound, notably the sponge *Homaxinella balfourensis* and its predators, underwent massive changes in abundance over a ten-year period because of high anchor-ice mortality and subsequent recovery (Dayton, 1989). Apparently the differences in anchor-ice formation resulted from changes in water temperatures due to changes in predominant current directions induced by El Niño-Southern Oscillation changes (Dayton, 1989).

Below 15 m depth at Cape Evans, *Leptophytum coulmanicum* covers all rock and rubble surfaces, along with basal crusts of *Phyllophora*, sparse, small plants of *Phyllophora* and Bryozoa and three asteroids (*Diplasterias brucei, Odontaster meridionalis, Porania* sp.) (Miller & Pearse, 1991). Drift plants of algae from shallower depths accumulate here (Zaneveld, 1966a) and, presumably, serve as food for some of the fauna. Patches of cobbles and sediments, as well as sponge spicule mats, interspersed between larger rock surfaces, each support additional animals. Large boulders support soft corals (*A. paessleri*), ascidians (*Cnemidiocarpa antarctica*), anemones (*Urticinopsis antarcticus*), sponges, urchins (*S. neumayeri*) and asteroids (*O. validus*). Giant nemerteans (*P. corrugatus*) are very abundant on cobble/sediment patches, with the heart urchin *Abatus shackletoni* burrowing into the sediment (Miller & Pearse, 1991). Spicule mat patches support dense diatom growths and are inhabited by bivalves (*Limatula hodgsoni*) and gastropods (*Trophon longstaffi*) (Miller & Pearse, 1991).

Zone 2 is characteristically inhabited by sessile and mobile animals, but algae appear less common below about 20 m depth within McMurdo Sound. The benthos appears highly variable from place to place, depending upon substrate, depth and other factors. Sessile taxa include alcyonarians (*Alcyonium paessleri*), actinarians (*Artemidactis victrix, Isotealia antarctica, Urticinopsis antarctica, Hormathia lacunifera*) stoloniferans (*Clavularia frankliniana*), hydrozoans (*Tubularia hodgsoni, Lampra parvula, Halecium arboreum*), ascidians (*Cnemidocarpa verrucosa*) (Dayton et al., 1970) and the sponge *Homaxinella balfourensis* (Dayton, 1989). Motile animals include seastars (*Odontaster validus*), the urchin *Sterechinus neumayeri, Parborlasia corrugatus*, pycnogonids (*Thaumastopygnon striata, Colossendeis robusta*) and the fishes *Trematomus bernacchii, T. centronotus.* All of these animals also occur below this zone.

At about 23 m depth just west of the tip of Cape Armitage in McMurdo Sound, the bottom comprises patches of exposed volcanic cobbles interspersed with fine sediments (0.03–0.25 mm diameter, covering c. 60% of the bottom) or sponge (*Cinachyra antarctica*) spicule mats up to 7 cm thick, both overlying a cobble basement (Battershill, 1989). This habitat apparently is subjected to considerable disturbance by anchor-ice formation and currents (Battershill, 1989), but ice scour is likely to be infrequent. Macrofauna, predominantly sponges, covers about 35% of the total bottom area leaving much bare cobble, sediment and spicule surface available for colonisers. Changes in cover, density and size of species present are apparently very slow (Battershill, 1990).

Approximately 35 species of macroinvertebrates were present here. Dominant sponges are *Cinachyra antarctica* and *Homaxinella erecta,* the latter an apparent rapid coloniser of disturbances and commonly found as shallow as 10 m depth nearby, but rare below 30 mm depth (Battershill, 1989). Other taxa present here included various sponges (*Polymastia* sp., *Polymastia invaginata, Inflatella belli, Mycale ascerata*), the alcyonarian *Alcyonium paessleri,* an ascidian (*Cnemidocarpa verrucosa*), the anemone *Urticinopsis antarcticus,* the bivalve *Limatula hodgsoni,* an urchin (*Sterechinus neumayeri*), the seastar *Odontaster validus,* a gastropod (*Trophon longstaffi*) and the large nemertean, *Parborlasia corrugatus* (Battershill, 1989). Three fish species were present in low densities also. This community was considered comparable to that of similar reefs in temperate waters around New Zealand in terms of both diversity and biomass (Battershill, 1989). However, it is not as rich as the assemblage found at slightly deeper adjacent locations within McMurdo Sound (Dayton et al., 1974).

Macroalgae present within Zone 2 in McMurdo Sound are *Phyllophora antarctica*, *Leptophytum coulmanicum*, *Monostroma hariotii* and *Hildenbrandia lecannellieri*. *Iridaea* is usually absent from this zone, apparently being restricted to depths shallower than about 10 m. *Phyllophora* appears to attain its greatest density at about 10–14 m depth, often in association with urchins (*Sterechinus neumayeri*), with small, stunted plants extending into deeper water, but this alga disappears by 24 m depth (Miller & Pearse, 1991). *Leptophytum* is a deeper-water species, largely absent shallower than about 10 m depth, attaining maximum thickness below 15 m depth. Thin *Leptophytum* crusts extend to beyond 30 m depth at New Harbour (Miller & Pearse, 1991). *Monostroma harotii* is found only locally as scattered plants attached to dead shells on shallow, sandy bottoms (Zaneveld, 1966b). It is rare in Zone 2. The crust-forming red, *Hildenbrandia*, has the greatest depth range in McMurdo Sound of these four species, occurring from 3 to 33 m depth and, thus, spanning Zones 1–3. North of McMurdo Sound, all of these macroalgae appear to extend deeper (Zaneveld, 1966b).

Below 33 m at McMurdo Sound lies Dearborn's (1965, in Dayton et al., 1970) **Zone 3**, characterised by an extremely physically stable benthic habitat and a complex benthos dominated by longer-lived species. Notable among this benthos are several species of sponges that contribute substantial vertical structure to the benthic community (Dayton et al., 1970, 1974). The transition between Zones 2 and 3 is very abrupt: over a 3 m depth range, the substrate changes from cobbles to a thick mat of siliceous sponge spicules (Dayton et al., 1970).

The fauna inhabiting Zone 3 is very diverse, reflecting complex food webs, often involving intense predation by various asteroids, including species that are predominantly deposit-feeders, such as *Odonataster validus* (Dayton et al., 1974). This sponge community has been studied in detail at the tip of Cape Armitage and Hut Point in McMurdo Sound by Dayton (Dayton, 1972; Dayton et al., 1970, 1974). The substratum comprises a mat (2–200 cm thick, nearly always >1m thick) of siliceous sponge spicules, usually overlying a layer of bivalve (mostly *Limatula hodgsoni*) valves (Dayton et al., 1970). A remarkable diversity of sponge species and growth forms cover about half (55%) of the bottom, providing a complex structure up to 2 m above the spicule mat (Dayton et al., 1974). These sponges include antler- and fan-shaped forms, as well as bush-like, volcano and ball-shaped ones. The structure of this sponge spicule mat community is maintained by complex biological interactions within an extremely stable physical environment (Dayton, 1972). Predator-prey relationships, with asteroids comprising the foundation species, and complex interspecific competitive interactions between sponges via chemical defences appear to underlie the diversity and structure of this community (Dayton, 1972; Dayton et al., 1970, 1974).

This complex community is inhabited by several other invertebrates and fishes, which use it for both refuge and perching. Although there is no published account of the biodiversity of this assemblage, Dayton et al. (1974) lists several important macroinvertebrates, many of which are poorly known:

Actinaria: *Stomphia selaginella, Artemidactis victrix, Urticinopsis antarcticus, Isotealia antarctica, Hormathia lacunifera.*

Hydroida: *Lampra parvula, L. microrhiza, Tubularia hodgsoni, Halecium arboreum*, other unidentified species.

Bryozoa: *Eminooecia carsonae, Terebripora frigida, Caberea darwinii.*

Mollusca: the bivalve, *Limatula hodgsoni*; nudibranchs (*Austrodoris mcmurdensis, Tritoniella belli, Notoeolidia gigas*, other unidentified aeolid nudibranchs); gastropods *Trophon langsfaffi*, unidentified chrome yellow gastropod.

Nemertea: *Parborlasia corrugatus.*

Polychaeta: unidentified sabellids.

Asteroidea: *Perknaster fuscus antarcticus, Acodontaster conspicuus, A. hodgsoni, Odontaster meridionalis, O. validus, Diplasterias brucei, Macroptychaster accrescens.*

Echinoidea: *Sterechinus neumayeri.*

Pycnogonidia: *Thavmastopycnon striata, Colosssendeis* spp., other pycnogonids).

Pterobranchia: *Cephalodiscus antarcticus*;

Ascidiacea: *Cnemidocarpa verrucosa.*

Ecological interactions and their role in structuring this benthic community have been investigated over several years in McMurdo Sound by Dayton and his colleagues, providing some seminal findings for marine ecology world-wide. Long-term studies involving caging, tagging and behavioural observations, primarily at one site in McMurdo Sound, have shown that large predatory species play important roles in determining the composition of these rich sponge communities. Despite the detail of these macrofaunal studies, however, there is no comprehensive description of the total fauna and its biodiversity within this complex community.

Other sites at similar depths further north in McMurdo Sound (Arrival Heights, Cinder Cones, Turtle Rock, Cape Evans, Cape Royds, Backdoor Bay, Dailey Islands) have very different benthic communities. Algae, scallops, sea urchins and high densities of *Odontaster validus* dominate these. Differences apparently result from increased sedimentation, unstable substrate or intense ice scour (Dayton et al. 1974).

Sponges decline in abundance below about 50 m depth at McMurdo Sound, with the dense sponge zone being replaced by a mix of bryozoans and sabellid polychaetes mixed with fewer sponges (Dayton, 1990). Although this sponge association is a striking feature of the benthos at 30–50 m in south-eastern McMurdo Sound, it is uncertain how universal it is at these depths. Dayton (1990) reported that apparently suitable substrate a few kilometres to the north of Hut Point lacked the sponge association and was inhabited by coralline algae and gorgonians.

5.1.3.2 Hard bottoms: Terra Nova Bay

Although broadly similar, zonation on shallow rocky shores at Terra Nova Bay differs in several respects. Shallowest depths (0.5 m) are largely bare of macroscopic organisms, with the exception of huge populations of the amphipod *Paramoera walkeri* (up to 6000 m^{-2}) grazing on spring and summer blooms of epilithic diatoms within this zone (Cattaneo-Vietti et al., 2000a). Below about 2 m depth, macroscopic algae grow in very high densities. Two red seaweeds (*Iridaea cordata, Phyllophora* *antarctica*) are abundant, with a few other algae also present (*Monostroma hariotti*, *Geminocarpus geminatus*) to 10–12 m depth (Cattaneo-Vietti et al., 2000a). *Iridaea cordata* dominates and appears to be a perennial, persisting over winter, with relatively high biomasses (3.5 kg m^{-2}) present in December (Cattaneo-Vietti et al., 2000a). Macroalgal densities peak in mid January at >4000 m^{-2} (Cormaci et al., 1996). An abundant, but species-poor epifuana is associated with this alga. This epifauna consists of four species: a small gastropod, an amphipod, one polychaete, and an isopod (Table 5.1.3.2.1) (Cattaneo-Vietti et al., 2000a).

Phyllophora antarctica gradually replaces *Iridaea cordata* to form dense beds dominating the algal flora on rocky bottoms at 16–25 m depth in Terra Nova Bay (Cattaneo-Vietti et al., 2000a; Gambi et al., 2000). It attains maximum densities (9760 m^{-2}) and biomass (1.5 kg m^{-2}) by mid-January. Consistent with the lower frequency of disturbance at this depth, the *Phyllophora* epifauna is considerably more diverse, but less abundant than that found on *Iridaea* at shallower depths. In addition to mobile species, the *Phyllophora* epifauna includes sessile animals also (e.g., hydroids, serpulid polychaetes, bryozoans) (Table 5.1.3.2.1).

A detailed investigation of the biota associated with these two species of algae at Terra Nova Bay found consistent, marked changes with depth, as well as substantial differences between years. Epifaunal diversity and abundance increased with increasing depth to about 12 m depth (Gambi et al., 1994; 2000). Much of this appears due to reduced ice scour and increased habitat complexity (presence/absence of macroalgae, biomass of *Phyllophora antarctica*) with depth over this range. Despite these differences, the epifaunal composition was remarkably consistent between locations at any one depth, despite some changes in relative abundances of dominant taxa and the occurrence of rare species (Gambi et al., 2000). There were also marked variations in epifaunal abundances between years that were greater (order of magnitude reductions) at shallower depths, apparently due to harsher winter conditions (Gambi et al., 2000).

The benthic environment below 25 m depth at Terra Nova Bay includes a greater variety of substrates, with both hard and soft substrates often interspersed. The encrusting red alga *Clathromorphum lemoineanum* replaces upright foliose algae below about 25 m depth in Terra Nova Bay. The primary structure within the community is provided by a diverse assemblage of soft corals (*Alcyonium* sp.) between 30 and 50–60 m depth, sponges (>10 species; often 2–3 kg m^{-2}), and gorgonians (*Thouarella* sp., *Primnoella* sp.) within c. 60–100 m depth (Cattaneo-Vietti et al., 2000a). A complex fauna, including numerous predators (e.g., *Barrukia cristata*, *Odontaster validus*, *Perknaster fuscus antarcticus*, *Acodonaster conspicuus*, *Diplasteria brucei*), is associated with this alga and the structuring sessile fauna (Cattaneo-Vietti et al., 2000a).

A *Serpula* community inhabits the sparse hard bottoms below about 100 m at Terra Nova Bay (Cattaneo-Vietti, 2000a). This is dominated by *Serpula narconensis*, a tube-building polychaete, and several bryozoans (encrusting *Ellisina antarctica*, *Arachnopusia decipiens*; erect *Reteporella* sp., *Isoschizoporella similis*, *Antarcticaetos bubeccata*, *Notoplites* spp., *Cellarinella* spp.; and rooted species *Isosecuriflustra angusta*, *Austroflustra vulgaris*) are the main inhabitants (Cattaneo-Vietti et al., 2000a).

Biodiversity increases with increasing depth and algal cover at Terra Nova Bay, especially for the macrofauna. This is increase in diversity, with a concomitant decrease in dominance by just 1–2 species, is most marked in the shallows where disturbance by ice is greatest (Fig. 5.1.3.2.1). Diversity and abundance are greatest within *Phyllophora* because this alga has more complex thalli, presenting larger surface areas for the fauna than do *Iridaea* thalli (Gambi et al., 1994). Further, there were marked changes in benthos diversity and density between years, especially at shallower (2–4 m) depths, where annual ice had a greater effect (Gambi et al., 1994; 2000).

Despite the high densities and rapid changes in both diversity and density of hard bottom benthos in Terra Nova Bay, preliminary research indicates that new hard substrates are colonized quite slowly. One-year old settlement plates in Terra Nova Bay were completely covered with algal films and filaments, with some sessile animals present (Amato et al., 1990; Relini & Amato, 1991). However, the biota of three-year old plates was much the same; the sparse, low epifauna lacked any large or erect taxa or individuals (Amato et al., 1990; Relini & Amato, 1991).

Shells of the large Antarctic scallop *Adamussium colbecki*, which live for up to 15 years, provide microcosms for epizoic organisms and reveal further insights into the slow pace of epizoic community development and near-shore environmental complexity in the Ross Sea region. Annual growth rings on larger (>65 mm diameter, >8 years old) individuals provide a means of determining the maximum age of epibionts and showed that one of the more abundant epibionts, the erect, branching sponge *Homaxinella balfourensis*, colonized rapidly, growing at 60 mm year^{-1} on average, but up to 130 mm year^{-1} maximum (Berkman, 1994).

Mean densities of scallops and their mean sizes decrease with depth in McMurdo Sound (Berkman, 1994). Small (<35 mm diameter) individuals are absent shallower than 10 m depth and they remain epizoic on larger individuals until c. 65 mm diameter (c. 8 years old), attaching by a byssus (Berkman, 1994). Very low numbers of epibionts are present on their shells up until about this size and age, when many scallops apparently migrate to less than 10 m depth to live individually in depressions in the sediment surface (Berkman, 1994). Presumably, epibionts are removed from the shells of small scallops when byssally attached, possibly by mechanical abrasion. Thus, although the substrate available for colonisation by epibionts is higher in the shallows, the proportion of shells colonized by macrofaunal species increases with increasing depth from 0–10 m to 21–30 m depth (Berkman, 1994). Reasons for this apparent enigma are uncertain, but Berkman (1994) considered that reduced salinities and/or siltation from summer melt-water reduced survival of either larval or mature epibionts at shallower depths.

5.1.3.3 Soft bottoms

The infauna of the Ross Sea is far less spectacular than the epifauna and has received relatively little attention. The few studies in the Ross Sea (Lowry, 1976; Dayton & Oliver, 1977; Cattaneo-Vietti et al., 2000a), along with those made elsewhere in Antarctica, however, suggest that the infauna of the Ross Sea is important. Zonation is much less obvious for soft bottom biotas at shallower depths (5–50 m depth) (Dayton, 1990). Instead, assemblage compositions are determined more by the species that are present locally and the factors influencing their distributions and abundances at smaller scales. More important among these smaller scale factors are organic carbon supply and past disturbances (physical and biological) (Dayton, 1990). Sediment particle size composition is likely to play a role also, as it does at lower latitudes.

5.1.3.3.1 Soft bottoms: McMurdo Sound

Several studies of hard bottom benthos in McMurdo Sound (e.g., Zaneveld, 1966b; Miller & Pearce, 1991; Dayton et al., 1970, 1974; Dayton & Oliver, 1977; Battershill, 1989), as well as in Terra Nova Bay (e.g., Cormaci et al., 1996; Cattaneo-Vietti et al., 2000a; Gambi et al., 2000) indicate that the sublittoral benthos of the Ross Sea varies markedly with depth, substratum and a host of other factors over relatively small spatial scales. Equivalent changes over similar spatial scales should, therefore, be expected in the shallow, soft-bottom benthos also. However, there are too few detailed investigations of soft-bottom benthos to evaluate this or to establish a meaningful understanding of this fauna in the region, as a whole.

Lowry's (1976) work at Cape Bird and Cape Hallett was the only investigation that attempted any comprehensive examination of the soft-bottom biodiversity in the entire region. Over 70 species were found at Cape Bird, but this is only half the biodiversity present in an equivalent benthic habitat at Cape Hallett (well north of McMurdo Sound) (Table 5.1.3.3.1.1). Dayton & Oliver (1977) reported 37 and 50 species from soft-bottoms at Cape Armitage and New Harbour, respectively, but provided no analyses of the compositions of these faunas.

Comparisons of benthos densities along east and west sides of McMurdo Sound and elsewhere in the Ross Sea (Table 5.1.3.3.1.1) illustrate the wide differences in infaunal composition over moderate distances. Dayton & Oliver (1977) attributed the very large differences between east and west sides of the Sound to differences in the quantities of organic carbon available to each assemblage. They argued that southern sites on the western shore (Garwood Valley) were bathed in predominantly north-flowing waters from beneath the permanent ice shelf and, hence, were relatively oligotrophic, compared to waters on the east side (McMurdo Station, Cape Armitage) which received abundant phytoplankton from in situ production and allochthonous production carried in by south-flowing currents (Dayton & Oliver, 1977).

Other evidence suggests that the east-west difference reported by Dayton & Oliver (1977) is more complicated. Direct measurements of surface sediment organic carbon content indicated little difference from east to west (Dunbar et al., 1989), but observations on total particulate vertical fluxes at different points revealed decreases from east to west, well north of Hut Point Peninsula, and an increase to the north from New Harbour (Dunbar et al., 1989). Stockton (1984) reported unpublished data indicating that the west side of McMurdo Sound, particularly "the moat area", is quite productive. Further, data for the foraminiferan fauna at Explorers Cove contradict Dayton & Oliver's (1977) notion that the west side of McMurdo Sound is oligotrophic, instead indicating a faunal standing stock and diversity comparable to that of temperate shelf and marginal marine habitats (Bernhard, 1987). Similarly, scallop biomass was relatively high on the west side of the Sound at Explorers Cove (Stockton, 1984). These observations appear to contradict Oliver & Dayton's appealingly simple notion and explanation that the west side of the Sound is oligotrophic (Stockton, 1984). Instead, these results suggest that the soft-bottom benthos is variable and patchy, as is the hard-bottom benthos elsewhere in the Ross Sea region.

Dayton (1990) remarked on two other features of the soft-bottom benthos off Cape Armitage/ McMurdo Station. First, densities of benthic invertebrates at this location were extremely high, among the highest reported for marine benthos world-wide (Dayton, 1990). Second, several species shared numerical dominance in this assemblage. The vertical stratification of the fauna and predatory behaviour of both some sessile and highly mobile species were considered to be important in maintaining this diversity in a habitat that was otherwise free from the disturbances by large predators, ice scouring and storm events that usually are important factors in structuring benthic assemblages (Oliver & Slattery, 1985; Dayton, 1990).

Studies of the soft bottom benthos of Winter Quarters Bay, just off McMurdo Station (one of the few shallow, soft-bottom habitats in McMurdo Sound), revealed an alongshore gradient of contamination from the north-eastern shore of the bay towards Cape Armitage (Lenihan et al., 1990; Lenihan & Oliver, 1995). The total densities of infauna and epifauna increased with increased distance from Winter Quarters Bay, and these were significantly negatively correlated with concentrations of hydrocarbons and metals (Cd, Ag, Pb, Cu, Zn, Ni) in the sediments (Lenihan et al., 1990; Lenihan & Oliver, 1995). In particular, large bivalves (*Laternula elliptica*) were abundant at most sites, but extremely rare within the bay, although dead shells were common there (Lenihan et al., 1990). Small, opportunistic polychaete worms were most abundant at the site of contamination, but both were absent from control sites at Cape Armitage (about 1 km away) and Cinder Cones (several kilometres distant). The incidence of other species with opportunistic life histories decreased away from the contamination site. These changes were found to be similar to those caused by two natural disturbances, anchor-ice uplift and iceberg scouring (Lenihan & Oliver, 1995).

Further experimental work showed that the survival and behaviour of amphipod crustaceans were adversely affected when placed in the contaminated sediments from this site (Lenihan, 1992). However, in field experiments on recolonisation rates of these contaminated sediments, 4–6 years elapsed before infaunal densities approximated those in surrounding undisturbed sediments (Lenihan & Oliver, 1995). Thus, although faunal responses to severe disturbance in the Ross Sea region are similar to those at more temperate latitudes, rates of recovery are far slower.

5.1.3.3.2 Soft bottoms: Terra Nova Bay

At Terra Nova Bay, soft sediments are found only below about 20 m depth, and they are increasingly finer at greater depths (Cattaneo-Vietti et al., 2000a). Gravel and coarse sands predominate at 20–50 m depth. Dominant epifaunal species are the echinoid *Sterechinus neumayeri* and the seastar *Odontaster validus* (Cattaneo-Vietti et al., 2000a). The infauna consists of few species (two bivalves: *Laternula elliptica*, *Limopsis* sp.; the polychaete *Aglaophamus ornatus*; the anemone *Urticinopsis antarcticus*) at moderate densities (up to 600 m^{-2}, combined) (Cattaneo-Vietti et al., 2000a). Macroalgae from higher on the shore (*Iridaea cordata*, *Phyllophora antarctica*) occur as drift on these sediments at times.

From 50 m (sometimes as shallow as 30 m) to about 70 m, dense populations of diatoms grow on the finer sediments, especially in semi-enclosed, sheltered embayments where penguin guano provides additional nutrients (Cattaneo-Vietti et al., 2000a). The Antarctic scallop, *Adamussium colbecki*, and its dead shell dominates the fauna in patches at these depths at densities as high as 80 m^{-2} (Cattaneo-Vietti et al., 2000a). Macrofaunal elements of this *Adamussium* community include volcano sponges (*Rossella* spp., *Scolymastia joubini*) growing up to 1.2 m tall, and a predatory gastropod (*Neobuccinum eatoni*) and the nemertean *Parborlasia corrugatus* (Cattaneo-Vietti et al., 2000a). A dense epifauna is found on the shells of living and dead scallops, comprising foraminiferans, bryozoans, and a spirorbid polychaete (Cattaneo-Vietti et al., 2000a).

Muddy, organically enriched sediments at about 70 m depth in more sheltered conditions, such as in Adélie Cove, may be inhabited by a *Yoldia* community (Cattaneo-Vietti et al., 2000a). *Yoldia eightsi*, a deposit-feeding bivalve, dominates (70–80 m^{-2}) here, along with *Adamussium colbecki* and a third bivalve, *Laternula elliptica*. Infauna, notably the polychaetes *Tharyx cincinatus* and *Leitoscoloplos mawsoni*, attain very high densities (combined 10 000 m^{-2}) (Cattaneo-Vietti et al., 2000a).

Various assemblages occur at depths below about 80 m and extend to 150–200 m. Most widespread is the *Spiophanes* community in which the dominant, tube-building polychaete *Spiophanes tcherniai* attains high densities (3000 m^{-2}) (Cattaneo-Vietti et al., 2000a). Other animals found here include an opisthobranch (*Philine alata*), the foraminiferan *Cibicides lobatulus*, and several small bivalves (*"Montacuta" nimrodiana*, *Yoldiella antarctica*, *Philobrya sublaevis*, *Pseudokellya cardiformis*, *Mysella gibbosa*). Where sediments have high organic contents, the echinoid *Abatus* sp. is an important addition to this assemblage.

Gambi et al. (1997), in their study of coastal polychaete assemblages at Terra Nova Bay, noted that a few sites with the lowest polychaete diversity occurred close to an Adélie penguin rookery. Whilst species number was low at these sites, densities of the dominant deposit-feeding polychaetes were high (*Leitoscoloplos mawsoni*, 4100 m^{-2}; *Tharyx cincinnatus*, 6630 m^{-2}). Gambi et al. (1997) therefore supposed that "Data presented here on the benthos inside Adélie Cove are a first indication of the importance of penguin rookeries in affecting macrobenthic density and standing crop, even though on a relatively small scale, by increasing the local organic matter supply." Supporting evidence for this assertion comes from an earlier study that noted that species diversity off Cape Bird was relatively low compared to other sites in the vicinity of McMurdo Sound (Ross Sea) (Lowry, 1976, cited in Knox, 1986). Cape Bird is the site of a number of large Adélie penguin rookeries (Wilson, 1990), however, the spatial association between low benthic diversity and the penguin rookery was not commented upon by Lowry (1976) when he noted that the deposit-feeding polychaete *Spiophanes tcherniai* achieved densities of >10 000 m^{-2}.

The nature of the relationship between organic enrichment and benthic species diversity/composition has long been established (Pearson & Rosenberg, 1978). That is, at relatively high levels of organic matter loading benthic assemblages are often species poor, and are frequently dominated by deposit-feeding polychaetes occurring in very high densities. Thus, it is our present contention that the Adélie penguin rookeries in the Ross Sea as a whole, which are spatially extensive and vary in size from a few thousand up to hundreds of thousands of pairs (Taylor et al., 1990), provide significant amounts of organic matter to the benthos and are in part responsible for the structure of macrofauna assemblages in the nearshore areas of this region.

Another assemblage at these depths comprises a diverse community of crustaceans, polychaetes and the bivalve *Limatula hodgsoni* inhabiting sediments containing free sponge spicules or overlain by dense spicule mats (Cattaneo-Vietti et al., 2000a). In some areas, spicules contribute up to 50% of sediment dry weights. In places there are spicule mats similar to those described from the Ross Sea and elsewhere (Dearborn, 1967; Cattaneo-Vietti et al., 2000a). It appears that these spicules in sediments and spicule mats at Terra Nova Bay are derived from sponges living on adjacent hard bottoms, rather than from sponges living on the soft bottoms.

Beyond about 150 m depth, another polychaete, *Laonice weddellia*, dominates, and brachiopods are present attached to small pebbles.

In a separate quantitative study of soft bottom polychaetes off Terra Nova Bay, 77 species were found at densities of up to 12 000 m^{-2} between 23 and 194 m depth (Gambi et al., 1997; see also Gambi & Castelli, 1994; Cantone et al., 2000). Just four species (*Tharyx cincinnatus*, *Spiophanes tcherniai*, *Leitoscoloplos mawsoni*, *Laonice weddellia*) contributed >75% of total individuals on bottoms ranging from poorly sorted gravels to well sorted coarse sands. There were appreciable changes in faunal composition with depth and its associated complex of factors (disturbance, substrate heterogeneity, habitat complexity). Greatest densities and diversity were at 140 m depth where medium sand, the predominant substrate fraction, was mixed with erratic rocks and boulders (Gambi et al., 1997).

5.2 Deeper coastal and offshore biota

Benthos below diving depths has received relatively little attention since Bullivant (1967b) and Dearborn (1967). Lowry (1976) surveyed the benthos off Cape Bird (northern Ross Island) and in Moubray Bay (Cape Hallett) using a 0.1 m^2 Smith McIntyre grab. The Italian Antarctic Programme also has a very active, shallow-water benthic programme, with some deeper water investigations within the Ross Sea region.

Benthos from a very wide depth range is discussed together here because many Antarctic benthic animals appear quite ubiquitous with respect to depth (Knox & Lowry, 1977; Dayton, 1990). Below the reach of anchor-ice and platelet formation, substratum, water movement (currents), food supply and biotic interactions appear to be the dominant factors influencing species distributions on soft bottoms (Picken, 1985; Dayton, 1990).

5.2.1 Macrobenthos

Bullivant (1967b) identified a number of different assemblages of animals comprising the benthos on various sediments at different depths, and at different locations within the Ross Sea, based on examination of the macrofauna only. His analysis of the fauna was far from comprehensive, being based on about 15 stations within McMurdo Sound and about 30 stations beyond McMurdo Sound. Dell (1972) added a little more detail to Bullivant's scheme by contributing names of some groups (ophiuroids, asteroids, corals, pyconognids) identified from the original collections subsequent to Bullivant's (1967b) work. Kennett (1968) found a general correlation between the distribution of Foraminifera within the Ross Sea and Bullivant's (1967b) assemblages (see below). However, many more taxa remain to be identified and added to these data to flesh out our understanding of the biodiversity of the benthic fauna at different depths on different substrates within the Ross Sea.

Attempts to integrate Lowry's (1976) findings with those of Bullivant (1967b) proved impossible because each study selectively sampled different components of the benthos on quite different scales. Despite this limitation, Bullivant's work provides the best available understanding of Ross Sea benthic biodiversity below 40–50 m depth.

The following description of the benthos focuses on communities or assemblages, groupings of plants and animals that appear to co-occur reasonably consistently within certain types of habitats. It is recognised that this approach inappropriately defines entities that may be artificial or restricted in occurrence (e.g., taxa deemed characteristic of an assemblage may occur within another, quite different assemblage). Nonetheless, the notion of assemblages or communities is used here as a relatively easy way to summarise aspects of the diversity within the region's benthos. The schema draws heavily on Bullivant's (1967b) system, with additional information from Dell (1972) and papers by other workers for habitats or groups not covered by Bullivant. For the purposes of this discussion, assemblages are described in order of increasing depth.

The **McMurdo Glass Sponge Assemblage** occupies unsorted rock debris, overlain by a deep (few cm to >2 m) mat of siliceous sponge spicules and bivalve shells within McMurdo Sound at depths of 30–180 m (Bullivant, 1967b; Dayton et al., 1974). Several species of sponges cover about half of the bottom, with three species (the rossellid sponges, *Rossella racovitzae, R. nuda, Scolymstra joubini*) making up most of the sponge cover and biomass (Dayton, 1972; Dayton et al., 1974). In addition to the rossellid sponges, the total fauna is extremely diverse and includes numerous seastars (*Odontaster validus, Perknaster fuscus, Acodontaster conspicuous, Diplasterias brucei*), bivalves, gastropods, alcyonarians, hydroids, anemones, bryozoans, ascidians and sabellid polychaetes. Dayton and his co-workers investigated the dynamics of this assemblage over many years. Their key findings are summarised above. Assemblages similar to this fauna are known from Terra Nova Bay (Cattaneo-Vietti et al., 2000a) and the biota of an isolated seamount east of Beaufort Island (just north of Ross Island) closely resembles the McMurdo Sound Glass Sponge Assemblage (Bullivant, 1967b). Presumably, plankton-rich currents, like those where this assemblage is found in McMurdo Sound, also sweep these habitats. These observations suggest that this assemblage may be present on shallow-water, hard (cobble to bedrock) bottoms free from ice scour and wherever there are abundant summer supplies of phytoplankton.

Deeper in McMurdo Sound (250–800 m depth), the fauna comprises the **McMurdo Sound Mixed Assemblage**, a variant of the Deep Shelf Mixed Assemblage (Bullivant, 1967b). Substrates at these depths are mixed sediments containing a high proportion of coarse rock particles. The fauna intergrades with the shallower assemblage, with glass sponges abundant amongst the fauna at the shallowest stations in this zone. Main elements of the assemblage include polychaetes worms, cellularine bryozoans, sponges and various echinoderms, as well as molluscs (*Cyclocardia astartoides, Thracia meridionalis, Limatula hodgsoni, Notochiton mirandus, Trophon* sp.) and crinoids (notably *Promachocrinus kerguelensis*). Bullivant (1967b) tentatively considered that the fauna at 460 m depth in Terra Nova Bay also belongs to this assemblage.

Most widespread on the gently sloping shelf beyond McMurdo Sound and occupying a zone parallel to the shore south from Cape Adare and east of the edge of the Ross Ice Shelf is a **Deep Shelf Mud Bottom Assemblage.** Sediments within this area are mud or sandy mud with erratic boulders. This assemblage comprises abundant tubicolous polychaetes, with common sipuncilids (*Golfingia margaritacea capsiformis, G. andersonni*) and an arenaceous foraminifer (*Rhabdammina* sp.) at depths of 420–750 m (Bullivant, 1967b). Other elements of this fauna include ophiuroids (especially *Amphipodia joubini*, also *Ophionotus victoriae*), holothurians, and occasional crustaceans, molluscs, asteroids, echinoids and crinoids (Bullivant, 1967b). Other species identified from this assemblage subsequently include pycnogonids (*Colossendeis lillei, C. megalonyx*), a coral (*Flabellum impensum*), a scaphopod mollusc (*Dentalium majorinum*), and seastars (*Bathybiaster loripes obesus, Psilaster charcoti, Luidiaster gerlachei, Notasterias armata*) (Dell, 1972).

Within the area inhabited by the Deep Shelf Mud Bottom Assemblage are two basins reaching depths of more than 1000 m. Although Bullivant (1967b) did not sample these, he believed that samples taken by the 1902 National Antarctic Expedition indicated that the fauna inhabiting these basins resembles that of the Deep Shelf Mud Bottom Assemblage. Based on fish faunas, Andriashev (1977) believed that such pseudobathyal basins supported faunas more similar to that on their surrounding shelves than to those found at equivalent depths on continental slopes.

Gambi & Bussotti's (1999) Station A at 810 m depth appears to be within such a basin, but it is difficult to compare the two faunas. Bullivant (1967b) focussed on epifauna and large infauna recovered from dredging, whereas Gambi & Bussotti (1999) analysed the entire fauna by major taxa taken in replicate box-corer samples. This analysis revealed a fauna dominated by polychaetes (58%) and bivalve molluscs at total mean densities of 430 individuals m^{-2} (range 250–600, n = 5). Most species were surface and sub-surface deposit feeders, indicating that the assemblage relies on deposition of organic matter from the water column.

The **Deep Shelf Mixed Assemblage** occurs widely in shallower waters to seaward of the Deep Shelf Mud Bottom assemblage on fine sediments with scattered erratic boulders at depths of 250–520 m (Bullivant, 1967b). It comprises tubicolous polychaetes, bryozoans, ophiurorids, crinoids, other echinoderms, gorgonians and molluscs. Animals later identified from stations included in this assemblage (Dell, 1972) include:

Molluscs: *Limatula hodgsoni, Cyclocardia astartoides, Thracia meridionalis, Cadulus dalli antarcticus.*
Ophiuroids: *Ophiacantha antarctica, Amphipodia joubini.*
Asteroids: *Porania antarctica glabra.*
Pycnogonids: *Pycnogonum gaini, Ammothea (Ammothea) glacialis, Achelia (Pigrolavatus) spicata, Austroraptus polaris.*

Again, comparison with Bullivant (1967b) tentatively suggests that Gambi & Bussotti's (1999) Station B sampled the Deep Shelf Mixed Assemblage. They reported a poor epifauna of few bryozoans, small ophiuroids, asteroids and amphipods, plus a large foraminiferan. The infauna was dominated by polychaetes

(78% of individuals), with abundant amphipods, tanaids and bivalves at toatal mean densities of 1040 m^{-2} (n = 7). Notably, capitellid polychaetes were among the more abundant polychaetes here, inhabiting deeper sediments (Gambi & Bussotti, 1999). Thus, they considered the assemblage to be surface and sub-surface deposit feeding, dependent upon sedimentation of organic matter from the overlying water column.

A **Pennell Bank Assemblage**, third main Ross Sea assemblage, occurs on this large feature at depths of 200–380 m, as well as on another shallow bank between the Pennell Bank and Cape Adare (Bullivant, 1967b). Bottoms on these features consist of cobbles (up to several cm diameter) embedded in a muddy sand, interspersed with patches of muddy sand. Calcareous bryozoans, gorgonaceans, stylasterine corals, tunicates and echinoderms, notably ophiuroids, are the most conspicuous elements of this assemblage. Animals subsequently identified and reported by Dell (1972) include:

Corals: *Flabellum impensum, Caryophyllia antarctica;*
Ophiuroids: *Ophiacantha antarctica, Amphiura belgicae, Ophioceres incipiens, Ophiurolepis gelida.*
Asteroids: *Peribolaster powelli.*
Pycnogonids: *Achelia (Pigrolavatus) spicata, Colossendeis lilliei.*

The fauna of the shelf outer edge appears to vary with substrate and with depth according to Bullivant's (1967b) interpretation. A minor **Shelf Edge Barnacle Assemblage** occurs on rocky bottoms at the outer edge of the deep shelf at 350–500 m deep, seemingly where there are strong bottom currents (Dayton et al., 1982). The dominant macrofauna was the large barnacle, *Bathylasma coralliforme* (previously known as *Hexelasma antarcticum*), which covers exposed rocks around which dead barnacle plates form a deep, almost homogeneous substrate (Dell, 1972). The coral *Flabellum impensum* occurs here also (Dell, 1972).

This assemblage was also sampled by Gambi & Bussotti (1999). Crustaceans, notably barnacles (*Bathylasma* sp.), were the most abundant (50% of total individuals) and conspicuous element of this fauna. Polychaetes contributed about one third of individuals and echinoderms about 16%. Total faunal mean density was about 520 m^{-2} (n = 7). Their work confirmed the coarse nature of sediments and the high current speeds at this shelf edge site, leading them to interpret the assemblage as predominantly epifaunal suspension feeding, dependent upon horizontally-advected food material (Gambi & Bussotti, 1999).

On the continental slope itself, Bullivant (1967b) recognised a **Deep Slope Cobble Assemblage** which has three forms. At the top of the slope (320–360 m depth), cobble bottoms with some muddy sand are inhabited by a **Stylasterine Coral Assemblage** (Bullivant, 1967b). The stylasterine coral *Errina* and two scleractinian corals (*Flabellum impensum, F. antarcticum*) are important here (Dell, 1972). Below this at 460–590 m depth, the ***Gardineria antarctica*** **Assemblage**, dominated by the solitary scleractinian corals *Gardineria* and *Flabellum antarcticum*, along with the pycnogonid *Pycnogonum gaini*, occurs on cobbles mixed with gravel and mud. Further down the slope (820–1340 m depth), a **Brachiopod Assemblage** appears on cobbles mixed with some mud (Bullivant, 1967b).

Beyond the slope, the sparse fauna of the **Deep Ooze Assemblage** inhabits diatomaceous ooze at depths of 1200–2200 m, possibly extending to 3560 m depth (Bullivant, 1967b).

Attempts to compare the benthos from various shallow (<55 m depth) stations in the Ross Sea with Bullivant's classification were inconclusive. Generally, either the collecting methods yielded insufficient material (these depths were often sampled via ice-holes in winter) or only parts of the fauna collected have been reported (Bullivant, 1967b). Incomplete reporting also hampered comparisons with collections made by the RRS Discovery during the 1930s. However, Bullivant believed that catches by 22 dredge hauls made by various earlier expeditions supported his "rather loose classification of the Ross Sea benthos" (Bullivant, 1967b: 70).

5.2.2 Meiobenthos

The biodiversity of foraminiferan assemblages in the Ross Sea has been investigated at several different scales; the entire region (Kennett, 1968), McMurdo Sound (Ward et al., 1987) and Explorers Cove, a harbour on the west side of McMurdo Sound (Bernhard, 1987), as well as work in Terra Nova Bay (Violanti, 1990, 1992). Another study examined changes in benthic foraminiferans around a source of organic enrichment at Pram Point, McMurdo Sound (Anderson & Chagué-Goff, 1996).

Studies of Foraminifera from 108 stations in the Ross Sea yielded 210 species and 102 genera. In considering Bullivant's (1967b) Ross Sea macrofaunal assemblages, Kennett (1968: 35) noted "a general correlation between the distribution of these [macrofaunal] assemblages and that of the microfaunal [foraminiferan] assemblages". In addition to this spatial distribution pattern, the benthic Foraminifera also exhibit quite marked zonation with depth (Kennett, 1968). The Foraminifera comprised two contrasting groups within the depth range (90–3570 m) sampled: an abundant calcareous foraminiferan fauna restricted to depths shallower than 550 m, and a sparse fauna of non-calcareous, arenaceous (agglutinated; tests consisting of sand grains, spicules, etc., glued together) taxa occurring below 430 m depth (Kennett, 1968). Note, some agglutinated species occur within both faunas, with a few exceptions. Calcareous taxa are restricted to the shallower depths, however, because of the increased solubility of calcium carbonate with increased carbon dioxide concentration, decreased temperature and increased hydrostatic pressure at greater depths (Kennett, 1968). Within these two broad zones, there are several abrupt changes in the fauna with depth.

Forty species occur in waters less than 300 m depth, but the upper limit of 19 species occurs at 270 m depth. Another, broad boundary spanning 450–550 m is the calcium carbonate solution boundary (calcium carbonate compensation depth, CCD), marking the lower limit of almost every calcareous species and the upper limit of ten arenaceous species (Kennett, 1968). Some 69 species occur within the 270–550 m depth range, making this the zone of greatest biodiversity for this group in the region. A further boundary at 1300 m depth marks the lower limits for three species and upper limits for another three. About 56 species inhabit the 550–1300 m depth range. Diversity below 1300 m is reduced to about 27 species. The maximum depths of six species and the shallowest of another three indicate another boundary at 2200 m depth (Kennett, 1968). These results are in general agreement with Pflum's (1966) findings based on a more restricted (92 species, 47 genera) investigation of the Ross Sea Foraminifera. Overall, therefore, these results indicate a low diversity at shallower (<270 m) depths, maximum diversity between 270 and 550 m, and a decrease in diversity with increasing depth thereafter (Figs 5.1.3.2.1, 5.1.3.2.2).

In another investigation, nine benthic foraminiferan assemblages were distinguished from 59 species of living and dead material among 31 stations in the greater Ross Sea region (Osterman & Kellogg, 1979). Despite this study's significant limitations, it offers some preliminary findings. Assemblages appear correlated with a number of ecological and oceanographic variables, as well as the complex nature of the CCD and irregular bathymetry of the Ross Sea. The western Ross Sea is dominated by calcareous species, while the eastern sector is dominated by agglutinating (arenaceous) forms, despite being bathed by the same deep water mass. This difference is probably due to a shallower CCD in the east, where heavier pack ice reduces photosynthesis, which, in turn, elevates CO_2 concentrations. The opposite situation in the western Ross Sea depresses the CCD, allowing calcareous species to dominate the foraminiferan fauna.

Below the CCD, depth apparently controls the distribution of dominant species for the four agglutinating assemblages in the eastern Ross Sea. *Cyclammina* sp. occurs on the continental slope (1000–2000 m depth), while *Hormosina ovicula gracilis* is the dominant taxon within a 600–800 m deep trough on the continental shelf. Both *Reophax nodulosus* and *Milliammina arenacea* occur on the shelf at depths of 400–700 m, the latter primarily on the ridges of the shelf.

Depth is again the major control on the distribution of calcareous species in the west of the Ross Sea; *Globocassidulina subglobosa* dominates on shallow banks, as well as at 700–800 m depth near the depressed CCD approaching McMurdo Sound. *Ehrenbergina glabra* also occurs at shallow depths (500–600 m). The upper continental slope is characterised by *Cibicides lobatulus*, with *Trifarina earlandi* typical of deeper continental slope faunas to 1800 m depth. Food supply and depth are thought to separate these slope assemblages, with high productivity occurring over the upper continental slope, along with a depressed CCD.

Within McMurdo Sound, 73 species of living benthic Foraminifera comprised three assemblages distinguished on the relative abundances of eight agglutinated and four calcareous species (Ward et al., 1987). A high diversity (note, species numbers are not given, but diversity is expressed using Sanders' (1968) rarefaction method), **Shallow Water Assemblage** inhabiting depths shallower than 620 m consisted of calcareous and agglutinated species in approximately equal proportions. Depths greater than 620 m were inhabited by a **Deep Water Assemblage**, considerably lower in diversity and consisting almost entirely of agglutinated species (Ward et al., 1987). A **Harbour Assemblage** (New Harbour, Granite Harbour, basin east of Cape Roberts) spanning both depth zones comprised a low diversity of mostly agglutinated species (Ward et al., 1987). Re-examination of these data suggests that the Shallow Water Assemblage is divisible into a low diversity shallow zone at 80–270 m and a mid-depth zone of high diversity from about 320 to 620 m depth. Changes in diversity with depth are inconclusive for the shallow zone, but there is a marked decrease in diversity with increasing depth below about 320 m.

Four foraminiferan assemblages were recognised from an analysis of living and dead material from sediments in Terra Nova Bay (Violanti, 1990, 1992), each with a different depth range. An assemblage of mostly calcareous species occurred at 220 m depth (note, no information on diversity within each assemblage was given). Beyond this depth, few calcareous species were found. A margin assemblage of almost entirely arenaceous species characterised habitats near the coast and around Crary

Bank at 520–680 m depth. This was both rich and diverse. At 710–850 m depth, a low diversity assemblage of agglutinated foraminiferans was dominated by *Miliammina earlandi*. The fourth assemblage, the *Bathysiphon* assemblage, was more diverse than the margin assemblage. It was found only at 1000–1100 m depth (Violanti, 1992).

Diversity of Foraminifera in shallow waters within a single embayment (Explorers Cove) on the west side of McMurdo Sound increased with depth from 19 species among anchor ice-prone sediments at 4 m depth to 47 species among sediments beside erratic boulders at 26 m depth (Bernhard, 1987). Habitat stability was recognised as the most important factor determining this pattern. The total foraminiferan fauna identified at this site comprised 60 species, with almost a quarter (23%) of species found within only one of the seven different microhabitats sampled. Generally, calcareous foraminiferans predominated within boulder and sponge mat habitats, whereas agglutinating species dominated in the other five habitats (sediment under sponge spicule mats, shallow water, anchor-ice, open-water, seasonally anoxic basins).

Overall diversity and standing stock of this group at Explorers Cove was comparable to that from deep Pacific sediments and temperate shelf and marginal marine habitats (Bernhard, 1987). This faunal similarity and the apparent oligotrophic conditions here (Dayton & Oliver, 1977) have resulted in considerable interest in the Foraminifera of Explorers Cove because it represents a deep-sea fauna that is more accessible (DeLaca et al., 1981; Bernhard, 1987; Gooday, 1994; Gooday et al., 1994).

The effects of organic and inorganic pollution from sewage disposal on benthic foraminiferans were examined at Scott Base on Pram Point at the southwest corner of McMurdo Sound (Anderson & Chagué-Goff, 1996). Although no obvious spatial zonation was apparent, four different assemblages were identified. No foraminiferans were present at the point of the outfall, but there were 12–14 species just 15 m away. A third assemblage, mainly at intermediate distances from the outfall, comprised 14–16 species, one of which (*Ehrenbergina glabra*) clearly dominated, contributing 34–51% of individuals. The fourth assemblage, the most widespread (seven stations), also comprised 14–19 species, with *Ehrenbergina glabra* overwhelmingly dominating, comprising more than 60% of the total foraminiferans present.

Results of these studies, overall, indicate an increase in live, benthic foraminiferan biodiversity with increasing depth to at least 47 species at 26 m within embayments. In open waters of McMurdo Sound and the Ross Sea, total foraminiferan diversity peaks at about 60 species at 350–400 m depth (Fig. 5.2.2.1). Diversity of calcareous species decreases quite dramatically beyond this depth, whereas diversity of arenaceous species increases to about 15 species at 800 m and remains at about this level to over 3000 m depth (Fig. 5.2.2.2). Also, human activities, specifically from outfalls, can influence distributions of species and assemblage compositions over quite small spatial scales.

Comparison of the McMurdo Sound Foraminifera fauna (124 species) with assemblages in other polar regions, reveals many elements in common with faunas in the Weddell Sea and Antarctic Peninsula, as well as strong links with Arctic assemblages (Ward, 1984). Cold water temperatures, high salinity and constant physical conditions are the main factors underlying these similar foraminiferan assemblages. Within the Antarctic region, the taxa present are very similar throughout, particularly at the generic level. Previous studies (Green, 1960; Anderson, 1975) showed that foraminiferal distribution varies more with the CCD than with water depth.

5.3 Benthos under permanent ice

Beneath permanent ice, notably under the Ross Ice Shelf, and under areas where sea ice often persists from year to year, in situ primary production (phytoplankton, epontic or ice algae and benthic micro and macro algae) may be greatly reduced or completely absent (Littlepage & Pearse, 1962; Knox, 1994). In such situations, allochthonous organic matter, primarily phytoplankton, carried into such habitats by currents is the only new source of organic carbon (Dayton, 1990). Benthos at White Island and Black Island, some 30–50 km back from the edge of the permanent Shelf edge lives in complete darkness, yet is surprisingly abundant and diverse (Littlepage & Pearse, 1962; Dayton & Oliver, 1977; Collen, 1979; Knox, 1986).

The first collections beneath the Ice Shelf were made through tide cracks at White Island by Littlepage & Pearse (1962), who used a grab and baited traps to collect benthos from depths of 43 and 75 m depth at White Island and 40 m depth at the Koettlitz Glacier, 22 and 28 km, respectively, from the Shelf edge. Although they did not identify all taxa collected, Littlepage & Pearse (1962) noted representatives of 14 major groups, including common shallow-water species from McMurdo Sound, such as the amphipod *Orchomenella proxima*, the bivalve *Limatula hodgsoni*, the sea star *Odontaster validus*, the nemertean *Parborlasia corrugatus* and the fish *Trematomus bernacchii*. These taxa, the presence of sponges and a thick layer of sponge spicules, shells and worm tubes on the bottom suggests an assemblage similar to the McMurdo Glass Sponge Assemblage. A trap set 80 km back from the ice shelf edge, near Minna Bluff, also caught a fish, but no other animals (Bruchhausen et al., 1979).

Intensive sampling through tide cracks in the Ice shelf on the north side of White Island revealed a diverse benthic fauna of more than 300 species (Knox, 1994). This fauna was dominated by epifaunal animals, principally sponges, alcyonarians, bryozoans and hydroids. Two species of fish were common (another two were rare), along with detritivorous amphipods. In reviewing information on this fauna, Knox (1994) believed that it was similar in species composition to that at similar depths in McMurdo Sound.

Life beneath the Ross Ice Shelf is not confined to its coastal margins and close proximity to seasonally open water. The Ross Ice Shelf Project discovered a "significant biological community" (Bruchhausen et al., 1979: 450) comprising crustaceans and fish in 273 m of water beneath 420 m of ice (almost 600 m below sea level), some 430 km from the Shelf's seaward margin (Lipps et al., 1979a; Stockton, 1982). A television camera lowered into the underlying water column detected amphipods (at least one species in thousands), a 70 mm long isopod (*Serolis trilobitoides*), mysids and/or euphausiids, and a fish (Lipps et al., 1979a; Stockton, 1982). These crustaceans included five amphipods (*Abyssorchomene rossi*, *?Abyssorchomene* sp. (possibly new), *Cyphocaris* n. sp., *Uristes* n. sp., unidentified gammaridean), a mysid (*Antarctomysis maxima*) and several harpacticoid copepods (Stockton, 1982). The most abundant species (*?Abyssorchomene* sp.) included juveniles, males and females, with adults of both sexes in all reproductive states (Stockton, 1982). Half (49%) of the 120 individuals examined had material in their guts which included bacteria mixed with sediment, pieces of crustacean remains and tissue from conspecifics. These observations suggest resident populations of amphipods, some of which may prove to be unique to sub-ice shelf environments.

No living benthic infauna was found in ten 225 mm diameter cores (total area sampled: 0.33 m^2) retrieved from beneath the Ice Shelf at this point, although meiofaunal bivalve, gastropod, ostracod and Foraminifera shells were found (Lipps et al., 1979a). Nor were there any signs of an infauna or epifauna from television and photographs of the bottom (Lipps et al., 1979a). Sparse populations of bacteria, algae, microzooplankton and large zooplankton were found throughout the water column, with densities at 20 m depth (below the ice bottom) an order of magnitude greater than those at 110 and 200 m depth (Azam et al., 1979). Planktonic bacterial biomass, assimilation rates, and sediment respiration rates were similar to those reported for the deep sea (Azam et al., 1979). Thus, several components of a possible food web were identified, but the ultimate source of organic carbon appears to be primary production from the open ocean.

Based on these observations, the biota under the Ross Ice Shelf resembles that of oligotrophic deep seas with approximately equivalent bacterial densities and organic carbon in the sediments, and dominated by mobile scavengers (Lipps et al., 1979a). However, Dayton (1990) considered that the very high abundance of carnivorous, scavenging amphipods so far from the open sea may imply some autochthonous food supply.

5.4. Biodiversity of major benthic groups

A major area of biological research in the Ross Sea region, as well as in Antarctica generally, is the investigation of physiological and biochemical adaptations of selected species to life in such an extreme environment. Although beyond the bounds of this review, it is appropriate to touch on some key issues facing animals and plants inhabiting Antarctic waters.

Many Antarctic marine species are stenothermal and eurybathic. As a result of the cold temperatures and highly seasonal productivity, growth is slow and seasonal, animals often mature late and may grow to large sizes, although low calcium availability in cold waters limits the size of some taxa with calcareous exoskeletons or shells (Picken 1985). Reproduction is predominantly via large yolky eggs, brooding or viviparity, without planktonic development (Dell, 1972; Picken, 1980). Reproduction tends to be highly seasonal, with juveniles released to capitalise on the spring-summer peaks in primary production and food availability (Sagar, 1980; Picken, 1980, 1985).

5.4.1 Sponges

The total sponge diversity reported from the Ross Sea region comprises 233 species in 103 genera (Table 5.5.1). Sponges, through both their diversity and their biomass, are a very important component of the region's benthos.

Siliceous sponges comprise a substantial proportion of benthic biomass around Antarctica and this fauna is more abundant in these waters than in many other seas (Dell, 1965; Barthel, 1992). The sponge community of McMurdo Sound is perhaps the best-known marine benthic community in the whole region as a result of Dayton and his co-workers' detailed work over several years (e.g., Dayton et al., 1970, 1974; Dayton, 1989). Here, sponges are a very important component of the benthos, although the depth limits of this abundant, diverse sponge community seems fairly restricted. More than 20 larger, conspicuous species are present in the spicule mat assemblage. Sponges are rare shallower than 33 m depth and much less abundant below 45–50 m depth in McMurdo Sound, even though most species occur deeper than this (Bullivant, 1967b; Dayton, 1990). Indeeed, sponges seem largely confined to shallower waters: Bullivant (1967b) found his McMurdo Sound Glass Sponge Assemblage shallower than 183 m depth, and only three of the 49 species of sponges (mostly demosponges) found in the vicinity of Terra Nova Bay occurred deeper than 300 m (Cattaneo-Vietti et al., 2000). Sponges do occur considerably deeper in McMurdo Sound and the western Ross Sea (Dearborn, 1967) where they seem less important ecologically.

The importance of sponges in the biodiversity of the region lies not simply in the diversity of the group itself, but also in the role of sponges in increasing habitat and trophic diversity. At McMurdo Sound, the sponges are eaten by a variety of asteroids (Dayton et al., 1974) and, probably, several other smaller animals also. The erect physical structure of many living sponges increases the habitat complexity, presenting a range of types of spaces available for associated invertebrates and fishes (Barthel, 1992).

Perhaps more importantly, accumulations of dense of glass spicules from hexactinellid sponges, as spicules free in the sediment, as clumps or aegagropila, and as mats up to 1.5 m thick, provide a complex substrate with enormous surface areas for diverse animals, as well as diatoms (Cattaneo-Vietti et al., 2000b). Spicule mat habitats appear reasonably widespread and extensive in the Ross Sea (Dayton et al., 2000; Cattaneo-Vietti et al., 2000b), as well as around Antarctica (Barthel 1992). Diatoms occur well below the surface of spicule mats and chlorophyll a levels increase with depth into the spicule mat to at least 8 cm (Cattaneo-Vietti et al., 2000b), indicating both an accumulation of settling diatoms amongst the complex interstices within the mat, as well as a refuge from grazers. Furthermore, recent work indicates that light is transmitted along these glass spicules, conceivably allowing diatoms to photosynthesise when below the surface of a spicule mat and development of specific spicule mat diatom assemblages (Cattaneo-Vietti et al., 2000b).

Yet another stream of research based on work in the Weddell Sea indicates that spicule mats, which probably develop over very long time scales (hundreds of years), develop from an ecological succession (Barthel, 1992). According to this notion, hexactinellid sponge larvae settle on glacial erratic stones and boulders on mud bottoms, grow over several generations (and hundreds of years), adding more and more spicules to the bottom. As spicules accumulate, a more diverse assemblage of sponges and bryozoans settles and grows, adding to the hard biogenic material on the substrate (Barthel, 1992). After yet further time and subsequent settlements of new generations of sponges and bryozoans, a diverse community of sponges and other associated invertebrates evolves on a thick mat of siliceous spicules (Barthel, 1992). Such a process is intuitively appealing and could explain some of the assemblages found in McMurdo Sound that did not quite fit Bullivant's (1967b) Glass Sponge Assemblage.

The relatively narrow depth range of these abundant, diverse sponge associations is interesting. Dayton et al. (1970, 1974) considered that anchor-ice limited the shallowest depths of occurrence of these associations to 33 m depth. However, although dense sponge communities and spicule mats occur at Terra Nova Bay, their upper limit is considerably deeper at 50–60 m depth, even though anchor-ice is relatively insignificant here (Cattaneo-Vietti et al., 2000a). Maximum depths for these sponge communities are interesting also. Sponges decline in abundance and dominance below about 50 m in McMurdo Sound (Dayton, 1990). Bullivant (1967b) indicates that they extend deeper, but the two stations for this assemblage were dredge tows, each extending from about 70 to 180 m depth. Lower limits of the Terra Nova Bay sponge community appear to be about 120 m depth (Cattaneo-Vietti et al., 2000b).

These observations suggest a pole-wards emergence of the sponge community and a narrowing of its depth range. Some factor other than anchor-ice restricts the upper limit of sponge communities, at least at Terra Nova Bay, and factors limiting the maximum depth of these communities are equally puzzling. It is intriguing to contemplate the role that diatoms living within these sponges (Cattaneo-Vietti et al., 2000) may play in this depth distribution.

5.4.2 Crustacea

Crustceans are a very important component of the benthos world-wide and Antarctica is no exception. In Antarctic waters generally, two features are particulary notable. First, reptant decapod Crustacea (crabs and lobsters) are absent (Dell, 1965). Second, many of the dominant crustaceans (amphipods and isopods) grow to very large sizes.

Amphipods are the most conspicuous benthic crustaceans, with the family Lysianassidae especially diverse. Present knowledge of the Ross Sea amphipod fauna is based almost entirely on collections made during the early 20th century, with scant new material reported since that time (Lowry & Bullock, 1976). Indeed, very little new information on the biodiversity of Ross Sea amphipods has been added since Barnard's (1930) monograph on the amphipods collected by the Terra Nova Expedition (1910–1913). The taxonomic literature reports 120 benthic species belonging to 66 genera from the Ross Sea, with others, especially several incompletely known species, reported in the ecological literature (Table 5.5.1). In comparison, over 450 benthic species are known from Antarctica as a whole (De Broyer & Jazdzewski, 1993), indicating that the Ross Sea amphipod fauna is poorly known.

Amphipods occupy nearly all habitats in Antarctica, ranging from the very stable abyssal depths to the very harsh shallow subtidal habitats. Amphipods appear to be the most abundant larger animal living beneath the permanent Ross Ice Shelf, being taken in large numbers beneath 400 m of ice over 400 km from its seaward edge (Stockton, 1982).

Isopods are much less abundant and not so diverse, with the 24 genera containing 41 known species (Table 5.5.1). There are an additional eight species (five additional genera) attributed to the Ross Sea, some on the basis of being 'circum-Antarctic'. Some of these Ross Sea species, including species of Serolidae and *Glyptonotus*, will be shown to belong to groups of sibling species, but that work is yet to be published.

Tanaids, close relatives of the isopods, are represented in the region by eight species in six genera (Table 5.5.1).

Isopods include some of the largest known crustaceans, the largest species in the Antarctic and Ross Sea is *Glyptonotus antarcticus*, known to reach a size of 12 cm. Most other species are in the size range of 5 to 30 mm, although Antarctic species tend to be larger than their warm-water congeners. Isopods are important organisms in contributing to marine biodiversity, and occupy a wide range of niches. Many species are believed to be detritus feeders, while others are well-known scavengers and predators; a number of species are parasites or micro-predators of fish. Some recent studies (Gudmundsson et al., 2000; Svavarsson et al., 1993) have shown that asellotan isopods, which are a large component (43%) of the Ross Sea species, specialise in feeding on foraminiferan Protozoa. Faunistically, Antarctic isopods have high diversity in two suborders, the Asellota and the Valvifera. The highly speciose Flabellifera, a suborder which contains several of the largest isopod families and is highly diverse in shallow (slope, shelf and inter-tidal) temperate and warm waters, is represented by few species in the Antarctic, with only 10 species recorded from the Ross Sea.

In general terms, therefore, there is a large number of isopod species recorded and described from Antarctica and, indeed, the isopod fauna can be considered relatively well documented. The Ross Sea has, in contrast to the Weddell Sea, remained comparatively little studied. Recent research in the Weddell Sea carried out by the German vessel *Polarstern*, has revealed a relatively high isopod diversity, much of which remains to be described. The sampling equipment and methods used in the Weddell Sea captures the small macro-benthos which makes up the greater part of the biodiversity, and, to date, such methods have not been used in the Ross Sea.

The number of isopods recorded from the Weddell Sea stood at 68 in 1991 (Brandt, 1991) but since then, at least a further eight species have been described, with yet more species known from the nearby South Atlantic and Magellan regions. With more fine-scale sampling it is likely that the Ross Sea would be found to have similar numbers of species of isopods.

Almost nothing appears to be known of meiofaunal crustaceans, particularly harpacticoid copepods and pododocopid ostracods, within the Ross Sea region. Other important benthic crustacean groups include the myodocopid ostracods, cumaceans, and cirripedes. There has been quite a lot of work completed on barnacles (Newman & Ross, 1971), but, as yet, the biodiversity and ecological importance of other crustaceans seems poorly understood.

5.4.3 Echinodermata

The echinoderm fauna of the Ross Sea region consists of a total of 157 species in 95 genera. Two groups, asteroids and ophiuroids, dominate with 51 and 42 species, respectively, in 31 and 26 genera (Table 5.5.1). Holothouroids are somewhat depauperate (20 species in 14 genera), perhaps a reflection of the dearth of infauna within the region and Antarctica, as a whole.

In general terms, the echinoderm fauna of the Ross Sea is simply a geographic section of a widespread Antarctic fauna; while some earlier studies suggested that regional subspecies were apparent, more recent publications tend to deny this. At the generic level, two distinct elements are evident. Firstly, there is a conspicuous element comprising several widespread genera present within the fauna (e.g., *Florometra* (Crinoidea); *Psilaster, Luidiaster, Odontaster, Henricia, Pteraster* (Asteroidea) ; *Gorgonocephalus, Ophiacantha, Amphiura, Ophiura* (Ophiuroidea); *Aporocidaris, Rhynchocidaris* (Echinoidea); *Cucumaria, Taeniogyrus* (Holothuroidea)). Secondly, another element comprises genera restricted to the Antarctic. These restricted genera include *Notocrinus, Anthometra, Eumorphometra, Isometra, Phrixometra, Promachocrinus* (Crinoidea); *Bathybiaster, Macroptychaster, Acodontaster, Pergamaster, Kampylaster, Perknaster, Cuenotaster, Diplasterias, Lysasterias, Notasterias, Psalidaster, Saliasterias* (Asteroidea); *Astrochlamy, Astrohamma, Ophiosparte, Euvondrea, Ophiogona, Ophionotus, Ophioperla, Ophiosteira, Theodoria* (Ophiuroidea); *Ctenocidaris, Notocidaris, Sterechinus, Abatus, Amphipneustes, Tripylus* (Echinoidea). Taxonomic diversity within families is often low (e.g., only two goniasterid asteroids are reported, while the south-west Pacific region has at least 30 species within this family).

One characteristic of the Antarctic echinoderms is that brood-protecting species occur within each class. Mortensen (1936) noted that about 50% of Antarctic and subantarctic ophiuroids are viviparous compared with about 15% from New Zealand. This is also evident in the irregular echinoids, many of which have well developed marsupia. Other brooding genera include *Notocrinus* (Crinoidea), *Pteraster*, and *Notasterias* (Asteroidea). In comparison, the echinoderm fauna of the Balleny Islands has significantly fewer species, though further collecting may reduce the difference. Spatangoid echinoids have yet to be reported from the Balleny Islands, but should be present if soft sediments can be sampled. The absence of crinoids from the Balleny Islands region is difficult to explain, because suitable substrates have been sampled.

Three species of echinoderms are recorded only from the Balleny Islands, and a fourth only from near Scott Island: *Labidiaster annulatus, Gorgonocephalus chilensis Ophiogona doderleini, Ophiura meridionali.* The very restricted occurrences of these species in the north of the Ross Sea, together with the reduced Balleny Islands fauna, suggests some latitudinal zonation of the echinoderm fauna in the region.

5.4.4 Polychaeta

While they are a major component of the benthos and almost ubiquitous wherever life can survive in Antarctic seas, polychaete worms are relatively inconspicuous habitat users rather than habitat creators. Apart from a few significant exceptions, they cannot be used for habitat classification in surveys of the fauna easily visible to a camera or diver. The only significant habitat creators among the polychaetes are reef-building serpulids. At least one serpulid species (discussed below) is important in the Antarctic as a habitat modifier.

The majority of polychaetes are mostly hidden from view, either burrowing in the sediment, or living inside or underneath the structures built by large sessile epifaunal organisms such as sponges, bryozoans, corals, and macroalgae. Thus, the richness of the polychaete fauna can be predicted from the type of substrata. Invariably, polychaetes will be an important part of the fauna in softer sediments and where biogenic structures are dense and complex, but they will be relatively sparse on bare pavement-like stony/rock bottoms, and on erosion-prone gravel/sand bottoms. This prediction holds true for Terra Nova Bay (Cantone et al., 2000). That study also confirmed that polychaetes play the same major role in Ross Sea soft bottoms (76% of all individuals) as elsewhere in the world, and cites other studies that found that polychaetes were important as food for Ross Sea nototheniid fishes. In addition, the authors found that the proportion of carnivorous polychaetes such as polynoids and nephtyids increased on hard ground, while deposits feeders such as maldanids and capitellids increased in soft sediment.

The total number of polychaete species recorded from the Ross Sea is comparatively modest at around 235 (Cantone et al., 2000) or 220 species in 140 genera, based on published records (Table 5.5.1). Knox and Cameron (1998) earlier reported that 15 of 184 species were unique to the Ross Sea area. No doubt many more Ross Sea species remain to be discovered, and much additional taxonomic work is needed to support ecological and experimental work. Certainly, (Cantone et al., 2000) concluded that Antarctic polychaetes are "still relatively poorly studied as regards their taxonomy and biogeography, as well as their ecological role". In comparison, there are around 650 known from the Antarctic continent (White 1984). New Zealand has well over 700 species, with about 200 endemics (Glasby & Read, in press). Although polychaete diversity may be comparable with that of New Zealand in some similar deep water, mud habitats, diversity of the Ross Sea polychaete fauna overall is likely to be somewhat lower than that of temperate New Zealand waters. This is because the coastal zone is disrupted by ice scour, anchor-ice, and permanent ice so that there are no shoreline, harbour and estuarine habitats where polychaetes usually abound. The large areas of sea bottom under the ice shelves are one of the unique Ross Sea habitats, but this habitat appears to be depauperate for polychaetes and other infauna, except close to the ice edge where high population densities may occur (Oliver & Slattery, 1985; Arntz et al., 1994).

Spectacular aggregations or 'reefs' of the Antarctic/subantarctic serpulid *Serpula narconensis* are claimed to be the largest serpulid reefs anywhere. Two such sites have been found: one on the Antarctic mainland at Ellis Fjord (longitude 70° E) and the other off South Georgia. These mass aggregations of the worm's calcareous tubes occur on sand and on rock from the shallows to 100 m depth, and support a large number of associated species (Kirkwood & Burton, 1988; Ramos & San Martin, 1999). While similar polychaete reefs have not yet been identified in the Ross Sea, *Serpula narconensis* is common in the area (Rosso & Sanfilippo, 1999), occurring in all five faunal assemblages described by Knox & Cameron (1998). It is highly likely that large patches of fragile serpulid reef occur in the Ross Sea, providing significant habitat for many species. Once found, it will be important to protect these large reefs from damage or destruction due to bottom trawling.

5.4.5 Mollusca

Dell (1990) considered that the shelled molluscan fauna of the Ross Sea to comprised 193 species, of which 25 were endemic. Most of these endemic species were micromolluscs that he considered likely to be more widely distributed. Based on our review of available literature for the Ross Sea region, the molluscan fauna consists of 273 species, made up of 184 gastropods, 56 bivalves, 22 nudibranchs, six scaphopods, four polyplacohorans and one aplacophoran (Table 5.5.1). These belong to some 152 genera. In comparison, the New Zealand fauna comprises 160 families, 552 genera, 1759 species (3.4 genera and 11 species per family). But some groups within the Ross Sea fauna show extensive radiation (e.g., 12 species of eledonid octopods). The Antarctic bivalve fauna (25 families, 36 genera, 66 species) is depauperate compared with Arctic fauna (31 families, 51 genera, 118 species). Generally, molluscs in the Ross Sea and elsewhere in cold waters, have thin, rather colourless shells that are poorly calcified, and often badly eroded in life.

The Antarctic scallop, *Adamussium colbecki*, is a significant element of the Ross Sea mollusc fauna. It is numerically abundant, reaching densities of up to 85 m^{-2}, represents a large amount of biomass, and may comprise more than 75% of the benthic biomass (1600 g wet weight m^{-2}) and widespread (Stockton, 1984; Albertelli et al., 1998). Notably, the principal source of mortality of this long-lived bivalve appears to be hyposaline water from melting ice affecting dense, shallow-water populations of larger individuals in late summer (Stockton, 1984). Predation, apparently, is low, even when a known predator, *Odontaster validus*, is abundant (Stockton, 1984).

This long-lived (>12 years) bivalve has a significant influence on the ecology of the benthos in at least three different ways. First, scallops provide a substrate for sessile species (Mullineaux & DeLaca, 1984; Berkman, 1994), thus increasing biodiversity within habitats. Second, its feeding activities influence the abundance and, perhaps, the presence of some species in the soft-bottom benthos (Mullineaux & DeLaca, 1984). Third, scallops transfer large amounts of phytoplankton and other detritus (up to 13.6 g m^{-2} day^{-1} (dry weight) of total suspended matter; 60 mg carbon m^{-2} day^{-1} (dry weight)) from the plankton to the sediments, principally as faecal pellets, thus increasing the amounts of organic detritus available for benthic deposit feeders (Albertilli et al., 1998; Chiantore et al., 1998).

5.4.6 Bryozoans

Bryozoans comprise one of the more significant components of suspension-feeding assemblages in the Ross Sea, documented first photographically by Bullivant (1959, 1961) followed by ecological analyses (Bullivant, 1967a). A total of 231 species belonging to almost 100 genera are reported from the Ross Sea region (Table 5.5.1). The most significant collections of Ross Sea bryozoans were made by the New Zealand Oceanographic Institute and these reside at NIWA, in Wellington. All of the samples were analysed by Dr Peter J. Hayward (University of Wales, Swansea) in 1991, who labelled and catalogued all specimens. This collection became the basis of a bryozoan data set on distributions in the Ross Sea, held at NIWA, which also includes data from publications and other historic expedition reports. Some new species in the NIWA samples were described by Dr Hayward as a result of his 1991 visit (Hayward 1993; Hayward & Ryland, 1993). Other new Ross Sea records were mentioned in his continent-wide guide to bryozoans of the order Cheilostomatida (Hayward, 1995).

The earliest collections of Antarctic invertebrates, including bryozoans, were made by James Clark Ross in coastal waters (including the northeastern Ross Sea) in the summer of 1842–43, during *Erebus* and *Terror* expeditions (Bullivant, 1967a). Joseph Dalton Hooker prepared many illustrations of the specimens collected. The surviving drawings, conserved at the Natural History Museum, London, include bryozoans

(Davenport & Fogg, 1989), but Ross's collections were not studied and were eventually destroyed. The history of later expeditions to the Ross Sea is given by Bullivant (1967a). Kirkpatrick (1902) was the first to describe a new bryozoan species from the Ross Sea — *Alcyonidium flabelliforme* (off Cape Adare). After that, significant collections from the Ross Sea (and elsewhere) were made by the 1901–04 National Antarctic Expedition, the 1910–14 *Terra Nova* Expedition, the 1925–51 *Discovery* Investigations, and the 1947–48 US Navy's Antarctic Expedition. Bryozoans from these expeditions were described by Hastings (1943) and in a series of papers by bryozoan workers Mary Rogick (Rogick, 1955, 1956a-c, 1957a,b, 1959a,b) and Peter Hayward and colleagues (Hayward 1991, 1992, 1993, 1995a,b; Hayward & Ryland, 1990, 1991, 1993; Hayward & Taylor, 1984; Hayward & Thorpe, 1987, 1988a-d, 1989a,b, 1990). These records have been included in the bryozoan database. Since then, additional species have been recorded from other expeditions (also recorded), bringing the total number of bryozoan species know from the Ross Sea to 230 (Table 5.5.1). These are distributed in the orders Ctenostomatida (2 species), Cyclostomatida (18 Species), and Cheilostomatida (210 species).

As in parts of the New Zealand, southern Australian, North Sea, Mediterranean, and Bahamian continental shelves, bryozoans in the Ross Sea and other parts of Antarctica can form a significant fraction of benthic biomass. Together with sponges, they are frequently the most significant occupiers of space (Bullivant, 1961), and bryozoan skeletons and sponge spicules may comprise the larger part of coarse bottom sediment (Bullivant, 1967b). In McMurdo Sound, stable benthic communities of sessile suspension-feeders, with their attendant epizoites and predators, develop below the reach of ice scour and anchor-ice formation, i.e., below 30 m, and between 30 and 60 m sponges appear to be the major space occupiers, although some erect bryozoans are common (Dayton et al., 1974). Suspension-feeding assemblages play an important role in transferring energy from the plankton to the benthos.

The most structurally significant Bryozoa are those with large, erect colonial morphologies, though some encrusting species may attain a large size (up to 7–8 cm across). The largest colonies in recently collected NIWA samples in the northeastern part of Ross Sea off Capes Adare and Hallett comprised flexibly erect fronds, relatively lightly calcified, buff-coloured *Kymella polaris* (which can exceed 10 cm), slender *Klugeflustra antarctica* (to 20 cm high), and purplish-red *Isosecuriflustra tenuis* (to 10 cm high). Large, robust, erect-rigid forms included stubby-branching *Orthoporidra compacta* (attaining 5 cm height and spread), three species of fenestrate lace-coral bryozoans of the genus *Reteporella* (7–15 cm high depending on the species), and the thinner, more-brittle laminate colonies of *Isoschizoporella tricuspis* (>20 cm high). Two species of *Cellarinella* (one of the most speciose Antarctic genera) form thickly calcified, flattened, branching colonies that are basally rooted. These are slow-growing perennials that, unlike most other bryozoans, have obvious growth-check lines. They also produce stolonal runners across the substratum that, in turn, produce other erect branches. These can become separated from the parent colony and broken fragments can regenerate easily. The result is often an interconnected clonal population covering an area of many square centimetres (see also Hayward, 1995). Winston (1983) found that species of *Cellarinella* reached greatest abundance at 300–600 m in the Ross Sea. Other erect species include smaller turfing crisiids, bugulids, and candids.

Most of the bryozoan diversity in the recent NIWA samples, as in Antarctic waters generally, is made up smaller, but numerically abundant encrusters, mostly two-dimensional, some mounded or nodular. These encrust the abundant rocks and gravel in the bottom sediments. The commonest species in order of numerical abundance in the recent NIWA samples include *Escharoides praestita*, *Micropora brevissima*, *Smittina incernicula*, *Lacerna hosteensis*, *Microporella stenporta*, and *Inversiula nutrix*. These appear to be the "weedy" opportunists among the species encountered. The most ubiquitous species were flexibly erect *Kymella polaris* and *Klugeflustra antarctica* (50% and 43% of stations respectively) and encrusting *Microporella stenoporta* and *Beania erecta* (both 43% of stations). In general, the most speciose bryozoan genera in the Ross Sea are erect *Cellarinella* (Sclerodomidae, 14 species), encrusting and frondose *Smittina* (Smittinidae, 14 species), encrusting, nodular, and pisiform *Osthimosia* (Celleporidae, 11 species), bushy, delicate *Camptoplites* (Bugulidae, 10 species), and erect, reticulate *Reteporella* (Phidoloporidae, 9 species).

Antarctic bryozoans cover most of the range of colonial morphologies known, including erect (bushy, foliaceous, rod-like, fenestrate, both lightly and heavily calcified) and encrusting (uniserial through multiserial, planar or mounded, also lightly and heavily calcified) and exhibit the same range of growth and reproductive strategies (r- and K-selected) as in temperate and tropical waters, so few generalisations can be made. Measurements have been made on relatively few species. Winston (1983) studied growth, reproduction, and mortality in erect, blade-like *Melicerita obliqua* (Cellariidae) and three species of *Cellarinella* (Sclerodomidae) with a similar colony form. All four species are apparently slow-growing, long-lived perennials, in some cases attaining more than 22 years old. *Melicerita* appears to recommence skeletal growth in late summer, while the *Cellarinella* species begin in early winter, continuing into late winter. *Cellarinella* produces only 5–10 embryos per colony annually compared to 100–200 for *Melicerita*, but *Cellarinella* can clone itself vegetatively. Brey et al. (1998) reported that *M. obliqua* forms one growth band per year, achieving a maximum length of 200 mm within 50 years, making this species the longest-lived bryozoan known. The annual production/biomass ratio for this species is 0.1 y^{-1}, in the range of other Antarctic benthic invertebrate populations. On the shelf (100–600 m water depth), production amounts to 3.34 mg C_{org} m^{-2} y^{-1} and, on the slope, 0.13 mg C_{org} m^{-2} y^{-1}.

Sanderson et al. (1994) produced the first experimental study of feeding in Antarctic bryozoans, using common *Himantozoum antarcticum* (Bugulidae). Its feeding rate (measured as mean feeding-current velocity) was comparable to that in temperate-water species at the lower end of their temperature range. Bryozoans are known for the phenomenon of polypide recycling — in which the gut and feeding apparatus (lophophore) can regress and regenerate several times within the same body wall, depending on the species. According to Barnes and Clarke (1998), Antarctic bryozoans have the longest zooid lifetimes (up to 5 years) and slowest polypide cycling (once per year, with polypide lifetimes up to 10 months) reported for any bryozoan so far.

5.4.7 Foraminifera

Several species of foraminiferans occur within the Ross Sea benthos and those present in McMurdo Sound have received particular attention. There is considerable difficulty in establishing the total foraminiferan biodiversity within the region because samples

often include subsurface sediments containing dead material and some workers have not adequately distinguished between living and dead taxa. This review identified about 800 species or subspecies in 171 genera from the Ross Sea (Table 5.5.1).
Foraminifera are single celled, amoeba-like protozoans that construct a shell or test of one to many chambers. An estimated 4000 living species (60 000 fossil species) of Foraminifera occur in the world's oceans making them among the most diverse and widely distributed protists in the ocean, playing a significant role in the economy and balance of the biosphere. Of these species, 44 are planktonic, living in the upper 300 m or so of the ocean. The remaining benthic species live on the bottom of the ocean, on shells, rock and seaweeds, or within the sand and mud of the seabed. Foraminifera are found in all marine environments, from intertidal to deep ocean, and from tropics to the poles, but, like most organisms, species of Foraminifera are particular about the environment in which they live. The composition of marine Foraminifera communities is largely influenced by the state of their surrounding environment. Their distribution and abundance is affected by abiotic factors such as temperature, salinity, dissolved oxygen availability and pH, and by biotic factors such as food, competition and predation (Murray, 1991). Changes in environmental conditions or ecological disturbances are rapidly reflected in foraminiferal assemblages. Further details of paleoecologic controls are discussed by van der Zwaan et al. (1999) in a comprehensive review.

Fully grown individuals range in size from 100 µm to almost 20 cm (arenaceous forms) long, although tests typically range from 0.1–1.0 mm long. The tests of all planktonic and the most numerous and diverse benthic Foraminifera are composed of calcite. Of the remaining benthic species some construct their tests from other secreted minerals such as aragonite and silica, while others utilise organic materials or cemented sediment particles (agglutinating forms) and tend to be most abundant under restricted conditions such as low salinity and anoxia. Foraminifera feed on a range of material from dissolved organic matter, particulate detritus, bacteria, diatoms and other single-celled phytoplankton, to small animals such as copepods. These broad food preferences make them ideally adapted to the benthic environment.

Several species of foraminiferans occur within the Ross Sea benthos and those present in McMurdo Sound have received particular attention. In addition to work on the diversity and distribution of this group, some studies have shown that these small organisms may have profound effects on populations of some macrobenthic species. Dayton (1990) reviewed some pertinent work showing that at least one free-living epizoic species can parasitise the scallop, *Adamussium colbecki*, whilst carnivorous species may occur in such high densities (e.g., in Explorers Cove, New Harbour, McMurdo Sound) and can consume such a wide range of benthic invertebrate larvae that their effects are likely to be more important than those of larger animals, such as seastars (*Odontaster*), ophiuroids (*Ophioonotus*) or crustaceans.

The distribution and ecology of benthic Foraminifera had, until recently, rarely been studied, especially in the deep sea and polar regions. Initial studies of the Antarctic and Ross Sea dealt with systematics and bathymetric distribution of taxa (e.g., Challenger Epedition (Brady, 1884; Barker, 1960), Terra Nova Expedition (Heron-Allen & Earland, 1922) and BANZARE Expedition (Parr, 1950)). Recently, more analyses of Antarctic foraminiferal assemblages have appeared, especially for areas of the Weddell Sea and Prydz Bay. The modern foraminiferal fauna of the Ross Sea was described and correlated with the physical and chemical parameters by McKnight

(1962), Pflum (1966), Kennett (1966, 1968), Ward (1984) and Ward et al. (1987). In particular, McKnight (1962) and Pflum (1966) established depth zonations based on foraminiferal assemblages. Quantitative data (Ostermann & Kellogg, 1979) distinguished discrete assemblages (albeit with insufficient stations, samples that were often too small, and no replication), while Bernhard (1987) distinguished biotopes on the basis of physical (substrate type) and biological parameters (productivity). Elsewhere in Antarctica, foraminiferal assemblages are correlated with depth and water mass characteristics, such as bottom current speed, oxygenation (e.g., Mackensen et al., 1990, 1995), productivity and food supply (e.g., Gooday et al., 1988).

These types of relationships are starting to be addressed within the Ross Sea region (e.g., Asioli, 1995; Violanti, 1996). The living benthic foraminiferan fauna on the far western Ross Sea between Terra Nova Bay and the slope off Cape Adare, a region of strongly irregular topography due to glacial erosion, displays great spatial variability and appears to be strongly affected by carbonate dissolution, oceanic circulation, and sedimentary processes (Violanti, 1996). A coastal calcareous assemblage (220 m) near Cape Washington is above the carbonate dissolution depth (CCD), in a region of low sediment accumulation. Violanti (1996) considered this to be a high-energy environment, indicated by the occurrence of *Trifarina angulosa* and *Cibicides* spp., but still a favourable environment with high organic matter, due to the presence of high species diversity and *Epistominella exigua.* A low diversity assemblage dominated by agglutinated Foraminifera, and with rare living calcareous specimens, occurs within Terra Nova Bay and eastwards into the terrigenous-dominated slopes of Drygalski Basin. Deposition near the CCD explains the infrequent calcareous forms, while transport processes and terrigenous deposition probably affect the agglutinated Foraminifera (Violanti, 1996).

Adjacent to the Drygalski Basin within areas of Terra Nova Bay, Asioli (1995) reported high surface productivity and suggested that accumulation of organic debris (i.e., a food supply) within the adjacent area supports populations of *Nonion barleeanum* and *Nonionella bradii.* The deepest assemblage within the Drygalski Basin is composed exclusively of agglutinated forms, indicating that this is below the CCD, and its high diversity attests to a low energy, detritus-rich environment (Violanti, 1996). The outer shelf of western Ross Sea between Cape Adare and Mawson Bank favours a *Trifarina angulosa* dominated assemblage, indicative of strong bottom currents and a high-energy regime in this area (Asioli, 1995).

Data on the distribution and ecology of benthic Foraminifera in Ross Sea is patchy, at best, due to the varying nature and age of studies within this region. During the time span of these studies, methods of collection, taxonomy, and the relationship of foraminiferan assemblages to the oceanic environment have greatly improved. However, it is apparent that the CCD, in association with bathymetry, is a dominant control on gross morphotype occurrence. Within the calcareous and agglutinating forms, proximity to ice shelves and pack ice, the influence of open ocean currents on the slope, the hydrodynamic regime and productivity all influence species distributions and assemblage compositions in this region.

5.4.8 Algae

There is a marked separation of subantarctic algal flora from the Antarctic algae by the Antarctic Convergence. Among the truly Antarctic algae (i.e., excluding subantarctic species), endemism increases with latitude (Dayton, 1990), with numbers of species also declining with increasing latitude along the western Ross Sea shore (Zaneveld, 1966b, 1968). Indeed, it appears that conditions at McMurdo Station represent the southern limits of occurrence for foliose algae (Dayton, 1990). A total of 33 species of benthic algae belonging to 24 genera are reported from the Ross Sea (Table 5.5.1).

Depths limits for growth of foliose algae in the Ross Sea are extremely deep. Dayton (1990) observed algae growing at 60 m depth at Cape Evans. At Possession Island, much further north in the Ross Sea, several species are reported from depths exceeding 300 m and one record places *Monostroma hariotii* as growing at 345 m depth (Wagner & Zaneveld, 1968). It appears that benthic algal growth requires less light under cold conditions, allowing them to grow naturally at greater depths at higher latitudes (assuming equivalent water clarity) (Heywood & Whitaker, 1984). Further, although dense patches of sea urchins (*Sterechinus neumayeri*) occur in places (e.g., Cape Evans) within the Ross Sea, there is no evidence that they control or even graze on macroscopic algae (Dayton, 1990).

5.5 Discussion

Because many Ross Sea benthic species are circum-Antarctic in occurrence, the faunal assemblages found in the Ross Sea are similar to those found elsewhere in Antarctica (Bullivant, 1967b). The rubble, boulder and rock nature of shallower (<500 m) substrates in the Ross Sea favours sessile benthic organisms, dependent on a more oceanic trophic system than that found in coastal environments at lower latitudes. Inputs from land are minimal in the Ross Sea, whereas sedimentation, riverine and sublittoral organic inputs strongly influence coastal benthic assemblages to considerable depths off most other continents. The high dependence on phytoplankton and marine snow means that suspension-feeding sponges and bryozoans feature more strongly in Ross Sea and Antarctic benthic faunas.

Most notable among the strongly suspension-feeding asemblages is the McMurdo Sound Glass Sponge Assemblage initially defined by Bullivant (1967b) and studied in greater detail by Dayton et al. (1970, 1974). Similar communities dominated by sponges were also reported from Terra Nova Bay (Cattaneo-Vietti et al., 2000). In such assemblages, large biomasses of suspension feeders add complex structure to the bottom topography, creating microhabitats utilised by numerous other mobile and sessile invertebrates. The dominance of suspension feeders within the Ross Sea is very much tied to the physical environment. A dearth of moderate to large patches of fine sediments suitable for colonization constrains deposit feeding as a life-style. Another constraint on deposit-feeding is the apparent low of accumulation of organic matter in sediments. Organic inputs from land and large macroalgae, the source of much of the organic matter supporting coastal deposit-feeding assemblages in lower latitudes, is absent in Antarctica. The benign hydrodynamic environment results in little transport or redistribution of organic matter other than by currents and deposition. Organic matter arriving on the bottom is not buried, but is available for resuspension or consumption by the abundant scavengers. Thus, the dominance of suspension feeding is not unexpected.

Dell (1965) noted large areas of bottom covered by thick layer of living, sessile colonial animals up to 750 mm high, probably due to abundant supply of planktonic detritus raining to the bottom. This fauna covers large areas with some species climbing on top of other animals. Specialised carnivores are prevalent in this environment. Large numbers of taxa are necrophagous, either obligate or facultative. In addition to groups that commonly exhibit this feeding mode (e.g., gastropods, seastars, amphipods), several others that are elsewhere are not regarded as necrophagous are found here (e.g., nemerteans, ophiuroids, echinoids, holothurians, pycnogonids) (Arnaud, 1970). Some species appear to switch from herbivory to necrophagy at times when there is insufficient diatom or other suitable material available (Arnaud, 1970). Thus, necrophagy, particularly facultative necrophagy, appears to be an adaptation to periodic or uncertain food supplies in Antarctica, just as it is for many animals living in the deep sea (Britton & Morton, 1994).

Other unusual aspects of the fauna include gigantism in a number of taxa (nemerteans, pycnogonids, isopods, amphipods), conceivably due to increased availability of oxygen (Chapelle & Peck, 1999; but see also Spicer & Gaston, 1999 and Peck & Chapelle, 1999 concerning the absence of crabs and the paucity of molluscs). Another unusual feature is the apparent widespread brooding life-history strategies among benthic animals (Arntz et al., 1994). This is thought to be an adaptation to overcome the uncertainties of prolonged planktonic larval development in an environment where primary production is restricted to a brief period each year (Arntz, et al., 1994).

The Ross Sea benthic fauna has high diversity in some taxa, but lacks some major groups such as crabs, many benthic fishes, sharks, gastropods, and balanomorph barnacles are represented by few species (Dayton, 1990). Also, the infauna appears depauperate and poorly developed; there are no large populations of bivalves and ampeliscid amphipods characteristic of the Arctic and infaunal polychaetes are not ubiquitously common. Large predators of the benthos (crabs, benthic fishes, rays) are largely lacking, especially when compared with Arctic benthos. The lack of physical disturbance by large predators has been suggested as one of the most important factors in the persistence of the dense benthic assemblages in McMurdo Sound (Oliver & Slattery, 1985). However, other factors are almost certainly involved.

Below 33 m, the physical environment is also particularly benign, albeit cold. Scouring by ice also is relatively rare. The physical factors usually so important in structuring shallow water sediment environments seem markedly less important in the Ross Sea and elsewhere in Antarctica, and this may be a major influence on the nature of the biota here. There are no inputs of terrestrial or riverine organic matter. Sedimentary inputs are limited to ice-rafted material, most of which is quite coarse (pebbles-cobble). Wave energy appears to be a small factor in near-shore and coastal environments for two reasons. Storms usually bring winds that blow offshore or parallel to shore so fetches for wave generation are mostly short. Pack ice tends to absorb and dissipate much of the energy in oceanic swell, long before it reaches shore (Shen & Squire, 1998). The pack ice also greatly reduces the formation of wind waves within the region and, together with fast ice, especially in winter, buffers shallower benthic habitats from wave energy. Consequently, the hydrodynamic environment is very benign, except where there are significant currents, such as at the shelf edge.

Fines are usually uncommon in the material arriving at the bottom and hydrodynamic energy is so low at the bottom that abrasion to produce fines is essentially non-existent. Thus, mud and sands do not dominate bottoms to the extent typical of most other coastal regions. Where deposits of these finer sediments do accumulate, they are usually poorly sorted.

In reviewing polar benthos generally, but with close attention to research on the benthos of McMurdo Sound, Dayton (1990: 666) considered that "benthic communities are organized around the nature, abundance, and predictability of organic inputs, their utilization, and the degree to which the structure of the community is influenced by various pattern[s] of disturbance". The east-west McMurdo Sound contrast in benthos is explained by differences in quantities and vertical fluxes of organic inputs to the benthos (Dayton & Oliver, 1977; Dayton, 1990). Dayton also believed that the benthos utilised organic inputs very efficiently, but, despite the high planktonic productivity, benthic animals grow slowly so that secondary production is low. Apparently, organic carbon is not accumulating in the bottom sediments, and microbial activity is low, suggesting that the benthic community itself is an important carbon sink in Antarctic waters (Dayton, 1990). There is some suggestion that substantial amounts of organic carbon are transported into the deeper basins within the Ross Sea continental shelf (Dunbar et al., 1989), but Dayton (1990) appears to discount this. Gambi & Bussotti (1999) report that substantial amounts of organic matter settle from the overlying water column to reach fine sediment, deposit-feeding communities of uncertain extent, both on the shelf and within deeper basins. This issue of organic carbon fluxes within the Ross Sea benthos system, including macro- and meiofauna, as well as the microflora, requires further attention, not only in shelf, deposit-feeding systems, but also within the eastern McMurdo Sound Glass Sponge Assemblage.

It is important to note that the benthos described above for any one depth zone is simply a superficial summary of what is actually present in a relatively sparse set of samples taken in the region over the last century. Numerous smaller and/or rarer species may be present, but are not included either for clarity or because they were not detected, identified, or reported in the original investigations. Further, the above descriptions present biotas within a zone as being largely homogeneous. This is not necessarily so. The *Iridaea* and *Phyllophora* zones at Terra Nova Bay are considered quite homogeneous on a large spatial scale (Gambi et al., 2000), but communities are quite heterogeneous on such a scale below 30–40 m depth (Cattaneo-Vietti et al., 2000). Hard and soft bottoms coexist at these depths, creating a mosaic of communities within this zone (Cattaneo-Vietti et al., 2000a).

These descriptions of the biodiversity of different hard and soft bottom communities at Terra Nova Bay provide a very useful starting point for understanding the biodiversity of these habitats (Cattaneo-Vietti et al., 2000a). However, the various studies contributing to Cattaneo-Vietti et al.'s (2000a) review are far from comprehensive, with significant elements of the benthos not included, and remaining to be studied adequately. For example, Gambi & Mazzella (1991: 352) stated that "Polychaetes and Peracarid Crustaceans (Isopods, Amphipods and Tanaids) were among the most abundant and diversified organisms" in samples from soft bottoms in Terra Nova Bay. Descriptions of the polychaete biodiversity have been published (Gambi & Castelli, 1994; Gambi et al., 1997; Cantone et al., 2000), but work on the peracarids apparently remains in progress. Obviously, there is considerably more work to be done to learn about the full biodiversity of these habitats.

The benthos at Terra Nova Bay extends further towards the surface than does that at McMurdo Sound. Ice scour apparently has an impact only to 2–10 m depth at Terra Nova Bay compared with to 15 m depth at McMurdo Sound. Also, anchor-ice has not been observed at Terra Nova Bay, so that one of the most important physical disturbances does not occur here (Cattaneo-Vietti et al., 2000a). Amelioration of these two factors appears to be largely responsible for large beds of algae persisting from year to year, and their presence has a profound effect on nearshore productivity and faunal abundances.

Dense beds of foliose macroalgae occur to considerable depths (>60 m) on rocky bottoms along much of the Ross Sea coastline (Dayton, 1990), but there are few reports of associated faunas. Sea urchins (*Sterechinus neumayeri*) apparently occur on crustose coralline bottoms rather than among macroscopic foliose algae (Dayton, 1990).

The overall biodiversity of the benthos in the region is summarised in Table 5.5.2. A total of almost 2500 species from 1100 genera are reported from the region's benthos and many more species await identification. Some groups are now quite well known (e.g., the echinoderms), but others are much less well known. For example, the total amphipod fauna is probably more than double that presently known. Other groups, such as the meiofaunal annelids and crustaceans, appear completely unreported. As a result, the true biodiversity of marine benthic habitats in the region is expected to be more than double the current total.

6. Biodiversity of fish

The fish fauna of the Ross Sea is an important part of the large predator fauna (Fig. 4.1–4.3) of the region (south of 60° S, 160° E to 150° W out to 3000 m) and includes benthic, benthopelagic and pelagic species that have been poorly sampled and appear to be only moderately well known. Recent bottom trawl sampling in the Ross Sea produced new records and four undescribed species (Eastman & Hubold, 1999). The authors also combined species records from Gon & Heemstra (1990) with those from two cruises undertaken in 1996–97 and 1997–98, and reported 80 species and 12 families. These included 54 (67.5%) notothenioids and 26 (32.5%) non-notothenioids. By comparison the well-sampled Weddell Sea fauna has a similar size and taxonomic composition with 83 species and 14 families comprising 69 (83%) notothenioids and 14 (17%) non-notothenioids.

In comparison with other Antarctic or boreal regions the Ross Sea fauna is diverse at the alpha (or local) level (Eastman & Hubold, 1999). The taxonomy of the nototheniids (the dominant fish family) and muraenolepids, is difficult and there has been little coordinated effort on sorting out the problems with these groups. There has been an increase in taxonomic work on the notothenioids in the last ten years or so (Eastman & Eakin, 2000).

The species list (Table 6.1) builds on the lists compiled by Gon & Heemstra (1990) and Eastman & Hubold (1999) by incorporating new species and new records (Andriashev & Stein, 1998; Chernova & Eastman, 2001; Vacchi et al., 2001). It also includes species (marked with an asterisk) not formally recorded from the Ross Sea but likely to be found in the area, including widespread, and circum-Antarctic species. Synonymies and nomenclature changes follow Eschmeyer (1998) [the online version], Eastman & Eakin (2000), and Voskoboinikova (2000).

The fauna is dominated by four notothenioid families (Nototheniidae, Artedidraconidae, Bathydraconidae, and Channichthyidae) which are mostly confined to Antarctic or sub-Antarctic waters. A fifth notothenioid family, Harpagiferidae, has not yet been recorded from the Ross Sea. Other important families include the Liparidae and Zoarcidae. The Liparidae comprise small fishes occurring to at least 5000 m depth. There are about 90 species in seven genera currently known from the southern hemisphere with about 67 species known from Antarctica (Andriashev, 1998; Andriashev & Stein, 1998). Many species, including some collected from the Ross Sea, are known from single specimens, but they may be more widespread. Other elements of the fauna that are species rich in lower latitudes to the north appear depauperate, e.g., Myctophidae.

Many species have large depth ranges possibly because the continental shelf is considered to extend out to 500–600 m, caused by the weight of the ice shelf, Angel (1997), in contrast to other areas where the shelf break is at about 200 m (Gon & Heemstra 1990). The benthic shelf fauna is species-rich but the number of species decreases with depth particularly past the shelf break. Many species have a circum-Antarctic distribution. There are three species considered to be possibly endemic to the Ross Sea, *Lycodichthys dearborni, Paraliparis devriesi* and *Artedidraco glareobarbatus* (Eastman & Hubold, 1999; Eastman & Eakin, 1999).

The effects of extracting organisms from the Ross Sea appears poorly known. The bottom long-line fishery for Antarctic toothfish (*Dissostichus mawsoni*) is the most obvious human activity likely to impact on the fish fauna. This has been carried out each summer starting in 1998 with recorded annual Antarctic toothfish catches of 41–753 tonnes, Hanchet et al. (unpublished). Recorded by-catch (of the total catch) included rattails (probably mostly *Macrourus whitsoni*) of 6–17%, rajid skates of 1–11%, muraenolepids about 1%, and others generally about or less than 1%. Eastman & Hubold (1999) provided "biomass" estimates of fish from two Ross Sea stations (the catch was sorted by species and weighed). Four small notothenioid species dominated. It is not known if krill fishing or other commercial fishing activities have been carried out in the Ross Sea and if so what their likely impacts on the fish fauna might have been.

There are no direct estimates of absolute or relative abundance for any fish species in the Ross Sea. Estimation of yields for the toothfish stocks in the Ross Sea is currently carried out by analogy with depth-area densities of Patagonian toothfish (*Dissostichus eleginoides*) from South Georgia (SC-CAMLR XX). Management of by-catch species includes the use of both catch limits and criteria that necessitate fishers moving away from an area if a certain threshold level of by-catch is taken. Fishers have recently initiated tagging studies on skates and toothfish, and carried out experimental 'research' longline sets, which may enable the future impact of fishing on the stocks to be determined.

The literature of the Convention on the Conservation of Antarctic Living Resources (CCAMLR) was not examined for this study but may provide at least a summary of research carried out to date. A review of a book (Sabourenkov, 2001) titled "Fish and fish resources of the Antarctic" by a Russian author (Shust, 1998; in Russian) provided little specific information other than the fact that there have been attempts by Russian researchers to estimate biomass using trawl and acoustic techniques elsewhere in the Antarctic region.

7. Biodiversity of birds

The birds of the Ross Sea region are an integral part of the Antarctci ecosystem (Fig. 4.1–4.3). Birds have been reported since the first scientific and exploration expeditions of the 1900s (e.g., Wilson, 1905; Ferrar, 1928; Friedmann, 1945) and more recently reviewed by, for example, Young (1981) and Harper et al. (1984). Subsequently, much attention has been placed on documenting the distribution and numbers of birds throughout the region. Much of the information regarding the distribution of birds at sea has been reported as a result of regular counts during voyages to the area (e.g., Dell, 1960; Darby 1970; Hicks 1973; Bassett & Wilson, 1983) or systematic surveys from vessels (e.g., Ainley, 1985; Saino & Guglielmo, 2000). In addition, there have been specific ornithological land-based surveys of snow-free areas (e.g., Stirling & Greenwood, 1970; Robertson et al., 1980). However, most of the scientific expeditions over the past 100 years have been concentrated in the western Ross Sea region. Consequently, it is not surprising that breeding locations of some species have been discovered in eastern areas relatively recently during what were primarily botanical expeditions (Broady et al., 1989; Greenfield et al., 1992). In addition, there is incomplete knowledge of the abundance and breeding status of some species at key locations such as the Balleny Islands (Robertson et al., 1980).

7.1 Seabird communities

Three distinct communities of birds are recognisable in the Ross Sea and the Antarctic waters to the north, with each community characterised by major and minor species (Table 7.1; Ainley et al., 1984). The community having the least spatial overlap with the others is that which occurs in the pack ice at the highest latitudes. This community comprises emperor penguin, Adélie penguin, Antarctic petrel, snow petrel, and south polar skua. Southern giant petrel, Antarctic fulmar and Arctic tern are minor components of the community. Finally, although Wilson's storm petrel is abundant in the region, it occurs primarily in high latitudes and has a distinct preference for open water, and so Ainley et al. (1984) considered it a minor component of this community. Southern giant petrel and southern black-backed gull are also minor components of this high latitude community, but only in open water. Chinstrap penguins are rare in the Ross Sea, with a small number breeding only on the Balleny Islands (Robertson et al., 1980). This penguin too is a high latitude specialist, but occurs in more open water than Adélie penguins, and so should be considered only a minor component of this community (Ainley et al., 1984).

Emperor penguin, Adélie penguin, Antarctic petrel and snow petrel are year-round residents of the pack ice, moving north to remain within the edge of the pack during winter, as determined by satellite tracking of Adélie penguins (Davis et al., 1996). Indeed, the penguins and snow petrel are considered obligatory associates of the pack ice (Ainley et al., 1984). During the austral winter, Antarctic petrels, Antarctic fulmars, southern giant petrel and Wilson's storm petrel range as far north as the seas off New Zealand (Heather & Robertson, 1996), while Arctic terns return north of the Arctic circle to breed.

The second community of seabirds occurs north of the pack ice, generally within waters containing icebergs (Ainley et al., 1984). The most characteristic species of this community is the Antarctic fulmar. Other species include Wilson's storm petrel, Antarctic petrel and mottled petrel, with minor species represented by light-mantled sooty albatross, southern giant petrel, cape petrel, snow petrel, and Antarctic prion (Ainley et al., 1984). With the exception of Antarctic petrel, none of these species ventures into the pack ice, except to reach nesting sites (Ainley et al., 1984). For example, cape petrels breed on the Balleny Islands, which are surrounded by pack ice during spring and early summer (Robertson et al., 1980), but are within the area of dense concentrations of icebergs (Ainley et al., 1984). A macaroni penguin seen in 1964 and 1973 on the Balleny Islands (Robertson et al., 1980), which lie within the iceberg zone during summer, is probably rare in the region, and so best considered a minor component of this community.

Mottled petrel breed on at The Snares and Solander Islands in the New Zealand region, but it is not known whether the birds feeding among the icebergs are breeders or not. Likewise, light-mantled sooty albatrosses breed far to the north, the closest site being Macquarie Island. However, it is known that light-mantled sooty albatrosses breeding on Macquarie Island commute to polar waters to feed (Weimerskirch & Robertson, 1994).

The third community is comprised of some of the most abundant and important species of the subantarctic avifauna (Watson et al., 1971) which move across the Polar Front and feed in the open sea just to the north of the ice (Ainley et al., 1984). The most widespread species are black-browed albatross, light-mantled sooty albatross, southern giant petrel, cape petrel, Antarctic prion, mottled petrel, sooty shearwater, short-tailed shearwater, black-bellied storm petrel, and southern skua. Other species, restricted more to the north, were king penguin, wandering albatross, grey-headed albatross, white-chinned petrel, blue petrel, white-headed petrel, and diving petrel (Ainley et al., 1984). A reason for some of these species preferring open water is that albatrosses and giant petrels in particular use dynamic soaring for energy efficient flight and this may be reduced in areas of extensive pack ice, where the ice dampens sea movements (Ainley et al., 1984).

It is now known that many of the birds in this third group commute to the region of the polar front to forage for themselves and their chicks on the islands far to the north. Recent examples of birds breeding on subantarctic islands and commuting to feed in the polar front include wandering albatrosses from the Kerguelen archipelago (Weimerskirch et al., 1993) and grey-headed albatrosses from Campbell Island (Waugh et al., 1999).

7.2 Breeding species

Eleven species of birds breed in the Ross Sea region (Table 7.2.1). The following is an updated summary of the information reviewed in Harper et al. (1984).

7.2.1 Emperor penguin

An estimated 40 000 pairs of emperor penguins breed in six colonies between Cape Roget and Cape Crozier. Two of the largest colonies in Antarctica occur at Cape Roget and Coulman Island, where 11 700 and 21 000 pairs respectively are estimated to breed. In general, the population appears to be increasing (Kooyman & Mullins 1990; Kooyman 1993) However, some colonies are susceptible to early breakout of the fast ice where the penguins breed, which results in poor breeding success (Kooyman 1993). Elsewhere in Antarctica, long-term studies of emperor penguin colonies have shown strong and contrasting effects of large-scale oceanographic processes and sea-ice extent on demography and the potential high susceptibility of the species to climate change.

Emperor penguins are one of the better studied seabirds in the Ross Sea region with information about it population size and trends (e.g., Stirling & Greenwood 1970; Kooyman & Mullins 1990; Kooyman 1993), breeding (e.g., Kooyman 1993), and food and feeding (Cherel & Kooyman 1998).

7.2.2 Adélie penguin

Adélie penguins are known to breed at 35 rookeries in the Ross Sea region, with a total of about 1 million breeding pairs (Waterhouse, 2001). The location of the breeding colonies is the result of several factors, including persistence of fast ice and presence of suitable ice- and snow-free ground. There are two main concentrations of Adélie penguins – northern Victoria Land and the southern islands of Franklin, Beaufort and Ross (Harper et al., 1984). In northern Victoria Land, about 475 000 pairs breed along about 150 km of coast, making it the densest concentration of this species on the Antarctic continent (Harper et al., 1990). There are only three known colonies in Marie Byrd Land, but this area has been little surveyed and additional colonies may exist (Harper et al., 1984). There have been long-term substantial fluctuations in the numbers of Adélie penguins breeding throughout the Ross Sea region (Waterhouse, 2001). Recently, Wilson et al., (2001) showed that there is a highly significant negative relationship between maximum extent of winter sea ice and numbers of breeding pairs, with a 5–6 year time lag. One reason is that when the maximum extent of sea ice extends farther north than usual, the penguins may be pushed beyond the productive water of the shelf break and lack of food leads to starvation or increased predation.

Adélie penguins are among the best studied species in the world and they have been extensively studied in the Ross Sea region. These studies have included reports on their distribution and abundance (e.g., Reid, 1964; Taylor & Wilson, 1990; Taylor et al., 1990), demography and population regulation (e.g., Wilson et al., 2001), breeding (e.g., Oelke, 1975; Spurr, 1975; Davis & McCaffrey, 1986), diet (e.g., Paulin, 1975; van Heezik, 1988; Ainley et al., 1998), and foraging movement and migration (e.g., Davis et al., 1988; Davis & Miller, 1992; Davis et al., 1996).

7.2.3 Chinstrap penguin

In the Ross Sea region chinstrap penguins breed only on the Balleny Islands, with a total population of about 10 pairs (Robertson et al. 1980).

7.2.4 Petrels

Six species of petrels breed in the Ross Sea region, with a total population probably numbering millions of pairs (Harper et al., 1984). In order of abundance these are: Antarctic petrel, snow petrel, Wilson's storm petrel and Antarctic fulmar; with Antarctic prion and cape petrel restricted to the northern Ross Sea. However, information on the numbers and distribution of these species in the Ross Sea region is very limited. On the basis of observations at sea Ainley et al. (1984) thought that there may be millions of pairs breeding in Marie Byrd Land, but apart from a colony estimated at 10 000 pairs (Broady et al., 1992), no new colonies have been discovered recently. Consequently, the only known confirmed breeding sites of this species in the Ross Sea region is at the Balleny Islands (Robertson et al., 1980), although they may also breed at Scott Island and Robertson Bay (Harper et al., 1984).

Snow petrel numbers are estimated at 2 million birds (Waterhouse, 2001), making it the second most abundant petrel species in the Ross Sea region. Two forms of snow petrel are thought to occur in the Ross Sea region. The larger subspecies, *Pagodroma nivea major,* is known to breed on Scott Island and the Balleny Islands (Robertson et al., 1980; Jouventin & Viot, 1985). The smaller subspecies, *P. nivea nivea,* is thought to breed in the Morozumi Range, and is known from at least eight other sites in Victoria Land (Greenfield et al., 1989). In addition, two small colonies are known from Marie Byrd Land (Greenfield et al., 1989).

Even less is known about Wilson's storm petrel breeding sites. It is known to breed on Scott Island and in at least eight locations in Victoria Land, with an estimated total population of 400 000 birds. Antarctic fulmars breed only at the Balleny Islands in the Ross Sea region, while Cape petrels breed at both the Balleny Islands and Scott Island, and Antarctic prions are known to breed only on Scott Island (Harper et al., 1984).

7.2.5 Skuas

South polar skuas appear to breed throughout the Ross Sea region wherever snow- and ice-free land is available (Harper et al., 1984). Major concentrations of skuas occur near Adélie penguin colonies, although they do also nest in many other places (Harper et al., 1984). Counts are only available for Cape Adare, Cape Hallett and the McMurdo Sound area. About 1500 pairs breed on Ross Island with the Cape Crozier population by far the largest; and this may be a large proportion of the Ross Sea region total population (Spellerberg, 1967; Ainley et al., 1986; Harper et al., 1990). Population decreases associated with human activity have occurred. For example, skua populations at Cape Hallett decreased from 180 pairs in 1959/60 to 98 pairs in 1971/72 (Harper et al., 1984), and then to 83–85 pairs in 1982/83 (Pascoe, 1984).

South polar skuas have been studied extensively in the Ross Sea region with topics including breeding (e.g., Young, 1963; Spellerberg, 1971), territory (Young, 1972), food (Young, 1994; Mund & Miller, 1995); and demography (Ainley et al., 1990).

Southern skua breeding is only thought to occur at the Balleny Islands (Robertson et al., 1980).

8. Biodiversity of marine mammals

Most of the information regarding marine mammals comes from systematic counts of animals at sea (e.g., Bassett, 1983; Ainley, 1985) and demographic studies at specific breeding areas (e.g., Siniff, 1980; Testa & Siniff, 1987; Schreer & Testa, 1992). In addition, there have been extensive studies of the adaptations to polar and marine environments of Weddell seals, which is perhaps the most studied marine mammal in the world. Unfortunately, little is known of the biology of other polar specialists among the marine mammals in the Ross Sea, beyond their relative abundance and foraging habits. These marine mammals form an important part of the large predator population in the region (Fig. 4.1–4.3).

8.1 Seals

Of the five species of seal recorded in the Ross Sea, the most abundant is the crabeater seal followed, order of abundance, by Weddell seal, leopoard seal, Ross seal, and southern elephant seal (Ainley, 1985). The Weddell, crabeater and Ross seals are exclusively Antarctic species, being rarely reported north of the Antarctic Circle (Waterhouse, 2001). The distribution of all these species is influenced by ice conditions throughout the year, with distinct habitat preferences being exhibited by the different species. Consequently, Weddell seals are found primarily near or on fast ice attached to the shore, while crabeater seals and leopard seals are more common in the unconsolidated pack ice and Ross seals are most frequently found on consolidated pack ice. Southern elephant seals are rare summer-only vagrants to the Ross Sea, straying into the area from their northern breeding grounds on subantarctic islands (Brownell & Ainley, 1976). Crawley (1990) reviews the biology of all the seals that occur in the Ross Sea.

8.1.1 Crabeater seals

Crabeater seals are the most abundant marine mammal in the Ross Sea, with an estimated population of 204 000 individuals (Ainley, 1985). Within the Ross Sea, crabeater seals are associated with heavy pack ice, particularly over the Antarctic Slope Front in the northern Ross Sea (Ainley, 1985). In the pack ice they usually occur in singles or in pairs (Gilbert & Erikson, 1977). The crabeater seal consumes krill almost to the exclusion of anything else (Oritsland, 1977).

Because of their shy behaviour and difficult habitat, little is known of their biology (Waterhouse, 2001).

8.1.2 Weddell seals

Weddell seals are the second-most common seal in the Ross Sea, with estimates ranging from 32 000 to 50 000 individuals (Stirling, 1969; Ainley, 1985). These figures may underestimate the actual total because Stirling's (1969) estimate did not include animals that may occur in the vicinity of the King Edward VII Peninsula. Ainley (1985) conducted systematic censuses of marine mammals and birds during five cruises in the Ross Sea and estimated 0.054 individuals per km^2.

Weddell seals occur only in pack-ice within about 200 km of the fast-ice areas where it breeds (e.g., along the coast of Victoria Land and Ross Island) (Ainley, 1985).

During the summer, they are generally associated with fast ice adjacent to the shore, where they establish breeding and maintain access to the sea by using perennial tide cracks (Waterhouse, 2001). A relatively stable population of about 1500 animals occurs on the eastern side of McMurdo Sound (Testa & Siniff, 1987), with about a further 500 animals on the western side of McMurdo Sound, mostly near the Strand Moraines and Blue Glacier (Ross et al., 1982).

The distribution of Weddell seals changes by April, with adults leaving the breeding colonies and moving northwards with the pack ice. Satellite tracking of females from breeding colonies in McMurdo Sound showed that most remained in the northern part of the Sound during winter, although some travelled as far as 500 km north beyond the Sound (Testa, 1994). Ice conditions, the availability of prey, and the abundance of predators such as leopard seals and killer whales appear to determine where adults and young go when they disperse from the breeding colonies (Testa, 1994).

Weddell seals obtain their food by diving for up to 75 minutes and to depths of 600 m, although most dives are to depths of 100–400 m. Antarctic toothfish comprise one of the main prey species of Weddell seals in McMurdo Sound and a significant increase in toothfish numbers in this area from October to mid-November may be the reason why so many Weddell seal breeding colonies are established there (Ross et al., 1982). However, the significance of toothfish in the diet may be overestimated as smaller species of fish, plus squid, probably constitute a greater proportion of the total diet (Burn et al., 1998).

8.1.3 Leopard seal

An estimated 8000 leopard seals inhabit the Ross Sea, with most occurring on pack-ice in frontal areas (Ainley, 1985). Most sightings made by Ainley (1985) were in the western Ross Sea, which supports the densest concentrations of Adélie penguins, a frequent prey species of the seals. The diet of leopoard seals comprises mostly krill, penguins and fish, although crabeater seals are also common prey (Oritsland, 1977). In summer, individual leopard seals may cruise the sea off Adélie penguin colonies, taking birds as they approach the shore on their way to or from feeding (Penny & Lowry, 1967).

Little is known of other aspects of the biology of leopard seals.

8.1.4 Ross seal

An estimated 5000 Ross seals occur in the Ross Sea (Ainley, 1985), which is only a small proportion of the estimated 101 000 individuals that occur in the Pacific sector of Antarctica (Gilbert & Erickson, 1977). Consequently, Ainley (1985) concluded that Ross seals are irregularly distributed with high concentrations in localised areas, and that the Ross Sea is apparently not an area where this species concentrates. They appear to occur in very low densities throughout the loose pack ice of the outer Ross Sea and adjacent parts of the South Pacific (Ainley, 1985).

Little is known about the biology of the species, apart from observations made from ships and the examination of dead animals. Squid and fish appear to be the main components of the diet (Oritsland, 1977; Skinner & Klages, 1994).

8.1.5 Southern elephant seal

This is the least common seal in the Ross Sea, with an estimated 40 animals at any one time during early summer (Ainley, 1985). Elephant seals do not breed in the Ross sea and the nearest breeding site is on Macquarie Island, 2400 km to the northwest (Waterhouse, 2001).

8.2 Whales

Information about whales in the Ross Sea comes primarily from surveys of their distribution and numbers carried out by systematic surveys (e.g., Bassett & Wilson, 1983; Butterworth & Best, 1982; Ainley 1985). While reviews of the biology of Antarctic whales include those of Brown & Lockyer (1984), Knox (1994) and Kasamatsu & Joyce (1995).

Of the eight species of baleen whales (Mysticete) and 12 species of toothed whales (Odontocete) that occur in the Southern Ocean south of the Antarctic Convergence (Knox, 1994), six species of baleen whales and six species of toothed whales have been reported from the Ross Sea region (Waterhouse, 2001). Of the baleen species, minke, blue, fin and humpback whales occur within the Ross Sea, south of 68°S, with sei and dwarf minke whales occurring south of 60° S (Waterhouse, 2001). Minke whales are the most numerous whale within the Ross Sea, with an estimated 14 300 individuals (Ainley, 1985). This is considerably fewer than the number estimated to occur in an area 2.5 times larger, but including, the Ross Sea (Butterworth & Best 1982). However, the discrepancy could be explained by the timing of the cruises – Ainley's (1985) cruises occurred primarily during December, but those of Butterworth & Best (1982) were more than a month later. During the intervening time a heavy band of pack ice that had closed the Ross Sea from the Pacific moved or dispersed, and so this may have enabled more whales to enter the Ross Sea by the time of the later censuses. In some years minke whales penetrate the Ross Sea much earlier in the season, as shown by Saino & Guglielmo (2000) who found very large numbers of these whales as far south as 74° S during November. Ainley (1985) found that most minke whales were in light pack ice, and so was a species of the ice-edge habitat. Another important factor governing the occurrence of the species was the Antarctic Slope Front and the frontal activity in the western Ross Sea associated with the ice edge and the northward flowing current there. Fin whale sightings (Bassett & Wilson, 1983) indicate that they prefer ice edge habitats, particularly along the Ross Ice Shelf. Baleen whales feed on krill over the continental slope of the Ross Sea region (Knox, 1994). For example, Saino & Guglielmo (2000) encountered a large proportion of minke whales where acoustic surveys indicated very large swarms of krill.

Of the odontocetes, sperm whale, killer whale, Arnoux's beaked whale and southern bottlenose whale occur south of 68° S in the Ross Sea, while long-finned pilot whale and hourglass dolphin occur as far south as 68° S (Waterhouse, 2001). Killer whales are the most abundant of the toothed whales, with an estimated 3400 individuals in the Ross Sea (Ainley, 1985). They are usually reported in pods over the continental shelf and within the pack ice edge. In addition, their occurrence was associated with the Antarctic Slope Front and the vicinity of the ice edge in the western Ross Sea, near Ross Island, and so they were probably responding to both the ice edge and the fronts (Ainley, 1985). The highest densities of sperm whales have been reported from the inner Ross Sea, with the southernmost sightings at 74° S (Waterhouse, 2001). Low numbers of Arnoux's and southern bottlenose whales have been reported from the Ross Sea (Waterhouse, 2001). Toothed whales have a varied diet, with killer whales preying on squid, fish, penguins, seals and other whales and dolphins, while sperm whales feed primarily on squid (Knox, 1994).

9.0 Understanding the relationships between ecosystem functioning and biodiversity

So far in this summary we have presented a catalogue of species, the data sources, the state of the samples or records and the spatial locations of original collections. In addition, we have used information on the broad patterns of Antarctic marine biodiversity, the main drivers of ecosystems, key species of Antarctic marine ecosystems, and life histories strategies of Antarctic biota to assess the recorded biodiversity and develop a Ross Sea synthesis. Nevertheless this biodiversity is supported and maintained by a complex web of interactions and processes that we have not addressed here in any depth.

It is possible to come to erroneous conclusions concerning the importance of some elements of an ecosystem based on their standing stocks alone. For example, a group that has a relatively small biomass may superficially seem to be unimportant. But when a group with a low standing stock (biomass) but high production/biomass ratio is considered, it is possible to see that such a group is able to produce more living biomass than is evident from its standing stock alone. Such groups (e.g., squids) can be very important, especially if they are a dominant food item in an ecosystem.

Therefore another essential aspect in understanding the resilience and vulnerability of Ross Sea biodiversity is knowledge of the rates of biological processes occurring there, the production/biomass and consumption/biomass characteristics of the biota, and knowledge of the standing stocks of functional groups of the biota. This aspect is beyond the scope of the present review, but should be considered carefully as an essential component of future research effort in the region.

10. Status of existing taxonomic collections

Collections of Ross Sea flora and fauna have been limited in space and time over the 160 year period since the first collections were made (Table 3.1). Amongst the more extensive collections are: 258 stations from the British Antarctic (*Terra Nova*) Expedition, 1910, 75 Transantarctic Expedition stations 1956, 92 Stanford University stations in 1958, 49 *Endeavour* stations in 1958–59, 93 Balleny *Glacier* 1965 stations, 106 *Eltanin* 27 stations in 1967, 116 *Eltanin 32* stations in 1968, 91 *Eltanin* 51 stations in 1972, 108 Italian *Polar Queen* stations in 1988, 73 Italian *Cariboo* stations in 1989, and 53 Italian ROSSMIZE stations in 1994. Other material (e.g. macroalgae) were sampled in other events (see Zaneveld 1968) that are not necessarily captured in Table 3.1.

During the process of extracting information for this study it was clear that we don't have a complete picture of the whereabouts and degree of analysis of all of this material, nor can we be sure that we have identified all publications that relate to this material.

Samples from these expeditions and other events are deposited in the institutions indicated in the right hand column of Table 3.1. The bulk of the material is held in the The Natural History Museum, London, in New Zealand in the collections of the National Institute of Water and Atmospheric Research (NIWA) and Museum of New Zealand (Te Papa), Smithsonian Institution, Washington, D.C., the Natural History Museum of Los Angeles County, Los Angeles, and a lesser amount at the P.P. Sirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia.

Some of the New Zealand-held material has been published in the series "*The Fauna of the Ross Sea*", published as New Zealand Oceanographic Memoirs, as well as published material on material from the Balleny Islands on the echinoderms (McKnight, 1975, 1976a, b) and molluscs (Dell, 1990). Nevertheless a number of taxa have been identified and reside in NIWA records. These identifications, sometimes incomplete, have been entered into the BioRoss database associated with this report. Similarly identifications that are to be found in the records of the Smithsonian Institution (http://www.nmnh.si.edu/iz/usap/), but that are not always to be found in published works, are also entered into the BioRoss database. It is clear a significant amount of unidentified material exists in all collections. Unidentified material for the Balleny Islands includes sponges, Hydrozoa, Alcyonacea, Gorgonacea, Pennatulacea, Zoanthidae, Actinaria, Scleractinia, Nemertea, pycnogonids, various crustacean groups, Echiura, Brachiopoda, holothurians, ascidians, urochordates, and fish.

11. Discussion

11.1 Large scale distribution patterns

11.1.1 Microalgae

Microalgal biodiversity has a strong seasonal and geographic component that is driven by seasonal changes in the Ross Sea environment. Microalgae are adapted either to living in the water column, in the tide cracks in permanent ice, on the sea-ice interface, or in the sea ice itself. Therefore the flora observed at any one time in each environment is only a subset of the possible floras that can exist over time. Most of the creation of new organic matter occurs through the metabolic activities of these heterotrophic organisms. Therefore any environmental change that is detrimental to this part of biological diversity will have a far-reaching impact on all other parts of the marine food web. Most details of the life history strategies of microalgal species and their physiology are not known and the identities of Prochlorophyta, small Cyanobacteria, non-thecate dinoflagellates, and flagellates of various classes, are not well known.

11.1.2 Zooplankton

The Antarctic zooplankton fauna is composed of several elements. First, an epipelagic element that is restricted to circumpolar Antarctic waters. Second, seasonally migrating organisms that over winter by migrating down to depths around 1000 m, and timing their ascent to coincide with the spring / summer growth season. Third, deep-living species that have a much wider distribution, but which are found nearer the surface in Antarctic waters as the water masses in which they live out-crop in the Antarctic. Fourth, a "neritic" and even narrowly endemic element that is usually living a life associated in some way with the presence of ice. The details of this association are not at all well known.

Elements of the Ross Sea water column fauna have very restricted distributions associated mostly with permanent ice and one or appear to be endemic. For example, *Stephus longipes, S. antarcticum, Tharybis magna, Pareuchaeta erebi, Paralabidocera grandispina, Xanthocalanus harpagatus, Tisbe prolata, T. spinulosa* have only been recorded near or under permanent ice. *Pareuchaeta erebi* is found mainly under the Ross Ice Shelf, whereas *P. tycodesma* and *P. similis* while more abundant close to the ice shelf, also occur occasionally in modified Circumpolar Deep Water (Fontaine, 1988) (Fig. 4.4.3.1).

Some of these genera are commonly considered to be benthopelagic in other parts of the world, that is, living closely associated with the seafloor (*Stephus longipes, S. antarcticum, Tharybis magna, Xanthocalanus harpagatus, Aetideopsis antarctica*). In the case of the Antarctic habitats, the underside of the ice is an alternative surface with which copepods may be associated.

It appears that there may be some coastal habitats isolated enough that speciation has occurred. In the calanoid copepod genus *Paralabidocera* (this Acartiidae genus is endemic to Antarctica) one species (*Paralabidocera antarctica*) is know from the ice edge and sometimes in open water, but other closely related species are known from isolated habitats. *Paralabidocera antarctica* is an Antarctic species found in different sectors of Antarctica (Vervoort, 1957) and especially in the extreme south of the Ross Sea, but more recently two other species, from apparently restricted Antarctic localities, have be described: *P. grandispina* so far known only from the White Island tide crack in the Ross Sea (Waghorn 1979) and *P. separabilis* is known only from a fjord at about 100° E on the Antarctic continent (Brodsky & Zvereva, 1976). Similarly *Pareuchaeta erebi* and *P. tycodesma* are so far known only from the Ross Sea.

11.1.3 Sea ice community

Sea ice contains a complete ecosystem, with representatives of all major functional groups, from bacteria through to Crustacea, are present. Organisms live either in the brine channels that form between the columnar or platelet crystals within the ice, in the porous and adherent platelets that form at the ice-water interface in fast ice, and in the infiltration ice that forms where seawater enters the snow/ice interface, predominantly in pack ice. Algae, predominantly diatoms, but also representatives of many other groups, dominate primary production, but bacteria and a variety of microscopic and macroscopic animals are active heterotrophs (Bradford, 1978; Sullivan & Palmissano, 1984; Garrison et al., 1986). In addition, animals such as krill feed on the ice-associated algae and can arguably be considered components of the ice ecosystem (Stretch et al., 1988).

With the exception of the active animals that congregate under the ice, the sea ice community must be formed primarily from those organisms that are frozen into the ice during its formation. Organisms tend to be concentrated into the spaces that form during crystal elongation in congelation ice and their growth within these brine spaces is dependent on their tolerance of in ice conditions (Gunther & Dieckmann, 1999). Thus the ice biota is largely a subset of the plankton that can be frozen into the ice, survive, grow and reproduce. While the selective pressures in the ice may result in a characteristic community, the ephemeral mature of sea ice and the primarily serendipitous manner of colonisation, means that organisms specific to sea ice alone are unlikely to be successful.

The communities in pack and fast ice are often very similar. Differences mostly derive from the different methods of formation, and proximity to different inoculating habitats. Fast ice often has a more direct interaction with benthic communities, and the proximity of the sea floor means that colonisation by benthic organisms is more likely. In contrast ice that forms far from land is more likely to be dominated by pelagic-derived organisms. What's more the dynamic behaviour of pack ice, and the importance of frazil ice formation, is likely to result in a greater development of the infiltration layer compared to fast ice, where congelation and platelet ice dominate. Colonisation of the upper frazil/infiltration layer results in pack ice supporting an extensive upper-ice community, whereas in fast ice the bottom ice community tends to prevail (Stoecker et al., 1993).

11.1.4 Benthic communities

All Antarctic regions, including the Ross Sea, share relatively constant physical parameters, notably temperature, salinity, and substrata, with no obvious physical or biological barriers occurring south of the Antarctic Convergence (Dayton 1990). There are profound changes in benthos composition in most coastal regions in response to changes in substrate and a complex of factors associated with water depth, but apparently identical benthic assemblages occur around the entire continent, within each main habitat. Thus, biogeographic analysis indicates a predominantly circum-Antarctic fauna. A few smaller, more localised faunas have been recognised (Hedgpeth 1971), but these may be local variants of more widespread assemblages in response to some local change in environmental conditions.

In McMurdo Sound, such profound changes appear to be due to differences in organic matter supply resulting from either reduced productivity at source due to snow and ice reducing light transmission, or due to currents delivering water with depleted organic carbon supplies. Marked shifts occur in species distribution / abundances in McMurdo Sound:

(a) between east and west sides due to eutrophic-oligotrophic differences in supply of allochthonous organic matter;
(b) a north-south infaunal density gradient occurs on the west side; and
(c) there is a marked change from a sponge-dominated fauna in the south to a seastar-dominated fauna in the north on the eastern side of McMurdo Sound (Dayton & Oliver 1977).

The McMurdo Sound east-west difference in benthos is mirrored by carbon flux; organic carbon in sediment traps on the eastern side of the Sound were 10–100 times greater than that in traps on the western Sound (Dunbar et al., 1989). These differences appear to arise because of currents that flow predominantly southwards on the eastern side and come from more productive areas, whereas those on the western side flow is from beneath the permanent ice shelf where virtually no primary production occurs (Barry 1988; Barry & Dayton 1988).

Such differences in community composition with different sources of organic carbon supply are apparent beyond McMurdo Sound also, but may be inextricably linked with physical factors. Communities on the Ross Sea shelf utilise rich sources of organic carbon settling out of the water column where hydrodynamic conditions are benign, principally through deposit feeding (Gambi & Bussotti, 1999). However, where the hydrodynamic environment does not allow organic matter to settle, such as at the margins of the shelf, suspension feeding communities develop.

11.1.5 Fish communities

The fish fauna is not well known. The midwater fauna in particular appears poorly known and benthic and benthopelagic fishes from nearshore to deep water have only been spasmodically sampled. This is evidenced by the fact that new species of fish have been described from material collected as recently as 1996 and 1997 (Chernova & Eastman, 2001; Eakin & Eastman, 1998; Eastman & Eakin, 1999). There appear to have been few surveys designed to systematically sample fish from the area in contrast for instance to the Weddell Sea where Germany has maintained a regular collecting programme for 15 years (Eastman & Hubold, 1999). Eastman & Hubold (1999) state " even in relatively shallow water, knowledge of specific and intraspecific diversity in the Ross Sea fauna is incomplete, and the discovery of a new species is a frequent occurrence. Research on fish assemblages lags far behind what is known for the Weddell Sea, although our study indicates some similarities. Additional collecting should be a priority as knowledge of species diversity is a fundamental requirement for research on the ecology and evolution of the Antarctic fish fauna." In addition the fauna from parts of the Ross Sea area defined above are particularly poorly known, e.g., the Balleny Island area where only about 21 fish species are recorded in the scientific literature in spite of the fact that there are about 94 species of fish recorded to date from the greater Ross Sea area.

There are major taxonomic problems with some of the main fish groups. The nototheniids are a problematic group as are the Artedidraconidae and the Muraenolepididae. Solving these problems would require large-scale taxonomic studies involving material from the whole of the sub- and Antarctic region (and beyond) utilising genetic (new material) and morphological methods. Collections of fish specimens from the region are widely distributed in institutions around the world.

11.1.6 Seabirds

The distribution of seabirds within the Ross Sea and the association of the birds with physical and biological features of the marine ecosystem have been examined by Ainley & Jacobs (1981), Ainley et al. (1984), Ainley (1985), and Saino & Guglielmo (2000). The results of all these studies show that the distribution and abundance of seabirds is influenced by oceanographic features, particularly the location of areas where food is abundant, the occurrence of pack ice, and the location of breeding sites. During cruises made in December and January over a 5-year period, Ainley (1985) found that seabirds were concentrated in some areas while large areas were essentially devoid of these top-level predators. Usually, these concentrations were in conjunction with oceanographic fronts particularly the Antarctic Slope Front, and in the pack ice of the southwestern Ross Sea. Few birds occurred in the centre of an algal bloom and seaward of the slope front. Saino & Guglielmo (2000) studied the at-sea distribution of seabirds in the western Ross Sea during mid- to late-spring 1994. They found that distribution patterns were similar to those reported by Ainley (1985), with the main concentration in the southwestern Ross Sea. Pack ice clearly affected the distribution of most species, with penguins more abundant where the pack ice was extensive. However, the opposite was true for Antarctic petrels.

11.1.7 Marine mammals

The distribution of marine mammals in the Ross Sea is not uniform. With the exception of the Weddell seal, which is constrained to breed on fast ice, and the requirement of the other seals to associate with pack ice, marine mammals should be able to move anywhere within the region. However, they show extreme discontinuity in their distribution indicating that, within the Antarctic ecosystem, prey are not equally available everywhere (Ainley, 1985). Therefore, to understand the factors that determine the distribution of marine mammals requires contemporaneous recording of biological and physical oceanographic data on a range of spatial scales.

12. Conclusions

- This review of the Ross Sea biodiversity, based on published research and museum records, was facilitated by the development of two databases as tools for compiling this report. A literature database was created for the Biodiversity of the Ross Sea (BDORS) using the bibliographic package Endnote, and a relational database (BioRoss) was created in Microsoft Access for expedition station information.
- Historical collections of biota come from more than 31 collecting events and include about 1500 sampling stations. These collections span the period from 1839–1994.
- The major habitats in the region are the islands, sub ice shelf, sea ice, fast ice, marginal ice zone, water column, and sea floor.
- Biodiversity of the Ross Sea has been described from several large collections, the bulk of which appear to reside at the The Natural History Museum, London, Smithsonian Institution, Washington D.C., the National Institute of Water and Atmospheric Research (NIWA), and the Natural History Museum of Los Angeles County, Los Angeles.
- Some of this material has not been studied. In some cases, the identity of taxa have been published, other taxa have been identified, but not published (identifications are in institutional databases). Other taxa have only been sorted at a high level and have not as yet been worked on. In general, a good deal of the flora and fauna is known although scant attention has been paid to smaller organisms or the total biota in aggregate.
- At least 141 microalgal taxa have been identified to species from the water column, sea ice, and tide crack, although many are still unidentified to this level. Far fewer species have been recorded in the tide crack and sea ice but many of the species recorded in conjunction with ice are also found in the water column.
- Known microzooplankton biodiversity in the Ross Sea is composed of 14 species of heterorotrophic or mixotrophic dinoflagellates, 17 species of ciliates,

20 species of Radiolaria, 11 species of Foraminifera, and 13 species of Acantharia. Many more taxa are yet to be identified to species and some have not been studied in much detail such that much of the fauna is yet to be discovered.

- Known zooplankton biodiversity in the Ross Sea is composed of approximately the following species: hydrozoans (18), siphonophores (3), scyphozoans (10), chaetognaths (8), polychaete worms (7), calanoid copepods (106), cyclopoid copepods (2), harpacticoid copepods (1), poecilostomatoid copepods (8), ostracods (18), amphipods (11), mysids (9), euphausiids (4), decapod larvae (3), pelagic decapods (5), pteropod molluscs (6), salps (3), appendicularians (7), and mesopelagic fish (21). It appears that the fauna is largely similar to that of the circum-Antarctic region as a whole.
- Large quantities of *Euphausia superba* have been recorded in the northern Ross Sea and near Balleny Islands.
- Known benthic biodiversity in the Ross Sea is composed of approximately 2500 species. Based on published reports, there are about 800 species of Foraminifera, 273 molluscs, 233 species of sponges, 94 species of Hydrozoa, 231 Bryozoa, 220 polychaetes, 157 echinoderms, 120 species of benthic amphipods, 41 species of isopods, as well as smaller numbers of other taxa. The total benthic biodiversity is expected to be more than double that presently known.
- Zonation is a feature of the biota on Ross Sea shores and bottoms, just as it is around most other landmasses. Intertidal biota are largely lacking, and subtidal zones increase in width and richness with depth, to at least 100 m. In deeper waters, depth gradients seem to impose faunal zonation pattern on mosaics of communities governed by other factors.
- Most of the marine benthic research carried out to date in the Ross Sea is either localised and project- or taxon-focussed work, thus leaving large gaps and contributing little to understanding of the region's biodiversity overall.
- The Ross Sea benthos is characterised by a great variety of species, the dominance of sessile animals on bottoms often largely composed of ice-rafted gravel, cobbles & boulders, and often very poorly sorted sediments. These communities may be multi-storeyed, with gigantism amongst sponges (*Rossella* spp.), alcyonarians, pycnogonids, amphipods (*Eusirus*, *Paramphithoe*), isopods (*Glyptonotus*, serolids), polychaetes (*Eulagisca gigantea*, *Laetmonice producta*), nemertean worms (*Parborlasia corrugatus*, up to 2 m long.
- The Ross Sea benthic fauna has high diversity in some taxa, but lacks some major groups such as crabs, lobsters, many families of benthic fishes, sharks, gastropods, and balanomorph barnacles are represented by few species. Also, the infauna appears depauperate and poorly developed; there are no large populations of bivalves and ampeliscid amphipods characteristic of the Arctic and infaunal polychaetes are not common. The lack of physical disturbance by large predators has been suggested as one of the most important factors in the persistence of the dense benthic assemblages in McMurdo Sound.
- The small Crustacea remain little studied. The sampling equipment and methods used in the past have not captured the small macro-benthos and meiobenthos (including harpacticoid copepods and pododocopid ostracods) that makes up the greater part of the biodiversity. To date such sampling methods have not been used in the Ross Sea.

- Despite the high densities of hard bottom benthos in Terra Nova Bay, preliminary research indicates that new hard substrates are colonized quite slowly. One-year old settlement plates in Terra Nova Bay were completely covered with algal films and filaments, with some sessile animals present and the biota of three-year old plates was much the same; the sparse, low epifauna lacked any large or erect taxa or individuals.
- Patterns of benthic biodiversity elucidated here from sparse sampling and usually incomplete analyses of the biota, now need to be re-assessed and refined. This could be done through an integrated research programme that includes systematic, wider-ranging investigation that takes into account substrate type, disturbance (e.g. ice scouring), development of assemblages (communities) with time, and the overlying primary productivity.
- The fish fauna of the greater Ross Sea area is not well known. It so far includes 94 species and 18 families. The four notothenioid families (Nototheniidae, Artedidraconidae, Bathydraconidae, and Channichthyidae) which are mostly confined to Antarctic or sub-Antarctic waters dominate, comprising 53% of the fauna. Other elements that are species rich in cool temperate waters appear depauperate, e.g., Myctophidae.
- The benthic shelf fish fauna is species-rich, but the number of species decreases with depth, particularly past the shelf break. Many species have a circum-Antarctic distribution. There are three species that are possibly endemic to the Ross Sea, *Lycodichthys deaborni, Paraliparis devriesi* and *Artedidraco glareobarbatus.*
- There are no direct estimates of absolute or relative abundance for any fish species in the Ross Sea.
- Thirty species of sea bird have been recorded from the Ross Sea. Knowledge of the seabirds inhabiting the Ross Sea region is patchy with some species among the most extensively studied in the world, while little is known beyond mere presence for other species. Perhaps the most obvious gaps in our knowledge concern the location of breeding sites of the six petrel species, plus information about the demography of these species. In addition, there is much to be learned about factors affecting the distribution of the birds at sea, and the interactions of seabirds with their prey species.
- The distribution of marine mammals in the Ross Sea is not uniform. With the exception of the Weddell seal, which is constrained to breed on fast ice, and the requirement of the other seals to associate with pack ice, marine mammals should be able to move anywhere within the region. However, they show extreme discontinuity in their distribution indicating that, within the Antarctic ecosystem, prey are not equally available everywhere.
- An essential aspect in understanding the resilience and vulnerability of Ross Sea biodiversity is knowledge of the rates of biological processes occurring there, the production/biomass and consumption/biomass characteristics of the biota, and knowledge of the standing stocks of functional groups of the biota. This aspect is beyond the scope of the present review, but should be considered carefully as an essential component of future research effort in the region.

13. Acknowledgements

This report was prepared with the specialist input from Drs Dennis Gordon, Niel Bruce, Hoe Chang, Stuart Hanchet, Sam McClatchie, Peter McMillan, Michel Kelly-Shanks, Don McKnight, Geoff Read, Helen Neil and Paul Sagar. The BioRoss database was created by Dick Singleton, and Dick Singleton and Isla Croft (amongst others) entered much of the data. Megan Gee created the BDORS bibliographic database, locating, entering, checking and correcting entries. Dr Don Robertson's review helped to improve the clarity and readability of the text.

14. Literature cited

Acosta-Pomar M.L.C.; Maugeri, T.L.; Bruni, V. 2000: Picoplankton abundance and biomass at Terra Nova Bay (Ross Sea, Antarctica) during the 1989–90 austral summer. *In*: Faranda, F.M.; Guglielmo, L.; Ianora, A. *eds* Ross Sea Ecology. Berlin, Springer-Verlag. p. 195–203.

Ainley, D.G. 1985: Biomass of birds and mammals in the Ross Sea. *In*: W.R. Siegfried, P.R. Condy, R.M. Laws (eds). *Antarctic nutrient cycles and food webs*. Berlin Heidelberg, Springer-Verlag. p. 498–515.

Ainley, D.G.; Jacobs, S.S. 1981. Seabird affinities for ocean and ice boundaries in the Antarctic. *Deep-sea research 28*: 1173–1185.

Ainley, D.G.; Morrell, SH.; Wood, R.C. 1986. South polar skua breeding colonies in the Ross Sea region, Antarctica. *Notornis 33*: 155–163.

Ainley, D.G.; O'Connor, E.F.; Boekelheide, R.J. 1984. The marine ecology of birds in the Ross Sea, Antarctica. *Ornithological monographs no. 32*. Washington D.C., American Ornithologists' Union.

Ainley, D.G.; Ribic, C.A.; Wood, R.C. 1990. A demographic study of the south polar skua *Cathracta maccormicki* at Cape Crozier. *Journal of animal ecology 59*: 1–20.

Ainley, D.G.; Wilson, P.R.; Barton, K.J.; Ballard, G.; Nur, N.; Karl, B. 1998. Diet and foraging effort of Adelie penguins in relation to pack-ice conditions in the southern Ross Sea. *Polar biology 20*: 311–319.

Albertelli,G.; Cattaneo-Vietti, R.; Chiantore, M.; Pusceddu, A.; Fabiano, M. 1998: Food availability to an *Adamussium* bed during the austral summer 1993/1994 (Terra Nova Bay, Ross Sea). *Journal of Marine Systems 17*: 425–434.

Alvarino, A.; Hosmer, S.C.; Ford, R.F. 1983a: Antarctic Chaetognatha: United States Antarctic Research Program, Eltanin Cruises 8–28, Part 1. *Antarctic Research Series 34(3)*: 129–338.

Alvarino, A.; Verfaille, D.F.; Ford, R.F. 1983b: Antarctic Chaetognatha: United States Antarctic Research Program, Eltanin Cruises 10–23, 25 and 27, Part 2. *Antarctic Research Series 39(2)*: 69–204.

Amato, E.; Relini, G.; Tursi, A. 1990: National research programme in the Antarctic: environmental impact assessment at sea: fouling experiment – first note. *National Science Commission of Antarctica Oceanographic Campaign 1987–88 Data Report II*: 263–277.

Amundsen, R. 1913: The Norwegian South Polar expedition. *Scottish Geographical Magazine 29*: 1–13.

Anderson, B.; Chague-Goff, C. 1996: Benthic Foraminifera and trace metals in sediments off the Scott Base Sewer Outfall, Antarctica. *Antarctic Data Series 18*: 1–34.

Anderson, J.B. 1975: Ecology and distribution of Foraminifera in the Weddell Sea of Antarctica. *Micropaleontology 21(1)*: 69–96.

Anderson, J.B.; Brake, C.; Domack, E.W.; Myers, N.; Singer, J. 1982: Sedimentary dynamics of the Antarctic continental shelf. *Antarctic Earth Sciences 1983*: 387–389.

Anderson, J.B.; Kurtz, D.D.; Weaver, F.M. 1979: Sedimentation on the Antarctic continental slope. *In*: Doyle, L.J.; Pilkey, O.H. *eds* Geology of continental slopes. Tulsa, OK, Society of Economic Paleontologists and Mineralogists. *Special Publication SEPM 27*: 265–283.

Andreoli, C.; Tolomio, C.; Moro, I.; Radice, M.; Moschin, E.; Bellato, S. 1995: Diatoms and dinoflagellates in Terra Nova Bay (Ross Sea – Antarctica) during austral summer 1990. *Polar Biology 15*: 465–475.

Andriashev, A.P. 1977: Some additions to schemes of the vertical zonation of marine bottom fauna. *In*: Llano, G.A. *ed.* Adaptations within Antarctic ecosystems: proceedings of the SCAR symposium on Antarctic biology. Washington D.C., Smithsonian Institution. p. 351–360.

Andriashev, A.P. 1998. A review of recent studies of southern ocean Liparidae (Teleostei: Scorpaeniformes). *Cybium 22 (3)*: 255–266.

Andriashev, A.P.; Stein, D.L. 1998. Review of the snailfish genus *Careproctus* (Liparidae, Scorpaeniformes) in Antarctic and adjacent waters. *Contributions in Science, Natural History Museum of Los Angeles County No. 470.* 1–63.

Angel, M.V. 1997: What is the Deep Sea? p. 1–41 *in* Randall and Farrell (eds) *Deep Sea Fishes.* Fish Physiology Volume 16. Academic Press, San Diego. 388 p.

Anon. 1931: Discovery investigations, station list 1927–29. *Discovery Reports 3*: 3–132, plates I-X.

Arnaud, P.M. 1970: Frequency and ecological significance of necrophagy among benthic species of Antarctic coastal waters. *In*: Holdgate, M.W. *ed.* Antarctic ecology volume 1. London, Academic Press. p. 259–267.

Arntz, W.E.; Brey, T.; Gallardo, V.A. 1994: Antarctic zoobenthos. *Oceanography and Marine Biology: an Annual Review 32*: 241–304.

Arrigo, K.R.; Robinson, D.H.; Worthen, D.L.; Dunbar, R.B.; DiTullio, G.R.; VanWoert, M.; Lizotte, M.P. 1999: Phytoplankton community structure and the drawdown of nutrients and CO_2 in the Southern Ocean. *Science 283*: 36–38.

Asioli, A. 1995: Living (stained) benthic Foraminifera distribution in the western Ross Sea (Antarctica). *Palaeopelagos 5*: 201–214.

Asioli, A.; Langone, L. 1997: Relationship between recent planktic Foraminifera and water mass properties in the Western Ross Sea (Antarctica). *Geografia Fisica e Dinamica Quaternaria 20(2)*: 193–198.

Atkinson, A. 1998: Life cycle strategies of epipelagic copepods in the Southern Ocean. *Journal of Marine systems 15*: 289–311.

Azam, F.; Beers, J.R.; Campbell, L.; Carluscci, A.F.; Holm-Hansen, O.; Reid, F.M.H.; Karl, D.M. 1979: Occurrence and metabolic activity under the Ross Ice Shelf, Antarctica, at Station J9. *Science 203(4379)*: 451–453.

Azzali, A.; Kalinowski, J. 2000: Spatial and temporal distribution of krill *Euphausia superba* biomass in the Ross Sea (1989–1990 and 1994). *In*: Faranda, F.M.; Guglielmo, L.; Ianora, A. *eds* Ross Sea ecology. Berlin, Springer-Verlag. p. 433–456.

Barbraud, C.; Weimerskirch, H. 2001. Emperor penguins and climate change. *Nature 411* 183–186.

Barker, R.W. 1960: Taxonomic notes on the species figured by H.B. Brady in his report on the Foraminifera dredged by H.M.S. Challenger during the years

1873–1876. *Society of Economic Paleontology and Minerals Special Publication 9*: 1–238.

Barnard, K. H. (1930). Crustacea. Part XI. Amphipoda. *British Antarctic ("Terra Nova") Expedition, 1910–1913 Natural History Reports Zoology Vol. VIII(4)*: 307–454.

Barnes, D.K.A.; Clarke, A. Seasonality of polypide recycling and sexual reproduction in some erect Antarctic bryozoans. *Marine Biology 131*: 647–658.

Barthel, D. 1992: Do hexactinellids structure Antarctic sponge associations? *Ophelia 36(2)*: 111–118.

Bassett, J.A.; Wilson, G.J. 1983: Birds and mammals observed from the M.V. Benjamin Bowring during the New Zealand-Ross Sea cruise January/February 1981. *Transglobe Expedition Scientific Report No. 3.*

Battershill, C.N. 1989: Distribution and abundance of benthic marine species at Cape Armitage, Ross Island, Antarctica – initial results. *New Zealand Antarctic Record 9(2)*: 35–52.

Battershill, C.N. 1990: Temporal changes in Antarctic marine benthic community structure. *New Zealand Antarctic Record 10(1)*: 23–27.

Benassi, G.; Ferrari, I.; Gentile, G.; Menozzi, P; McKenzie, K.G. 1992: Planktonic Ostracoda in the Southern Ocean and in the Ross Sea: 1989–1990. *In*: National Scientific Commission for Antarctica *ed.* Oceanographic Campaign 1989–1990, Data Report II. p. 247–300.

Benham, W. B. 1929: Polychaeta. *British Antarctic Terra Nova Expedition, 1910–1913, Natural History Reports. Zoology 8(2)*: 183–201

Berkman, P.A. 1994: Epizoic zonation on growing scallop shells in McMurdo Sound, Antarctica. *Journal of Experimental Marine Biology and Ecology 179*: 49–67.

Berkman, P.A.; Marks, D.S.; Shreve, G.P. 1986: Winter sediment resuspension in McMurdo Sound, Antarctica, and its ecological implications. *Polar Biology 6*: 1–3.

Bernhard, J.M. 1987: Foraminiferal biotopes in Explorers Cove, McMurdo Sound, Antarctica. *Journal of Foraminiferal Research 17(4)*: 286–297.

Berstein, R.; Kling, S.A.; Boltovskoy, D. 1999: Acantharia. *In*: Boltovskoy, D. ed. South Atlantic Zooplankton. Leiden, Backhuys Publishers. p. 75–147.

Borchgrevink, C.E. 1895: The "Antarctic"'s voyage to the Antarctic. *Geographical Journal 5*: 583–589.

Bradford, J.M. 1971: The fauna of the Ross Sea ; Part 8. Pelagic Copepoda. *New Zealand Oceanographic Memoir* 59: 1–46.

Bradford, J. M. 1978: Sea ice organisms and their importance to the Antarctic ecosystem (Review). *New Zealand Antarctic Record 1(2)*: 43–50.

Bradford, J.M. 1981: Records of *Paraeuchaeta* (Copepoda : Calanoida) from McMurdo Sound, Antarctica, with a description of three hitherto unknown males. *N.Z. Journal of Marine and Freshwater Research 15*: 391–402.

Bradford, J.M.; Wells, J.B.J. 1983: New calanoid and harpacticoid copepods from beneath the Ross Ice Shelf, Antarctica. *Polar Biology* 2 : 1–15.

Bradford-Grieve, J.; Fenwick, G. 2001: A review of the current knowledge describing the biodiversity of the Balleny Islands. Final research report for Ministry of Fisheries, Research Project ZBD2000/01 Objective 1 (in part), 38 p., 13 Tables, 7 figs.

Brady, G.S. 1907: Crustacea V. Ostracoda. *National Antarctic Expedition (1901–1904), Natural history. London, British Museum. III. Zoology and Botany.* 9 p., 3pls.

Brady, H.B. 1884: Report on the Foraminifera dredged by H.M.S. Challenger, during the years 1873–1876. *Reports of the Scientific Results of the Voyage of H.M.S. Challenger 9*: 1–814.

Brandt, A. 1991: Colonization of the Antarctic shelf by the Isopoda (Crustacea, Malacostraca). *Berichte zur Polarforschung 98*: i–iv, 1–240.

Brey, T.; Gutt, J.; Mackensen, A.; Starmans, A. 1998: Growth and productivity of the high Antarctic bryozoan *Melicerita obliqua*. *Marine Biology 132*: 327–333.

Brinton, E.; Ohman, M.D.; Townsend, A.W.; Knight, M.D.; Bridgeman, A.L. 1999/2000: Euphausiids of the World Ocean. Paris, UNESCO, distributed by ETI, University of Amsterdam. MacIntosh version (1999), ISBN 3–540–14770–5, Windows version (2000), ISBN 3–540–14673–3. Approx. 600 Mbytes.

British Musuem (Natural History) 1902: Report on the collections of natural history made in the Antarctic regions during the voyage of the "Southern Cross". London, British Museum (Natural History). 344 p. 53 pls.

Britton, J.C.; Morton, B. 1994: Marine carrion and scavengers. *Oceanography and Marine Biology: an Annual Review 32*: 369–434.

Broady, P.A.; Adams, C.J.; Cleary, P.J.; Weaver, S.D. 1989. Ornithological observations at Edward VII Peninsula, Antarctica, in 1987–88. *Notornis 36*: 53–61.

Brodie, J.W. 1965: Oceanography. *In*: Hatherton, T. *ed.* Antarctica. Reed, Wellington. p. 191–28.

Brodsky, K.A.; Zvereva, J.A. 1976: *Paralabidocera separabilis* n. sp. and *P. antarctica* (I.C. Thompson) (Copepoda, Calanoida) from Antarctica. *Crustaceana 31*: 233–240.

Brown, S.G.; Lockyer, C.H. 1984: Whales. *In*: R.M. Laws (ed) *Antarctic ecology*. London, Academic Press.

Browne, E.T. 1910: Coelenterata V. Medusae. *National Antarctic Expedition. Discovery 1901–1904, 5*: x p. , x pls.

Brownell, R.L. jr; Ainley, D.G. 1976: Southern elephant seals in the Ross Sea. *Antarctic journal of the United States 11*: 189–190.

Bruchhausen, P.M.; Raymond, J.A.; Jacobs, S.S.; De Vries, A.L.; Thorndike, E.M.; De Witt, H.H. 1979: Fish, crustaceans, and the sea floor under the Ross Ice Shelf. *Science 203*: 449–451.

Bullivant, J.S. 1959: Photographs of the bottom of the Ross Sea. *New Zealand Journal of Science* 2: 485–497.

Bullivant, J.S. 1961: Photographs of Antarctic bottom fauna. *Polar Record 10*: 505–508.

Bullivant, J.S. 1967a: New Zealand Oceanographic Institute Ross Sea Investigations. 1958–60: General account and station list. *New Zealand Oceanographic Institute Memoir 32*: 9–29.

Bullivant, J.S. 1967b: Ecology of the Ross Sea benthos. *New Zealand Oceanographic Institute Memoir 32*: 49–75.

Bunt, J.S.; Wood, E.J.F. 1963: Microalgae and Antarctic sea ice. *Nature 199*: 1254–1255.

Burfield, S.T. 1930: Chaetognatha. *British Antarctic Terra Nova Expedition, 1910–1913, Natural History Reports, Zoology 7(4)*: 203–228.

Burns, J.M.; Trumble, S.J.; Castellini, M.A.; Testa, J.W. 1998: Diet of Weddell seals in McMurdo Sound, Antarctica, as determined from scat collections and stable isotope analysis. *Polar biology 19*: 272–282.

Butterworth, D.D.; Best, P.B. 1982: Report of the Southern Hemisphere minke whale assessment cruise, 1980/81. *Report of the international whaling commission 32*: 835–873.

Cantone, G.; Castelli, A; Gambi, M.C. 2000: Benthic polychaetes of Terra Nova Bay (Ross Sea, Antarctica): species composition, biogeography and ecological role. *In*: Faranda, F.M.; Gugliemo, L.; Ianora, A. *ed.* Ross Sea ecology: Italianartide expeditions (1987–1995). Heidelberg, Springer-Verlag. p. 551–561

Car, M. 1967: Oceanographic cruise summary, Ross Sea, Antarctica. *Informational Report of the U.S. Naval Oceanographic Office. I.R. 67–79.* 18 p.

Carey, A.G. 1985: Marine ice fauna: Arctic. *In*: Horner, R.A. *ed.* Sea Ice Biota. Florida, CRC Press. p. 173–190.

Carli, A.; Pane, L. 2000: Crustacean decapod larvae in Terra Nova Bay and in the Ross Sea (Cruises 1987–88 and 1989–99). *In*: Faranda, F.M.; Guglielmo, L.; Ianora, A. *eds* Ross Sea ecology. Berlin, Springer-Verlag. p. 323–334.

Carlson, C.; Bates, N.R.; Ducklow, H.W.; Hansell, D.A. 1999: Estimation of bacterial respiration and growth efficiency in the Ross Sea, Antarctica. *Aquatic Microbial Ecology 19(3)*: 215–227.

Carrada, G.C.; Mangoni, O.; Russo, G.F.; Saggiomo, V. 2000: Phytoplankton size-fractionated biomass in the Ross Sea: spatial and temporal variations during the austral spring. *In*: Faranda, F.M.; Guglielmo, L.; Ianora, A. *eds* Ross Sea ecology. Berlin, Springer-Verlag. p. 433–456.

Cassie, V. 1963: Distribution of surface phytoplankton between New Zealand and Antarctica, December 1957. *T.A.E. Scientific Reports 7*: 1–11, 1 plate.

Catalano, G; Benedetti, F.; Predonzani, S.; Goffart, A.; Ruffini, S.; Rivaro, P.; Falconi, C. 2000: Spatial and temporal patterns of nutrient distribution in the Ross Sea. *In*: Faranda, F.M.; Guglielmo, L.; Ianora, A. *eds* Ross Sea Ecology. Berlin, Springer-Verlag. p. 107–120.

Cattaneo-Vietti, R.; Chinatore, M.; Gambi, M.C.; Albertelli, G.; Cormaci, M.; Di Geronimo, I. 2000: Spatial and vertical distribution of benthic littoral communities in Terra Nova Bay. *In*: Faranda, F.M.; Gugliemo, L.; Ianora, A. *ed.* Ross Sea ecology: Italianartide expeditions (1987–1995). Heidelberg, Springer-Verlag. p. 503–514.

Cattaneo-Vietti, R.; Bavestrello, G.; Cerrano, C.; Gaino, E.; Mazzella, L.; Pansini, M.; Sarà, M. 2000: The role of sponges in the Terra Nova Bay ecosystem. *In*: Faranda, F.M.; Gugliemo, L.; Ianora, A. *ed.* Ross Sea ecology: Italianartide expeditions (1987–1995). Heidelberg, Springer-Verlag. p. 539–549.

Chapelle, G.; Peck, L.S. 1999: Polar gigantism dictated by oxygen availability. *Nature 399*: 114–115.

Cherel, Y.; Kooyman, G.L. 1998. Food of emperor penguins (*Aptenodytes forsteri*) in the western Ross Sea, Antarctica. *Marine biology 130*: 335–344.

Chernova, N.V.; Eastman, J.T. 2001: Two new species of snailfish genus *Paraliparis* (Pisces: Liparidae) from the Ross Sea, Antarctica. *Journal of Fish Biology 59*: 92–104.

Chiantore, M.; Cattaneo-Vietti, R.; Albertelli, G; Misic, C.; Fabiano, M. 1998: Role of filtering and biodeposition by *Adamussium colbecki* in circulation of organic matter in Terra Nova Bay (Ross Sea, Antarctica). *Journal of Marine Systems 17*: 411–424.

Clough, J.W.; Hansen, B.L. 1979: The Ross Ice Shelf project. *Science 203*: 433–434.

Collen, J.D. 1979: Marine invertebrates from the Ross Ice Shelf, Antarctica. *Search 10(7–8)*: 274–275.

Collier, R.; Dymond, J.; Honjo, S.; Manganini, S.; Francois, R.; Dunbar, R. 2000: The vertical flux of biogenic and lithogenic material in the Ross Sea: moored sediment trap observations 1996–1998. *Deep-Sea Research II 47*: 3491–3520.

Cormaci, M.; Furnari, G.; Scammacca, B.; Alnogi, G. 1996: Summer biomass of a population of *Iridaea cordata* (Gigartinaceae, Rhodophyta) from Antarctica. *Hydrobiologia 326/327*: 267–272.

Cormaci, M.; Furnari, G.; Scammacca, B. 2000: The macrophytobenthos of Terra Nova Bay. *In*: Faranda, F.M.; Gugliemo, L.; Ianora, A. *ed.* Ross Sea ecology: Italianartide expeditions (1987–1995). Heidelberg, Springer-Verlag. p. 493–502.

Costanza, G.; Zagami, G.; Crescenti, N.; Granata, A. in press: Postembryonic naupliar development of *Stephos longipes* Giesbrecht, 1902 (Copepoda Calanoida) from the annual sea ice of terra Nova Bay, Antarctica. *Journal of Crustacean Biology.*

Countryman, K.A.; Gsell, W.L. 1966: Operation Deep Freeze 63 and 64 summer oceanographic features of the Ross Sea. *Technical Report of the U.S. Naval Oceanographic Office. I.R. 190.* 193 p.

Crawley, M.C. 1990: Weddell seal, crabeater seal, leopard seal, Ross seal, southern elephant seal. *In*: C.M. King (ed) *The handbook of New Zealand mammals.* Auckland, Oxford University Press.

Crescenti, N., Costanzo, G. et al. 1994: Developmental stages of *Antarctomysis ohlini* Hansen 1908 (Mysidacea) in Terra Nova Bay, Ross Sea, Antarctica. *Journal of Crustacean Biology 14(2)*: 383–395.

Crisafi, E.; Azzaro, F.; La Ferla, R.; Monticelli, L.S. 1999: Microbial biomass and respiratory activity related to ice melting upper layers in the Ross Sea (Antarctica). *In*: Faranda, F.M.; Guilielmo, L.; Ianora, A. *eds* Ross Sea Ecology. Berlin, Springer. p. 171–180.

Crisafi, E.; Azzaro, F.; La Ferla, R.; Monticelli, L.S. 2000: Microbial biomass and respiratory activity related to ice melting upper layers in the Ross Sea (Antarctica). *In*: Faranda, F.M.; Guilielmo, L.; Ianora, A. *eds* Ross Sea ecology. Berlin, Springer. p. 171–180.

Christensen, V.; Walters, C.J.; Pauly, D. 2000: ECOPATH with ECOSIM: a user's guide. University of British Columbia, Fisheries Centre, Vancouver, Canada and ICLARM, Penang, Malaysia. 125 p.

Cunningham, W.L.; Leventer, A. 1998: Diatom assemblages in surface sediments of the Ross Sea: relationships to present oceanographic assemblages. *Antarctic Science 10*: 134–145.

Daly, K.L.; Macaulay, M.C. 1991: Influence of physical and biological mesoscale dynamics on the seasonal distribution and behaviour of *Euphausia superba* in the Antarctic marine ice zone. *Marine Ecology Progress Series 79*: 37–66.

Darby, M.M. 1970. Summer seabirds between New Zealand and McMurdo Sound. *Notornis 17*: 28–55.

Dater, H.M. 1975: History of Antarctic Exploration and Scientific Investigation. *Antarctic Map Folio Series, American Geographic Society, New York, Folio 19.*

Davenport, J.; Fogg, G.E. 1989: The invertebrate collections of the *Erebus* and *Terror* Antarctic Expedition; a missed opportunity. *Polar Record 25*: 323–327.

David, P.M. 1965: The Chaetognatha of the Southern Ocean. *In*: Van Mieghem, J.; Van Oye, P.; Schell, J. *eds* Biogeography and ecology in Antarctica. The Hague, Dr. W. Junk Publishers. p. 296–323.

Davis, L.S.; Boersma, P.D.; Court, G.S. 1996. Satellite telemetry of the winter migration of Adelie penguins (*Pygoscelis adeliae*). *Polar biology 16*: 221–225.

Davis, L.S.; Miller, G.D. 1990. Foraging patterns of Adelie penguins during the incubation period. *In* K. Kerry & G. Hempel (eds) *Antarctic ecosystems: ecological change and conservation*. Berlin, Springer-Verlag.

Davis, L.S.; Ward, G.D.; Sadleir, R.M.F.S. 1988. Foraging by Adelie penguins during the incubation period. *Notornis 35*: 15–23.

Dayton, P.K. 1972: Towards an understanding of community resilience and the potential effects of enrichments to the benthos at McMurdo Sound, Antarctica. *In*: Parker, B. *ed.* Conservation problems in Antarctica. Allen Press. p. 81–95.

Dayton, P.K. 1989: Interdecadal variation in an Antarctic sponge and its predators from oceanographic climate shifts. *Science 245*: 1484–1486.

Dayton, P.K. 1990. Polar benthos. *In*: Smith, W.O. *ed.* Polar oceanography, part B: chemistry, biology, and geology. London, Academic Press. p. 631–685.

Dayton, P.K.; Newman, W.A.; Oliver, J.S. 1982: The vertical zonation of the deep-sea Antarctic acorn barnacle, *Bathylasma corolliforme* (Hoek): experimental transplants from the shelf into shallow water. *Journal of Biogeography 9*: 95–109.

Dayton, P.K.; Oliver, J.S. 1977: Antarctic soft-bottom benthos in oligotrophic and eutrophic environments. *Science 197*: 55–58.

Dayton, P.K.; Robilliard, G.A.; DeVries, A.L. 1969: Anchor ice formation in McMurdo Sound, Antarctica, and its biological effects. *Science 163*: 273–274.

Dayton, P.K.; Robilliard, G.A.; Paine, R.T. 1970: Benthic faunal zonation as a result of anchor ice at McMurdo Sound, Antarctica. *In*: Holdgate, M.W. *ed.* Antarctic Ecology Volume 1. London, Academic Press. p. 244–258.

Dayton, P.K.; Robilliard, G.A.; Paine, R.T.; Dayton, L.B. 1974: Biological accommodation in the benthic community at McMurdo Sound, Antarctica. *Ecological Monographs 44(1)*: 105–128.

Dayton, P.K.; Watson, D.; Palmisano, A.; Barry, J.P.; Oliver, J.S.; Rivera, D. 1986: Distribution paterns of benthic microalgal standing stock at McMurdo Sound, Antarctica. *Polar Biology 6*: 207–213.

Dearborn, J.H. 1965: Ecological and faunistic investigations of the marine benthos at McMurdo Sound, Antarctica. Unpubl. PhD thesis, Stanford University, Stanford.

Dearborn, J.H. 1967: Stanford University invertebrate studies in the Ross Sea 1958–61: General account and station list. *New Zealand Oceanographic Institute Memoir 32*: 31–46.

De Broyer, C.; Jazdzewski, K. 1993: Contribution to marine inventory: a checklist of the Amphipoda (Crustacea) of the Southern Ocean. Studiedocumenten van Het K.B.I.N. 73: 1–154.

DeLaca, T.E.; Karl, D.M.; Lipps, J.H.; 1981: Direct use of dissolved organic carbon by agglutinated benthic Foraminifera. *Nature 289(5795)*: 287–289.

Dell, R.K. 1965: Marine biology. *In*: Hatherton, T. *ed.* Antarctica. Wellington, A.H. & A.W. Reed. p. 129–152.

Dell, R.K. 1972: Antarctic benthos. *Advances in Marine Biology 10*: 1–216.

Dell, R.K. 1960. Seabird logs between New Zealand and the Ross Sea. *Records of the Dominion Museum, Wellington 3*: 293–305.

Dell, R. K. 1990: Antarctic Mollusca: with special reference to the fauna of the Ross Sea. *Bulletin of the Royal Society of New Zealand* 27: 1–311.

Dewhitt, H. H. 1970: The character of the midwater fish fauna of the Ross Sea, Antarctica. *In*: Holdgate, M. W. *ed* Antarctic ecology. London, Academic Press. p. 305–314.

Dieckmann, G.S.; Spindler, M.; Lance, A.; Ackley, S.F.; Ecken, H. 1991: Antarctic sea ice: a habitat for the foraminifer *Neogloboquadrina pachyderma*. *Journal of Foram Research 21 (2)*: 182–189.

Downes, M.T.; Howard-Williams, C.; Hawes, I.; Schwarz, A.-M. J. 2000: Nitrogen dynamics in a tidal lagoon at Bratina Island, McMurdo Ice Shelf, Antarctica. *In*: Davsion, W.; Howard-Williams, C.; Broady, P. *ed.* Antarctic ecosystems: models for wider ecological understanding. Christchurch, New Zealand Natural Sciences.

Ducklow, H. 1999: The bacterial component of the oceanic euphotic zone. *FEMS Microbial Ecology 30(1)*: 1–10.

Ducklow, H.; Carlson, C.; Smith, W. 1999: Bacterial growth in experimental plankton assemblages and seawater cultures from the *Phaeocystis antarctica* bloom in the Ross Sea, Antarctica. *Aquatic Microbial Ecology 19(3)*: 215–227.

Dunbar, R.B.; Leventer, A.R.; Mucciarone, D.A. 1998: Water column sediment fluxes in the Ross Sea, Antarctica: Atmospheric and sea ice forcing. *Journal of Geophysical Research 103(C13)*: 30741–30759.

Dunbar, R.B.; Leventer, A.R.; Stockton, W.L. 1989: Biogenic sedimentation in McMurdo Sound, Antarctica. *Marine Geology 85*: 155–179.

Eakin, R.R.; Eastman, J.T. 1998: New species of *Pogonophyrne* (Pisces, Artedidraconidae) from the Ross Sea, Antarctica. *Copeia 1998 (4)*: 1005–1009.

Eastman, J.T.; Eakin, R.R. 1999: Fishes of the genus *Artedidraco* (Pisces, Artedidraconidae) from the Ross Sea, Antarctica, with the description of a new species and colour morph. *Antarctic Science 11 (1)*: 13–22.

Eastman, J.T.; Eakin, R.R. 2000: An updated list for notothenioid fish (Perciformes; Notothenioidei), with comments on Antarctic species. *Archive of Fishery and Marine Research 48 (1)*: 11–20.

Eastman, J.T.; Hubold, G. 1999: The fish fauna of the Ross Sea, Antarctica. *Antarctic Science 11 (3)*: 293–304.

El-Sayed, S.Z. 1973: Biological Oceanography. *Antarctic Journal of the United States 8(3)*: 93–100.

Emison, W.B. 1968. Feeding preferences of the Adelie penguin at Cape Crozier, Ross Island. *Antarctic research series 12*: 191–212.

Efremenko, V.N. 1987: [Species composition and distribution of eggs and larvae of mesopelagic fishes in the Ross Sea sector.] *In*: Makarov, R.R. *ed.* Biological and Oceanographic Investigations of the Pacific Sector of Antarctica. *Sb. Nauchn. Tr. VNIRO*. p. 186–193.

Eschmeyer, W.N. (ed). 1998: Catalog of fishes. California Academy of Sciences. www.calacademy.org/research/ichthyology/catalog/fishcatsearch.html

Esnal, G.B. 1999: Appendicularia. *In*: Boltovskoy, D. *ed.* South Atlantic Zooplankton. Leiden, Backhuys Publisher. p. 1375–1400.

Fabiano, M.; Danovaro, R.; Crisafi, E.; La Ferla, R.; Povera, P. Acosta-Pomar, L. 1995: Particulate matter composition and bacterial distribution in Terra Nova Bay (Antarctica) during summer 1989–1990. *Polar Biology 15*: 393–400.

Faranda, F.M.; Guglielmo, L.; Ianora, A. 2000: Ross Sea Ecology. Berlin, Springer-Verlag. 604 p.

Farran, G.P. 1929: Crustacea. Part X. Copepoda. *British Antarctic Terra Nova Expedition, 1910–1913, Natural History Reports. Zoology 8(2)*: 203–306.

Ferrar, H.T. 1928. Birds of Ross Dependency. *New Zealand journal of science and technology 9*: 374–382.

Fontaine, M. 1988: Taxonomy and distribution of the *Antarctica* species group of the genus *Euchaeta* (Copepoda, Calanoida) *Antarctic Research Series 47*: 27–57.

Fowler, G. H. 1907: Chaetognatha. *National Antarctic Expedition (1901–1904) : natural history. Zoology and Botany III*: 6 p. , 1 Chart.

Fowler, J.A. 1973. A transect diagram for oceanic birds between McMurdo Sound, Antarctica, and New Zealand, February-March 1973. *Notornis 20*: 314–317.

Friedmann, H. 1945. Birds of the United States Antarctic Service expedition. *Proceedings of the American philosophical society 89*: 305–313.

Fryxell, G.A.; Doucette, G.J.; Hubbard, G.F. 1981: The genus *Thalassiosira*: the biopolar diatom *T. antarctica* Comber *Botanica Marina 24*: 321–335.

Gambi, M.C.; Buia, M.C.; Mazzella, M.L.; Lorenti, M.; Scipione M.B. 2000: Spatio-temporal variability in the structure of benthic populations in a physically controlled system off Terra Nova Bay: the shallow hard bottoms. *In*: Faranda, F.M.; Gugliemo, L.; Ianora, A. *ed.* Ross Sea ecology: Italianartide expeditions (1987–1995). Heidelberg, Springer-Verlag. p. 527–538.

Gambi, M.C.; Bussotti, S. 1999: Composition, abundance and stratification of soft-bottom macrobenthos from selected areas of the Ross Sea shelf (Antarctica). *Polar Biology 21*: 347–354.

Gambi, M.C.; Castelli, A. 1994: First quantitative data on coastal soft bottoms populations off Terra Nova Bay (Ross Sea, Antarctica): polychaetes. *National Science Commission of Antarctica Oceanographic Campaign 1989–90 Data Report III*: 179–186.

Gambi, M.C.; Castelli, A.; Guizzardi, M. 1997: Polychaete populations of the shallow soft bottoms off Terra Nova Bay (Ross Sea, Antarctica): distribution, diversity and biomass. *Polar Biology 17*: 199–210.

Gambi, M.C.; Lorenti, M.; Russo, G.F.; Scipione, M.B. 1994: Benthic associations of the shallow hard bottoms off Terra Nova Bay, Ross Sea: zonation, biomass and population structure. *Antarctic Science 6(4)*: 449–462.

Gambi, M.C.; Mazzella, L. 1991: Second Italian Oceanographic expedition in the Ross Sea, Antarctica: preliminary report on the quantitative and functional studies of benthic communities of Terra Nova Bay. *National Science Commission of Antarctica Oceanographic Campaign 1989–90 Data Report I*: 349–367.

Garrison, D. L., S. Mathot, et al. 1995: Phytoplankton and microzooplankton community structure in the Ross Sea polynya: November and December 1994. *Antarctic Journal of the United States 30(5)*: 212–214.

Garrison, D.L.; Sullivan, C.W.; Ackley, S.F. 1986: Sea ice microbial communities in Antarctica. *Bioscience 36*: 243–250.

Garstang, W. 1933: Report on the Tunicata, Part I Diololida. *British Antarctic Terra Nova Expedition, 1910–1913, Natural History Reports. Zoology 4*: 195–251.

Gilbert, J.R.; Erickson, A.W. 1977: Distribution and abundance of seals in the pack ice of the Pacific sector of the Southern Ocean. *In* G. Llano (ed) *Adaptation within Antarctic ecosystems.* Washington, Smithsonian Institution.

Glasby, C.J.; Read, G.B. In press: Polychaeta. *In* Gordon, D.P. *ed.* The New Zealand Inventory of Biodiversity: A Species 2000 Symposium Review. Christchurch, Canterbury University Press.

Gloerson, P.; Mernicky, A. 1998: Oscillatory behavior in Antarctic sea ice concentrations. *Antarctic Research Series 74*: 161–172.

Goffart A.; Catalano, G.; Hecq, J.H. 2000: Factors controlling the distribution of diatoms and *Phaeocystis* in the Ross Sea. *Journal of Marine systems 27*: 161–175.

Gon, O.; Heemstra, P.C. (eds). 1990: *Fishes of the Southern Ocean.* J.L.B. Smith Institute of Ichthyology, Grahamstown. 462 p.

Gooday, A.J. 1994: The biology of deep-sea Foraminifera: a review of some advances and their significance in paleoecology. *Palaios 9*: 14–31.

Gooday, A.J.; Bowser, S.S.; Bernhard, J.M. 1994: The Foraminifera of Explorers Cove, Antarctica: a deep-sea assemblage in shallow water? *Antarctic Journal of the United States 29(5)*: 149–151.

Gooday, A.J.; Bett, B.J.; Shires, R.; Lambshead, P.J.D. 1998: Deep-sea benthic foraminiferal species diversity in the NE Atlantic and NW Zarabian Sea: a synthesis. *Deep Sea Research II 45*: 165–201.

Gow, A.J.; Ackley, J.W.; Govoni, J.W.; Weeks, W.F 1998: Physical and structural properties of land-fast sea ice in McMurdo Sound, Antarctica. *Antarctic Research Series 74*: 355–374.

Granata, A.; Guglielmo, L. 2000: Spatial distribution and feeding habits of larval and juvenile *Pleuragramma antarcticum* in the western Ross Sea (Antarctica). *In* Faranda, F. M.; Guglielmo, L.; Ianora, A. *eds* Ross Sea Ecology. New York, Springer-Verlag. p. 369–394.

Green, K.E. 1960: Ecology of some Arctic Foraminifera. *Micropaleontology 6(1)*: 57–78.

Greenfield, L.G.; Smellie, J.M. 1992. Known, new and probable snow petrel breeding locations in the Ross Dependency and Marie Byrd Land. *Notornis 39*: 119–24.

Gudmundsson, G.; von Schmalensee, M.; Svavarsson, J. 2000: Are foraminifers (Protozoa) important food for small isopods (Crustacea) in the deep sea? *Deep-Sea Research 47*: 2093–2109.

Gunson, D. 1991: Life in Antarctica: A profile of the McMurdo Sound ecosystem. Poster published with *New Zealand Geographic 9*.

Gunther, S.; Dieckmann, G. S. 1999: Seasonal development of algal biomass in the snow-covered fast ice and the underlying platelet layer in the Weddell Sea, Antarctica. *Antarctic Science 11(3)*: 305–315.

Hanchet, S.M.; Horn, P.L.; Stevenson, M.L. Unpublished: The New Zealand toothfish fishery in sub-area 88.1 from 1997–98 to 2000–01. CCAMLR WG-FSA-01/63.

Harper, P.C.; Knox, G.A.; Spurr, E.B.; Taylor, R.H.; Wilson, G.J.; Young, E.C. 1984. The status and conservation of birds in the Ross Sea sector of Antarctica. *In* J.P. Croxall, P.G.H Evans, R.W. Schreiber (eds) *Status and conservation of the world's seabirds.* International Council for Bird Preservation Technical Publication no. 2.

Hasle, G.R.; Syvertsen, E.E.; Steindinger, K.A.; Tangen, K. 1996: Identifying marine diatoms and dinoflagellates. Toronto, Academic Press. 598 p.

Hastings, A.B. 1943: Polyzoa (Bryozoa) I. Scrupocellariidae, Epistomiidae, Farciminariidae, Bicellariellidae, Aeteidae, Scrupariidae. *Discovery Reports 22*: 301–510, pls 5–13.

Hatherton, T.; Dawson, E.W.; Kinsky, F. 1965: Balleny Islands Reconnaissance Expedition, 1964. *New Zealand Journal of Geology and Geophysics 8*: 164–179.

Hawes, I.; Howard-Williams, C.; Downes, M.T.; Schwarz, A-M. S. 1997: Environment and microbial communities in a tidal lagoon at Bratina Island, McMurdo Ice Shelf, Antarctica. *In*: Battaglia, B.; Valencia J.; Walton D.W.H. *eds* Antarctic Communities: Species, Structure and Survival. Cambridge, Cambridge University Press. p. 170–177.

Hays, J.D. 1965: Radiolaria and late Tertiary and Quaternary history of Antarctic Seas. *Antarctic Research Series 5*: 125–184.

Hayward, P.J. 1991: Systematic studies on some Antarctic and sub-Antarctic Ascophora (Bryozoa: Cheilostomata). *Zoological Journal of the Linnean Society 101*: 299–335.

Hayward, P.J. 1992: Some Antarctic and sub-Antarctic species of Celleporidae (Bryozoa, Cheilostomata). *Journal of Zoology 226*: 283–310.

Hayward, P.J. 1993: New species of cheilostomate Bryozoa from Antarctica and subantarctic southwest Atlantic. *Journal of Natural History 27*: 1409–1430.

Hayward, P.J. 1995a: A new species in the Antarctic genus *Toretocheilum* (Bryozoa: Cheilostomatida). *Journal of Natural History 29*: 215–218.

Hayward, P.J. 1995b: *Antarctic Cheilostomatous Bryozoa.* Oxford University Press, Oxford. xi + 35 p.

Hayward, P.J.; Ryland, J.S. 1990: Some Antarctic and subantarctic species of Microporellidae (Bryozoa: Cheilostomata). *Journal of Natural History 24*: 1263–1287.

Hayward, P.J.; Ryland, J.S. 1991: New and little-known Bryozoa from Antarctica and the southwest Atlantic. *Bulletin du Muséum national d'Histoire naturelle 4*: 241–261.

Hayward, P.J.; Ryland, J.S. 1993: Taxonomy of six Antarctic anascan Bryozoa. *Antarctic Science 5*: 129–136.

Hayward, P.J.; Taylor, P.D. 1984: Fossil and Recent Cheilostomata (Bryozoa) from the Ross Sea, Antarctica. *Journal of Natural History 18*: 71–94.

Hayward, P.J.; Thorpe, J.P. 1987: The systematic position of *Smittia inclusa* Waters, an endemic Antarctic bryozoan. *Journal of Natural History 21*: 1469–1476.

Hayward, P.J.; Thorpe, J.P. 1988a: A new family of cheilostome Bryozoa endemic to Antarctica. *Zoological Journal of the Linnean Society 93*: 1–18.

Hayward, P.J.; Thorpe, J.P. 1988b: New genera of Antarctic cheilostome Bryozoa. *Journal of Natural History 22*: 773–799.

Hayward, P.J.; Thorpe, J.P. 1988c: Species of *Arachnopusia* (Bryozoa: Cheilostomata) collected by Discovery Investigations. *Journal of Natural History 22*: 773–799.

Hayward, P.J.; Thorpe, J.P. 1988d: Species of *Chaperiopsis* (Bryozoa, Cheilostomata) collected by Discovery Investigations. *Journal of Natural History 22*: 45–69.

Hayward, P.J.; Thorpe, J.P. 1989a: Membraniporoidea, Microporoidea and Cellarioidea (Bryozoa, Cheilostomata) collected by Discovery Investigations. *Journal of Natural History 23*: 913–959.

Hayward, P.J.; Thorpe, J.P. 1989b: Systematic notes on some Antarctic Ascophora (Bryozoa, Cheilostomata). *Zoologica Scripta 18*: 365–374.

Hayward, P.J.; Thorpe, J.P. 1990: Some Antarctic and sub-Antarctic species of Smittinidae (Bryozoa: Cheilostomata). *Journal of Zoology 22*: 137–175.

Heather, B.D.; Robertson, H.A. *The field guide to the birds of New Zealand.* Auckland, Viking.

Hedgpeth, J.W. 1971: Perspective of the benthic ecology in Antarctica. *In*: Quam, L.O. *ed.* Research in the Antarctic. Washington, D.C., American Society for the Advancement of Science. p. 93–136.

Hedgpeth, J.W. 1973: Systematic zoology. *Antarctic Journal of the United States 8(3)*: 106–108.

Hendy, N.I. 1964: An introductory account of the smaller algae of British coastal waters. Part V. Her Majesty's Stationary Office, Fishery Investigation Series IV, 317 p.

Herdman, W.A. 1910: Tunicata. *National Antarctic Expedition (1901–1904), Natural History (Zoology and Botany) 5*: x pp., x pls.

Heron, G.A.; Bradford-Grieve, J.M. 1995: Pelagic Copepoda: Poecilostomatoida: Oncaeidae. *N.Z. Oceanographic Institute Memoir 104*: 1–57.

Heron-Allen E.; Earland, A. 1922: Protozoa. Pt II Foraminifera. *British Antarctic Terra Nova Expedition, 1910, Zoology, 6 (2)*: 25–268.

Heywood, R.B.; Whitaker, T.M. 1984: The Antractic marine flora. *In*: Laws, R.M. *ed.* Antarctic ecology. Volume 2. Orlando, Academic Press. p. 373–410.

Hicks, G.R.F. 1973. Latitudinal distribution of seabirds between New Zealand and the Ross Sea, December 1970. *Notornis 20*: 231–250.

Hopkins, T.L. 1987: Midwater food web in McMurdo Sound, Ross Sea, Antarctica. *Marine Biology 96*: 93–106.

Horrigan, S.G. 1981: Primary production under the Ross Ice Shelf. *Limnology and Oceanography 26*: 378–382.

Ikeda, T. 1985: Life history of Antarctic krill *Euphausia superba*: A new look from an experimental approach. *Bulletin of Marine Sciences 37*: 599–608.

Jacobs, S.S.; Giulivi, C.; O'Hara, S.; Ardai, J. 1995: Plumbing the Ross Sea polynya. *Antarctic Journal of the United States 30*: 197–199.

Jefferies, M. O.; Adolphs, U. 1997: Early winter ice and snow thickness distribution, ice structure and development of the western Ross Sea pack ice between the ice edge and the Ross Ice Shelf. *Antarctic Science 9(2)*: 188–200.

Johnson, G.L.; Kyle, P.R.; Vanney, J.R.; Campsie, J. 1982: Geology of Scott and Balleny Islands, Ross Sea, Antarctica, and morphology of adjacent seafloor. *New Zealand Journal of Geology and Geophysics 25*: 427–436.

Jouventin, P.; Viot, C.R. 1985. Morphological and genetic variability of snow petrels *Pagodroma nivea. Ibis 127*: 430–441.

Kasamatsu, F.; Joyce, G.C. 1995: Current state of Odontocetes in the Antarctic. *Antarctic science 7*: 365–379.

Kennett, J.P. 1966: Foraminiferal evidence of a shallow calcium carbonate solution boundary, Ross Sea, Antarctica. *Science 153(3732)*: 191–193.

Kennett, J.P. 1968: The fauna of Ross Sea. Part 6. Ecology and distribution of Foraminifera. *New Zealand Oceanographic Institute Memoir 46*: 1–48.

Kirkpatrick, R. 1902: XVI. Polyzoa. p. 286–289 *in*: *Report on the Collections of Natural History Made in the Antarctic Regions During the Voyage of the 'Southern Cross'*. Trustees of the British Museum, London.

Kirkwood, J.M. 1996: The development of *Euphausia crystallorophias* in Ellis Fjord, Vestfold Hills, Antarctica. *Polar Biology 16*: 527–530.

Kirkwood, J.M.; Burton, H.R. 1988: Macrobenthic species assemblages in Ellis Fjord, Vestfold Hills, Antarctica. *Marine Biology (Berlin) 97(3)*: 445–457.

Knox, G.A. 1986: Recent New Zealand marine research in the Ross Sea sector of Antarctica. *Memoirs of the National Institute of Polar Research, Special Issue 40*: 345–363.

Knox, G.A. 1994: The biology of the southern ocean. Cambridge, Cambridge University Press. 444 p.

Knox, G.A.; Cameron, D.B. 1998: The marine fauna of the Ross Sea: Polychaeta. *NIWA Biodiversity Memoir 108*: 1–125.

Knox, G.A.; Lowry, J.K. 1977: A comparison between the benthos of the southern ocean and the north polar ocean with special reference to the Amphipoda and the Polychaeta. *In*: Dunbar, M.J. *ed.* Proceedings of the Polar Oceans Conference, Montreal, 1974. Calgary, Arctic Institute of North America. p. 423–462.

Knox, G.A.; Waghorn, E.J.; Ensor, P.H. 1996: Summer plankton beneath the McMurdo Ice Shelf at White Island, McMurdo Sound, Antarctica. *Polar Biology 16*: 87–94.

Kock, R. 1992: Ostracoden im Epipelagial vor der Antarktischen Halbinsel – ein Beitrag zur Systematik sowie zur Verbreitung und Populationsstruktur unter Berücksichtigung der Saisonalität. *Berichte Polarforschung 106*: 1–209.

Kooyman, G.L. 1993. Breeding habitats of emperor penguins in the western Ross Sea. *Antarctic science 5*: 143–148.

Kooyman, G.L.; Mullins, J.L. 1990. Ross Sea emperor penguin breeding populations estimated by aerial photography. *In* K.R. Kerry, G. Hempel (eds) *Antarctic ecosystems: ecological change and conservation.* Berlin-Heidelberg, Springer-Verlag.

Larson, R.J. 1986: Biology of Antarctic seas 16. Pelagic scyphomedusae (Scyphozoa: Coronatae and Semaecostomeae) of the Southern Ocean. *Antarctic Research Series 41(3)*: 59–165.

Larson, R.J.; Harbison, G.R.1990: Meduse from McMurdo Sound, Ross Sea including the description of two new species, *Leuckartiara brownei* and *Benthocodon hyalinus*. *Polar Biology 11*: 19–25.

Lenihan, H.S. 1992: Benthic marine pollution around McMurdo Station, Antarctica: a summary of findings. *Marine Pollution Bulletin 25(9–12)*: 318–323.

Lenihan, H.S.; Oliver, J.S. 1995: Anthropogenic and natural disturbances to marine benthic communities in Antarctica. *Ecological Applications 5(2)*: 311–326.

Lenihan, H.S.; Oliver, J.S.; Oakden, J.M.; Stephenson, M.D. 1990: Intense and localized benthic marine pollution around McMurdo Station, Antarctica. *Marine Pollution Bulletin 21(9)*: 422–430.

Leventer, A.; Dunbar, R.B. 1996: Factors influencing the distribution of diatoms and other algae in the Ross Sea. *Journal of Geophysical Research. 101(C8)* 18 489–18 500.

Lipps, J.H.; Ronan, T.E.; De Laca, T.E. 1979a: Life below the Ross Ice Shelf, Antarctica. *Science 203(4379)*: 447–449.

Lipps, J.H.; Berger W.H.; Buzas M.A.; Douglas R.G.; Ross, C.A. 1979b: Foraminiferal Ecology and Paleoecology. SEPM Short Course no.6, Houston.

Littlepage, J.L.; Pearse, J.S. 1962: Biological and oceanographic observations under the Antarctic ice shelf. *Science 137*: 679–681.

Littlepage, J.L. 1965: Oceanographic Investigations in McMurdo Sound, Antarctica. *Antarctic Research Series 5*: 1–37.

Lomakina, N. B. 1978: Euphausiids of the world ocean. Studies of the Fauna of the USSR, 118, St Petersberg, Zoological Instituteof the Academy of Science.

Longhurst, A. 1998: Ecological geography of the sea. San Diego, Academic Press. 398 p.

Lopez-Garcia, P.; Rodriguez-Valera, F.; Pedros-Allo, C.; Moreira, D. 2001: Unexpected diversity of small eukaryotes in deep-sea Antarctic plankton. *Nature 409*: 603–607.

Lowry, J.K. 1976: Studies on the macrobenthos of the Southern Ocean.Unpubl. PhD thesis, University of Canterbury,Christchurch. p. 1–147.

Lowry, J.K.; Bullock, S. 1976: Catalogue of the marine gammaridean Amphipoda of the Southern Ocean. *Royal Society of New Zealand Bulletin 16*: 1–187.

Lutschinger, S. 1993: The marine fauna of New Zealand: Chaetognatha (Arrow Worms). *New Zealand Oceanographic Institute Memoir 101*: 61.

Mackensen, A.; Grobe, H.; Kuhn, G.; Futterer, D.K. 1990: Benthic foraminiferal assemblages from the eastern Weddell Sea between 68° and 73°S: Distribution, ecology and fossilization potential. *Marine Micropaleontology 16*: 241–283.

Mackensen, A.; Schmiedl, D.K.; Harloff, J.; Giese, M. 1995: Deep-sea Foraminifera in the South Atlantic Ocean: ecology and assemblage generation. *Micropaleontology 41*: 342–358.

McKenzie, K.G.; Benassi, G.; Naidi, M.; Ferrari, I.; Menozzi, P. 1990: Report on planktic Ostracoda from the Ross Sea Antarctica. *In*: National Scientific Commission for Antarctica *ed.* Oceanographic Campaign 1989–1990, Data Report II. p. 171–229.

McKenzie, K.G.; Ferrari, I.; Benassi, G. 2000: Planktonic Ostracods in the Ross Sea: their distribution and associated environmental factors. *In*: Faranda, F.M.; Guglielmo, L.; Ianora, A. *eds* Ross Sea Ecology. Berlin, Springer-Verlag. p. 351–367.

McKnight, D.G. 1975: Some crinoids from the western Ross Sea. *NZOI Records 2(15)*: 173–76.

McKnight, D.G. 1976a: Echinoids from the Ross Sea and Balleny Islands. *NZOI Records 3(1)*: 1–8.

McKnight, D.G. 1976b: Asteroids from the Ross Sea and the Balleny Islands. *NZOI records 3(4)*: 21–32.

McKnight W.M. 1962: The distribution of Foraminifera off parts of the Antarctic coast. *American Paleontology Bulletins 44(201)*: 65–158.

Markov, K.K.; Bardin, V.I.; Lebedev, V.L.; Orlov, A.I.; Suetova, I.A. 1972: The geography of Antarctica. Jerusalem, Israel Program for Scientific Translation. 370 p.

Maugeri, T.; Gugliandolo, C.; Bruni, V. 1996: Heterotrophic bacteria in the Ross Sea (Terra Nova Bay, Antarctica). *Microbiologia (Bologna) 19(1)*: 67–76.

Medlin, L.K.; Lange, M.; Noethig, E-M. 2000: Genetic diversity in the marine phytoplankton: a review and a consideration of Antarctic phytoplankton. *Antarctic Science 12(3)*: 325–333.

Miller, D.G.M.; Hampton, I. 1989: Biology and ecology of the Antarctic krill (*Euphausia superba* Dana): A review. Biological Investigation of Marine Antarctic Systems and Stocks (BIOMASS) Vol. 9, SCAR / SCOR, Cambridge, England, Scott Polar Research Institute. 199 p.

Miller, K.A.; Pearse, J.S. 1991: Ecological studies of seaweeds in McMurdo Sound, Antarctica. *American Zoologist 31*: 35–48.

Monti, M.; Umani, S.F. 2000: Distribution of the main microzooplankton taxa in the Ross Sea (Antarctic): Austral summer 1994. *In*: Faranda, F.M.; Guglielmo, L.; Ianora, A. *eds* Ross Sea Ecology. Berlin, Springer-Verlag. p. 276–289.

Moro, I.,R.; Paccagnella, R.; Barbante, C.; Andreoli, C. 2000: Microalgal communities of the sea ice, ice-covered and ice-free waters of Wood Bay (Ross Sea, Antarctica) during the Austral summer 1993–94. *Marine Ecology 21(3–4)*: 233–245.

Mortensen, Th. 1936: Echinoidea and Ophiuroidea. *Discovery Reports 12*:199–348, 53 figs., 9 Pls.

Mountevans, E.R.G.R. 1913: The British Antarctic expedition, 1910–1913. *Geographical Magazine 24*: 11–28.

Mullineaux, L.S.; DeLaca, T.E. 1984: Distribution of Antarctic benthic foraminifers settling on the pecten *Adamussium colbecki*. *Polar Biology 3*: 185–189.

Mund, M.J.; Miller, G.D. 1995. Diet of south polar skua *Catharacta maccormicki* at Cape Bird, Ross Island, Antarctica. *Polar biology 15*: 453–455.

Murano, M.; Inoue, K.; Maruyama, T. 1982: Benthic fauna in the vicinity of Balleny Islands. *Transactions of the Tokyo University of Fisheries 5*: 197–201.

Murray, J. 1910: The scientific work of the British Antarctic expedition of 1907–9. *Geographical Journal 36*: 203–205.

Murray, J.W. 1991: Ecology and palaeoecology of benthic Foraminifera. London, Longman. 397 p.

Newman, W.A.; Ross, A. 1971: Antarctic Cirripedia. *Antarctic Research Series 14*: 1–257.

Nuccio, C.; Innamorati, M.; Lazzara, L.; Mori, G.; Massi, L. 1999: Spatial and temporal distribution of phytoplankton assemblages in the Ross Sea.. *In*: Faranda, F.M.; Guilielmo, L.; Ianora, A. *eds* Ross Sea Ecology. Berlin, Springer. p. 231–245.

Nuccio, C.; Innamorati, M.; Lazzara, L.; Mori, G.; Massi, L. 2000: Spatial and temporal distribution of phytoplankton assemblages in the Ross Sea. *In*: Faranda, F.M.; Guilielmo, L.; Ianora, A. *eds* Ross Sea Ecology. Berlin, Springer. p. 231–245.

Oelke, H. 1975. Breeding behaviour and success in a colony of Adelie penguins *Pygoscelis adeliae*) at Cape Crozier, Antarctica. *In* B. Stonehouse (ed) *The biology of penguins*. London, MacMillan.

Oliver, J.S.; Slattery, P.N. 1985: Effects of crustacean predators on species composition and population structure of soft-bodied infauna from McMurdo Sound, Antarctica. *Ophelia 24(3)*: 155–176.

Oritsland, T. 1977: Food consumption of seals in the Antarctic pack ice. *In* G. Llano (ed) *Adaptation within Antarctic ecosystems.* Washington, Smithsonian Institution.

Ostermann, L.E.; Kellog, T.B. 1979: Recent benthic foraminiferal distributions from Ross Sea, Antarctica: relation to ecologic and oceanographic conditions. *Jouranls of Foraminiferal Research 9(3)*: 250–269.

O'Sullivan, D. 1986: A guide to the ctenophores of the Southern Ocean. *ANARE Research Notes 36*: 43 p.

Palmisano, A.C.; Kottmeier, S.T.; Moe, R.L.; Sullivan, C.W. 1985: Sea ice microbial communities. IV. The effect of light perturbation in microalgae at the ice-seawater interface in McMurdo Sound, Antarctica. *Marine Ecology Progress Series 21*: 37–45.

Palmisano, A.C.; Sullivan, C.W. 1983: 1. Distribution, abundance and primary production of ice microalgae in McMurdo Sound, Antarctica in 1980. *Polar Biology* 2: 171–177.

Park, T.S. 1979: Calanoid copepods (Aetideidae and Euchaetidae) from Antarctic and subantarctic waters. *Antarctic Research Series 27*: 91–290.

Park, T.S. 1980: Calanoid copepods of the genus *Scolecithricella* from Antarctic and subantarctic waters. *Antarctic Research Series 31*: 25–79.

Park, T.S. 1982: Calanoid copepodes of the genus *Scaphocalanus* from Antarctic and subantarctic waters. *Antarctic Research Series 34*: 75–127.

Park, T.S. 1983: Calanoid copepods of some scolecithricid genera from Antarctic and subantarctic waters. *Antarctic Research Series 38*: 165–213.

Park, T.S. 1992: Calanoid copepods of the genus *Euaugaptilus* from Antarctic and subantarctic waters. *Antarctic Research Series 58*: 1–48.

Parkinson, C.L. 1998: Length of the sea ice season in the Southern Ocean 1988–1994. *Antarctic Research Series 74*: 173–186.

Parr, W.J. 1950: Foraminifera. *British, Australian and New Zealand Antarctic Research Expedition 1929–1931 Reports, Series B, 5(6)*: 235–392.

Pascoe, J.G. 1984. A census of the south polar skua at Cape Hallett, Antarctica. *Notornis 31*: 312–319.

Paulin, C.D. 1975. Feeding of the Adelie penguin *Pygoscelis adeliae*. *Mauri ora 3*: 27–30.

Pearson, T.H.; Rosenberg, R. 1978: Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology: An Annual Review 16*: 229–311.

Peck, L.S.; Chapelle, G. 1999: Amphipod gigantism dictated by oxygen availability? Reply. *Ecology Letters 2*: 401–403.

Penny, R.L.; Lowry, G. 1967: Leopard predation on Adélie penguins. *Ecology 48*:

Petrushevskaya, M.G. 1971: Radiolaria in the plankton and Recent sediments from the Indian Ocean and Antarctic. *In*: Funnell, B.M., Riedel, W.R. *eds* The Micropalaeontology of Oceans. Cambridge, Cambridge University Press. p. 319–329.

Pflum, C.E. 1966: The distribution of Foraminifera in the eastern Ross Sea, Amundsen Sea, and Bellingshausen Sea, Antarctica. *American Paleontological Bulletins 50(226)*: 151–209.

Picken, G.B. 1980: Reproductive adaptations of Antarctic marine invertebrates. *Biological Journal of the Linnean Society 14*: 67–75.

Picken, G.B. 1985: Benthic research in Antarctica: past, present and future. *In*: Gray, J.S.; Christiansen, M.E. *ed.* Marine biology of polar regions and effects of stress on marine organisms. Chichester, Wiley. p. 167–183.

Poulter, T.C. 1939: The scientific work of the second Byrd Antarctic expedition. *Scientific Monthly 49*: 5–20.

Ramos, A.; San Martin, G.. 1999: On the finding of a mass occurrence of *Serpula narconensis* Baird, 1885 (Polychaeta, Serpulidae) in South Georgia (Antarctica). *Polar Biology 22(6)*: 379–383.

Rawlence, D.J.; Ensor, P.H.; Knox, G.A. 1987: Summer tide-crack phytoplankton at White Island, McMurdo Sound, Antarctica. *New Zealand Journal of Marine and Freshwater research 21*: 91–97.

Reichardt, W.T. 1987: Burial of Antarctic macroalgal debris in bioturbated deep-sea sediments. *Deep-Sea Research 34 (10)*: 1761–1770.

Reid, B.E. 1964. The Cape Hallett Adelie penguin rookery – its size, composition and structure. *Records of the Dominion Museum 5*: 11–37.

Relini, G.; Amato, E. 1991: Italian Antarctic Research Programme: environmental impact assessment at sea: fouling experiment – second note. *National Science Commission of Antarctica Oceanographic Campaign 1989–90 Data Report I*: 379–391.

Reshetnjak, V.V. 1971: Occurrence of phaeodarian Radiolaria in Recent sediments and Tertiary deposits. *In*: Funnell, B.M., Riedel, W.R. *eds* The Micropalaeontology of Oceans. Cambridge, Cambridge University Press. p. 343–349.

Robertson, C.J.R.; Gilbert, J.R.; Erickson, A.W. 1980: Birds and seals of the Balleny Islands, Antarctica. *Records of the National Museum 1*: 271–279.

Rogick, M.D. 1955: Studies on marine Bryozoa. VI. Antarctic *Escharoides*. *Biological Bulletin 109*: 437–452.

Rogick, M.D. 1956a: Bryozoa of the United States Navy's 1947– 1948 Antarctic Expedition, I–IV. *Proceedings of the U.S. National Museum 105*: 21–317, 35 pls.

Rogick, M.D. 1956b: Studies on marine Bryozoa. *Clithriellum inclusum* (Waters) 1904. *Transactions of the American Microscopical Society 75*: 70–74.

Rogick, M.D. 1956c: Studies on marine Bryozoa. VII. *Hippothoa. The Ohio Journal of Science 56*: 183–191.

Rogick, M.D. 1957a: Studies on marine Bryozoa. IX. *Phylactellipora. The Ohio Journal of Science 57*: 1–9.

Rogick, M.D. 1957b: Studies on marine Bryozoa. X. *Hippadenella carsonae. Biological Bulletin 112*: 120–131.

Rogick, M.D. 1959a: Studies on marine Bryozoa. XI: Antarctic Osthimosiae. *Annals of the New York Academy of Sciences 79*: 9–42.

Rogick, M.D. 1959b: Studies on marine Bryozoa. XII. *Porella. The Ohio Journal of Science 59*: 233–240.

Rogick, M.D. 1965: Bryozoa of the Antarctic. p. 401–413 *in* van Mieghem, J.; van Oye, P. (eds), *Biogeography and Ecology in Antarctica: Monographiae Biologicae*. W. Junk Publishers, The Hague.

Ross, J.; Testa, J.W.; Winter, J.D.; Kuechle, L.; Reichle, R. 1982: Weddell seal population dynamics and Antarctic cod movement patterns in McMurdo Sound. *Antarctic journal of the United States 18*: 188–189.

Ross, J.C. 1847: A voyage of discovery and research in the southern and Antarctic regions during the years 1839–43. London, Murray. 2 vols.

Russo, A. 2000: Water mass characteristics during the ROSSMIZE Cruise (Western sector of the Ross Sea, November – December 1994) *In*: Faranda, F.M.; Guglielmo, L.; Ianora, A. *eds* Ross Sea Ecology. Berlin, Springer-Verlag. p. 83–93.

Rosso, A.; Sanfilippo, R. 1999: Shallow water bryozoans and serpuloideans from the Ross Sea. *In*: Faranda, F.M.; Gugliemo, L.; Ianora, A. *ed.* Ross Sea ecology: Italianartide expeditions (1987–1995). Heidelberg, Springer-Verlag. p. 515–525

Sabourenkov, E. 2001: Book Review. Fish and fish resources of the Antarctic. K. V. Shust. CCAMLR Science 8 (2001): 165–168.

Sagar, P.M. 1976: Life cycle and growth of the Antarctic gammarid amphipod *Paramoera walkeri* (Stebbing, 1906). *Journal of the Royal Society of New Zealand 10*: 259–270.

Saggiomo, V.; Carrada, G.C.; Mangoni, O.; Marino, D.; Ribera d'Alcalà, M. 1999: Ecological and physiological aspects of primary production in the Ross Sea. *In*: Faranda, F.M.; Guilielmo, L.; Ianora, A. *eds* Ross Sea Ecology. Berlin, Springer. p. 247–258.

Saino, N.; Guglielmo, L. 2000: ROSSMIZE expedition: distribution and biomass of birds and mammals in the western Ross Sea. *In*: F.M. Faranda, L. Guglielmo, A. Ianora (eds) *Ross Sea ecology*. New York, Springer-Verlag. p. 469–478.

Sanders, H.L. 1968: Marine benthic diversity: a comparative study. *American Naturalist 102*: 243–275.

Sanderson, W.G.; Thorpe, J.P.; Clarke, A. 1994: A preliminary study of feeding rates in the Antarctic cheilostomate bryozoan *Himantozoum antarcticum. In*: Hayward, P.J.; Ryland, J.S.; Taylor, P.D. (eds), *Biology and Palaeobiology of Bryozoans*. Olsen & Olsen, Fredensborg. p. 167–171

Sara, M.; Balduzzi, A.; Barbieri, M.; Bavestrello, G.; Bianchi, C.N.; Boero, F.; Cattaneo-Vietti, R.; Corriero, G.; Morri, C.; Pansini, M. 1990: Hard bottom benthos?: an analysis of tits composition, distribution and of the adaptive strategies of species. *National Science Commission of Antarctica Oceanographic Campaign 1987–88 Data Report II*: 249–260.

Schnack-Schiel, S.B. in press: Specific aspects of the study of life cycles of Antarctic copepods. *Hydrobiologia.*

Schnack-Schiel, S.B.; Thomas, D.; Dieckmann, G.S.; Eicken, H.; Gradinger, R.; Spindler, M.; Weissenberger, J.; Mizdalski, E.; Beyer, K. 1995: Life cycle strategy of the Antarctic calanoid copepod *Stephos longipes. Progress in Oceanography 36*: 45–75.

Schnack-Schiel, S.B.; Thomas, D.N.; Dahms, H-U.; Haas, C.; Mizdalski, E. 1998: Copepods in Antarctic sea ice., *Antarctic Research Series 78*: 173–181.

Schreer, J.F.; Testa, J.W. 1992: Population ecology of Weddell seals in McMurdo Sound. *Antarctic Journal of the United States 27*: 152.

Scottish Geographical Magazine 1905a: The scientific results of the National Antarctic Expedition 21: 318–321.

Sedwick, P.; DiTullio, G.; Mackey, D. 1996: Dissolved iron and manganese in surface waters of the Ross Sea, austral summer 1995–1996. *Antarctic Journal of the United States 31*: 128–130.

Sertorio, T.Z.; Licandro, P.; Ossloa, C.; Artegiani, A. 2000: Copepod communities in the Pacific sector of the Southern Ocean in early summer. *In*: Faranda, F.M.; Guglielmo, L.; Ianora, A. *eds* Ross Sea Ecology. Springer-Verlag, Berlin. p. 291–307.

Sertorio, T.Z.; Markhaseva, E.L. in prep.: Calanoid copepods from the south Pacific with notes on some rare species of the Spinocalanidae and Tharybidae families (Italian Antarctic Experidition 1989–90).

Shackleton, E.H. 1920: South: The story of Shackleton's last expedition, 1914–17. New York, Macmillan. 380 p.

Shen, H.H.; Squire, V.A. 1998: Wave damping in compact pancake ice fields due to interactions between pancakes. *Antarctic Research Series 74*: 325–341.

Siniff, D.B. 1980: Seal population dynamics and ecology. *Journal of the Royal Society of New Zealand 11*: 317–327.

Skinner, J.D.; Klages, N.T.W. 1994: On some aspects of the biology of the ross seal, *Ommatophoca rossii*, from King Haakon VII Sea, Antarctica. *Polar Biology 14*: 467–472.

Spellerberg, I. F. 1967. Distribution of the McCormick's skua (*Catharacta maccormicki*). *Notornis 14*: 201–207.

Spellerberg, I.F. 1971. Aspects of McCormick skua breeding biology. *Ibis 113*: 357–363.

Spicer, J.L.; Gaston, K.J. 1999: Amphipod gigantism dictated by oxygen availability? *Ecology Letters* 2: 397–400.

Spurr, E.B. 1975. Breeding of the Adelie penguin *Pygoscelis adeliae* at Cape Bird. *Ibis 117*: 324–338.

Stewart, B.S.; Yochem, P.K.; Gelatt, T.S.; Siniff, D.B. 1998: Dispersal and habitat use of Weddell seals (*Leptochynotes weddelli*) in the Ross Sea, Antarctica, during their first year of life. *New Zealand Natural Sciences 23 (supplement)*: 195.

Stockton, W.L. 1982: Scavenging amphipods from under the Ross Ice Shelf, Antarctica. *Deep-Sea Research 29*: 819–835.

Stockton, W.L. 1984: The biology and ecology of the epifaunal scallop *Adamussium colbecki* on the west side of McMurdo Sound, Antarctica. *Marine Biology 78*: 171–178.

Stoecker, D.K.; Buck, K.R.; Putt, M. 1992: Changes in the sea-ice brine community during the spring-summer transition, McMurdo Sound, Antarctica. I. Photosynthetic protists. *Marine Ecology Progress Series 84*: 265–278.

Stoecker, D.K; Buck, K.R.; Putt, M. 1993: Changes in the sea-ice brine community during the spring-summer transition, McMurdo Sound, Antarctica. II. Phagotrophic protists. *Marine Ecology Progress Series 95*: 103–11

Stoecker, D.K.; Gustafson, D.E.; Merrell, J.R.; Black, M.M.D.; Baier, C.T. 1997: Excystment and growth of chrysophytes and dinoflagellates at low temperatures and high salinities in Antarctic sea-ice. *Journal of Phycology* 33: 585–595.

Stirling, I. 1969: Distribution and abundance of the Weddell seal in the western Ross Sea, Antarctica. *New Zealand Journal of Marine and Freshwater Research 3*: 191–200.

Stirling, I.; .Greenwood, D. 1970. The emperor penguin colony at Cape Washington in the western Ross Sea, Antarctica. *Notornis 17*: 277–279.

Stretch, J.J.; Hamner, P.P.; Hamner, W.M.; Michel, W.C.; Cook, J.; Sullivan, C.W. 1988: Foraging behaviour of Antarctic krill *Euphausia superba* on sea ice microalgae. *Marine Ecology Progress Series 44(2)*: 131–139.

Sullivan, C.W.; McClain, C.R.; Comiso, J.C.; Smith, W.O. 1988: Phytoplankton standing crops within an Antarctic ice edge assessed by satellite remote sensing. *Journal of Geophysical Research 93*: 12: 487–12 498.

Sullivan, C.W., Palmisano, A.C. 1984: Sea ice microbial communities: distribution, abundance and divesity of ice bacteria in McMurdo Sound, Antarctica, in 1980. *Applied and Environmental Microbiology.* 47: 788–795.

Svavarsson, J.; Gudmundsson, G.; Brattegard, T. 1993: Feeding by the asellote isopods (Crustacea) on foraminifers (Protozoa) in the deep sea. *Deep-Sea Research 40(6)*: 1225–1239.

Swithinbank, C. 1968: Ice movement in the McMurdo Sound area of Antarctica. *In*: International Symposium on Antarctic Glaciological Exploration. New Hampshire, USA, Hanover. p. 472–487.

Tattersall, W.M. 1908: Crustacea. VII. Schizopoda. *National Antarctic Expedition 1901–1904 (Zoology) 4*: 42 p., 8 pls.

Tattersall, O.S. 1965: The fauna of the Ross Sea 4. Mysidacea. *New Zealand Oceanographic Institute Memoir 27*: 1–36.

Taylor, R.H.; Wilson, P.R. 1990. Recent increase and southern expansion of Adelie penguin populations in the Ross Sea, Antarctica, related to climate warming. *New Zealand journal of ecology 14*: 25–29.

Taylor, R.H.; Wilson, P.R.; Thomas, B.W. 1990. Status and trends of Adelie penguin populations in the Ross Sea region. *Polar record 26*: 293–304.

Taylor, T.G. 1930: Antarctic Adventure and Research. New York, Appleton. 245 p.

Testa, J.W. 1994: Over-winter movements and diving behaviour of female Weddell seals (*Leptochynotes weddelli*) in the southwestern Ross Sea. *Canadian Journal of Zoology 72*: 1700–1710.

Testa, J.W.; Siniff, D.B. 1987: Population dynamics of Weddell seals (*Leptochynotes weddelli*) in McMurdo Sound, Antarctica. *Ecological Monographs 57*: 149–165.

Umani, S.F.; Chemelli, M.; Monti, M. 1992: Microzooplankton populations' temporal trend in Terra Nova Bay. *In*: National Scientific Commission for Antarctica ed. Oceanographic Campaign 1989–1990, Data Report II. p. 153–158.

Vacchi, M.; La Mesa, M.; Greco, S. 2000: The coastal fish fauna of Terra nova Bay, Ross Sea, Antarctica. *In*: Faranda, F.M.; Guglielmo, L.; Ianora, A. *eds* Ross Sea Ecology. Berlin, Springer. p. 457–468.

Vacchi, M., La Mesa, M., et al. 2001: First occurrence of *Acanthodraco dewitti* Skóra 1995 (Notothenioidei, Bathydraconidae) in the Ross Sea. *Polar Biology* (published online 4 February 2001).

Van der Zwaan, G.J.; Duijnstee, I.A.P.; den Dulk, M.;, Ernst, S.R.; Jannink, N.T.; Kowenhoven, T.J. 1999: Benthic foraminifer: proxies or problems? A review of paleocological concepts. *Earth-Science Reviews 46*: 213–246.

van Heezik, Y. 1988. Diet of Adelie penguins during the incubation period at Cape Bird, Ross Island, Antarctica. *Notornis 35*: 23–26.

Vanucci, S.; Bruni, V. 1999: Small nanoplankton and bacteria in the Western Ross Sea during sea-ice retreat (spring 1994). *Polar Biology 22(5)*: 311–321.

Vervoort, W. 1957: Copepods from Antarctic and subantarctic plankton samples. *Report of the British, Australian and New Zealand Antarctic Research Expedition 1929–31, ser. B, 3*: 1–160, 138 Figs.

Vervoort, W. 1965: Notes on the biogeography and ecology of free-living, marine Copepoda. *In*: Van Mieghem, J.; Van Oye, P.; Schell, J. *eds* Biogeography and ecology in Antarctica. The Hague, Dr. W. Junk Publishers. p. 381–393.

Violanti, D. 1990: Distribution of living benthic formainifera from Terranova Bay (Antarctica) – preliminary data. *National Science Commission of Antarctica Oceanographic Campaign 1987–88 Data Report II*: 233–237.

Violanti, D. 1992: Foraminifera from Terra Nova Bay (Antarctica) 1987–88. *In*: Gallardo, V.A.; Ferretti, O.; Moyano, H.I. *eds* Oeanografia in Antartide. Chile, U. de Concepción. p. 353–357.

Violanti, D. 1996: Taxonomy and distribution of recent benthic foraminifers from Terra Nova Bay (Ross Sea, Antarctica), Oceanograhic Campaign 1987/1988. *Palaeontographica Italica 83*: 25–71.

Voskoboinikova O.S. 2000: Comparative osteology of *Dacodraco hunteri* and it's position within the family Channichthyidae (Notothenioidei). *Zoologicheskij zhurnal 79(3)*: 321–332. [In Russian, English summary].

Waghorn, E.J. 1979: Two species of Copepoda from White Island, Antarctica. *New Zealand Journal of Marine and Freshwater Research 13*: 459–470.

Waghorn, E.J.; Knox, G.A. 1988: Summer tide-crack zooplankton at White Island, McMurdo Sound, Antarctica. *New Zealand Journal of Marine and Freshwater research 22*: 577–582.

Walker, A.O. 1907: Crustacea III. – Amphipoda. *National Antarctic Expedition (1901–1904) Natural History. Zoology and Botany III*: 1–39, pls 1–13.

Ward, B.L. 1984: Distirbution of mondern benthic Foraminifera of McMurdo Sound, Antarctica. Unpublished thesis, Victoria University of Wellington, Wellington.

Ward, B.L.; Barrett, P.J.; Vella, P. 1987: Distribution and ecology of benthic Foraminifera in McMurdo Sound, Antarctica. *Palaeogeography, Palaeoclimatology, Palaeoecology 58*: 139–153.

Watanabe, K. 1982: Centric diatom communities found in the Antarctic sea-ice. *Antarctic Record 74*: 119–126.

Waterhouse, E.J. (*ed.*) 2001: Ross Sea region 2001: A state of the environment report for the Ross Sea region of Antarctic. New Zealand Antarctic Institute, Christchurch New Zealand. 265 p.

Watson, G.E.; Angle, J.P.; Harper, P.C.; Bridge, P.C.; Schlatter, R.P.; Tickell, W.L.N.; Boyd, J.C.; Boyd, M.M.1971. *Birds of the Antarctic and subantarctic.* Antarctic map folio series, folio 14. American geographical society.

Waugh, S.M.; Weimerskirch, H.; Cherel, Y.; Shankar, U.; Prince, P.A.; Sagar, P.M. 1999. Exploitation of the marine environment by two sympatric albatrosses in the Pacific Southern Ocean. *Marine ecology progress series 177*: 243–254.

Weimerskirch, H.; Robertson, G. 1994. Satellite tracking of light-mantled sooty albatrosses. *Polar biology 14*: 123–126.

Weimerskirch, H.; Salamolard, M.; Sarrazin, F.; Jouventin, P. 1993. Foraging strategy of wandering albatrosses during the breeding season: a study using satellite telemetry. *Auk 110*: 325–342.

White, M.G. 1984: Marine benthos. *In*: Laws, R. M. *ed* Antarctic Ecology II. London, Academic Press. p. 421–461.

Williams, R.T.; Robinson, E.S. 1980: The ocean tide in the southern Ross Sea. *Journal of Geophysical Research 85(C11)*: 6689–6696.

Wilson, E.A. 1905. On the whales, seals and birds of Ross Sea and South Victoria Land. *In* R.F. Scott. *The voyage of the Discovery*. Volume 2. London, Smith, Elder and Co.

Wilson K.-J. 1990: Fluctuations in populations of Adelie penguins at Cape Bird, Antarctica. *Polar Record 26(159)*: 305–308.

Wilson, P.R.; Ainley, D.G.; Nur, N.; Jacobs, S.S.; Barton, K.J.; Ballard, G.; Comiso, J.C. 2001. Adelie penguin population changes in the Pacific sector of Antarctica: realtion to sea-ice extent and the Antarctic circumpolar current. *Marine ecology progress series 213*: 301–309.

Winston, J.E. 1983: Patterns of growth, reproduction and mortality in bryozoans from the Ross Sea, Antarctica. *Bulletin of Marine Science 33*: 688–702.

Winston, J.E.; Hayward, P.J. 1994: Bryozoa of the US Antarctic Research Program: Preliminary report. *In*: Hayward, P.J.; Ryland, J.S.; Taylor, P.D. (eds), *Biology and Palaeobiology of Bryozoans*. Olsen & Olsen, Fredensborg. p. 205–210.

Wolfenden, R.N. 1908: Crustacea. 8. Copepoda. *National Antarctic Expedition 1901–1904 VI (Zoology)*: 1–46, 7 pls.

Yaldwyn, J.C. 1965: Antarctic and subantarctic decapod Crustacea. *In* van Mieghem, J.; van Oye, P. *eds* Biogeography and ecology in Antarctica. The Hague, Dr. W. Junk Publishers. p. 324–332.

Young, E.C. 1963. The breeding behaviour of the south polar skua. *Ibis 105*: 203–233.

Young, E.C. 1972. Teritory establishment and stability in McCormick's skua. *Ibis 114*: 234–244.

Young, E.C. 1981. The ornithology of the Ross Sea. *Journal of the royal society of New Zealand 11*: 287–315.

Young, E.C. 1994. *Skua and penguin: predator and prey.* Cambridge, Cambridge University Press.

Zaneveld, J.S. 1966a: Vertical zonation of Antarctic and subantarctic benthic marine algae. *Antarctic Journal of the United States 1*: 211–213.

Zaneveld, J.S. 1966b: The occurrence of benthic marine algae under shore fast-ice in the western Ross Sea, Antarctica. *In*: Young, E.G.; McLachlan, J.L. *ed.* Proceedings of the Vth International Seaweed Symposium, Halifax, 1965. Oxford, Pergamon Press. p. 217–321.

Zaneveld, J.S. 1968: Marine benthic algae, Ross Island to Balleny Islands. *In*: Balech, E.; El-Sayed, S.Z.; Hasle, G.; Neushul, M.; Zanevald, J.S. *eds* Primary productivity and benthic marine algae of the Antarctic and subantarctic. *Antarctic Map Folio Series 10*: 1–12. pls 13–15.

Zernov, V.V. 1993: [On the floristic regionalization of the southern Ocean.] *Antarktika 32*: 141–150.

Table 3.1. Stations sampled in the Ross Sea.

	Number stations	Date	Notes	Location of Specimens
Erebus and Terror Expedition	4	Sep 1839-Sep 1843	Expedition sponsored by British Admiralty in association with British Association and Royal Society Leader: Capt. James Clark Ross RN	The Natural History Museum, London
'Southern Cross' Expedition, 1898-99	2	13-Jan-1899	Expedition lead by C. Borchgrevink. Samples taken in pack ice near Cape Adare.	The Natural History Museum, London
British Antarctic 'Nimrod' Expedition, 1907-09	5	8-Apr-1908	Lead by Ernest Shackleton, stations in McMurdo sound	The Natural History Museum, London
National Antarctic Expedition 1901-1904	approx. 170	10-Dec-1910	S.S. 'Discovery'. lead by Captain Scott. Fish, marine benthos and plankton collections.	The Natural History Museum, London
British Antarctic ("Terra Nova") Expedition, 1910	258	10-Dec-1910	Antarctic benthic, plankton and shore collection samples from 10 Dec 1910 to 22 Jan 1913	The Natural History Museum, London
"Sir James Clark Ross" whaling exopedition	3	10-Feb-1924	Samples taken near Ross Ice Shelf	The Natural History Museum, London plankton and benthos
S.S 'C.A.Larsen', 1928-29	29	22-Nov-1928	29 stations made by a member of the Discovery Investigations team from the whaling factory 'C.A. Larsen', 22 Nov 1928 to 14 Feb 1929	The Natural History Museum, London zooplankton 0 - <200 m
Discovery II Expedition, 1936	34	2-Jan-1936	Ross sea plankton, benthos and fish sampled 2 Jan to 6 Feb 1936	The Natural History Museum, London
US Naval Expedition	5	14-Jan-1948	Expedition led by Comdr David C. Nutt 1947-1948	Smithonsian Institution, Washington D.C.
Soviet Antarctic Expedition, 1955-56	12	27-Mar-1956	Biological Sudies from the Research Ship 'Ob', Academy of Sciences of the USSR. Stations north of Ross Sea from 27 - 31 March 1956	P.P. Sirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia (stratified plankton samples and benthos); Zoological Institute, RAS, St Petersberg, Russia (integrated surface plankton samples)
Trans Antarctic Expedition	75	24-Dec-1956	Plankton and benthic stations from USS 'Glacier', HMNZS 'Endeavour' and from ice edge and ice holes. Stations 1 to 100. Dec 1956 to Feb 1958.	Museum of New Zealand (Te Papa) plankton and benthos?
Deep Freeze	32	29-Jan-1956	Miscellaneous biota probably taken from the USNS *Edisto, Glacier, Northwind,* and *Staten Island* 1956 to 1959.	Smithonsian Institution, Washington D.C.
Soviet Antarctic Expedition, 1957-58	13	25-Mar-1958	Biological Sudies from the Research Ship 'Ob', Academy of Sciences of the USSR. Ross Sea stations from 25 March to 1 April 1958	P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow and Zoological Institute, Russian Academy of Sciences, St Petersberg, Russia
Stanford University Benthic Invertebrate Studies in Antarctica	92	11-Nov-1958	Benthic stations from USS 'Glacier', USCGC 'Eastwind' and from ice edge and ice holes.	Natural History Museum of Los Angeles County, Los Angeles benthos gdavis@nhm.org
Ross Sea 'Endeavour' 1959	25	20-Dec-1958	HMNZS 'Endeavour'. 20 Dec 1958 to 16 Feb 1959. NZOI stations A448 to A472 and bottom photos	NIWA Wellington plankton, benthos, and photos
Ross Sea 'Endeavour' 1960	24	27-Dec-1959	HMNZS 'Endeavour'. 27 Dec 1959 to 1 Feb 1960. NZOI Stations A516 to A540	NIWA Wellington
Southern Ocean 'Edisto' 1961	3	13-Dec-1960	USS 'Edisto', 13 dec 1960 to 22 Feb 1961. NZOI Stations A644 to A646	NIWA Wellington benthos
Ross Sea 'Endeavour' 1961	6	27-Dec-1960	HMNZS 'Endeavour'. 27 Dec 1960 to 22 Feb 1961. NZOI Stations A573 to A642	NIWA Wellington benthos
Cape Hallett Winter Party	29	17-Jan-1962	Miscellaneous marine biota collected at Cape Hallett 17 Jan to 12 Oct 1962 and deposited at NIWA station numbers Z1779-Z1808	NIWA Wellington
Balleny Glacier 1964	8	8-Mar-1964	Reconnaissance expediton on USS Glacier. NZOI stations D212 to D219, 8-11 Mar 1964.	NIWA Wellington benthos
Balleny Glacier 1965	85	12-Jan-1965	Expedition on USS Glacier to Balley Islands and Ross Sea, NZOI stations E168 - E255, 12 Jan 1965 to 12 Feb 1965	NIWA Wellington benthos
Eltanin Cruise 27	106	10-Jan-1967	Ross Sea Jan-Feb 1967. Midwater trawls, bottom trawls and cores.	Smithonsian Institution, Washington D.C. plankton and benthos http://www.nmnh.si.edu/iz/usap/
Eltanin Cruise 32	116	1-Jan-1968	Ross Sea, Jan-Feb 1968. Lamont-Doherty Geological Observatory of Columbia University. Bottom Photographs, Trawl samples from USNS Eltanin	Smithonsian Institution, Washington D.C. plankton http://www.nmnh.si.edu/iz/usap/
Eltanin Cruise 51	91	17-Jan-1972	Ross Sea, Jan-Feb 1972, WP2 (University of Canterbury), IKMT and Bongo and benthic samples were taken	Smithonsian Institution, Washington D.C. plankton http://www.nmnh.si.edu/iz/usap/ http://gdcmp1.ucsd.edu/scl_coll.html; NIWA Wellington WP2 plankton samples (Z3285-Z3293; Z3959-Z3964)
White Island Ice Hole	11	22-Dec-1976	Samples taken through ice near White Island by Univ. Canterbury	University of Canterbury, Christchurch?
Polar Queen Cruise	108	29-Feb-1988	Italian oceanographic expedition on R/V Polar Queen, 20 Dec 1987 to 29 Feb 1988 in Terra Nova Bay	Museo Nazionale dell'Antartide, Italy plankton and benthos http://www.mna.it
Umitaka Maru III	4	1-Feb-1981	Balleny Islands late Jan-early Feb, Fish pump samples, Longhurst Hardy Plankton Recorder samples, benthos sample west of Sturge Island	Tokyo University of Fisheries?
Cariboo Cruise	73	25-Nov-1989	Italian oceanographic expedition on R/V Cariboo, 25 Nov 1989 to 20 Feb 1990. Balleny Is and western Ross Sea	Museo Nazionale dell'Antartide, xxxx, Italy plankton and benthos http://www.mna.it
R.V. Akademik Ioffe 1992	7	23-Feb-1992	Russian contribution to the World Ocean Circulation Experiment. Western part of leg parallel to Antarctica occupied stations in vicinity of Balleny Islands	P.P. Sirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia
ROSSMIZE Cruise	53	14-Nov-1994	Italian Ross Sea Marginal Ice Zone Ecology cruise. R/V Italica, 14 Nov 1994 to 16 Dec 1994	Museo Nazionale dell'Antartide; Italy http://www.mna.it
Western Ross Sea 2001	12	4-Feb-2001	Expedition studied benthic communities of Cape Hallett, Possession and Balleny Islands 26 Feb - 9 Mar 2001, aboard RV *Tangaroa sponsored* by Ministry of Fisheries, New Zealand	NIWA Wellington

Table 4.1.1.1. List of phytoplankton taxa recorded from the Ross Sea. (from Cassie, 1963; Andreoli et al., 1995; Cunningham & Leventer, 1998; Nuccio et al., 2000). * denotes cosmopolitan species (this list of cosmopolitan species is probably not exhaustive).

BACILLARIOPHYCAEA
Achanthes brevipes Agardh
Achanthes groelandica (Cleve) Grunow
Achanthes vinventii Manguin
Acanthes sp.
Actinocyclus actinochilus (Ehrenb.) Sim.
Actinocyclus cholnoyi van Landigham
Actinocyclus curvatulus Janisch
Actinocyclus ehrinbergii Ralfs
Actinocyclus ingins Rattr.
Actinocyclus oliverianus O'Meara
Amphipleura rutilans (Trentepohl) Cleve
**Amphiprora kjellmanii* Cleve
Amphiprora cf. *kufferathii* Manguin
Amphiprora oestrupii V. Heurck
**Amphiprora paludosa* Wm. Smith
**Asteromphalus hepactis* (Bréb.) Ralfs
**Asteromphalus hookerii* Ehrenb.
Asteromphalus hyalinus Karsten
Asteromphalus parvulus Karsten
Azpeitia spp.
Centric diatoms spp.
**Chaetoceros atlanticus* Cleve
Chaetoceros bulbosus (Ehrinberg) Heiden.
Chaetoceros cf. *criophilum* Castr.
Chaetoceros deflandrei Manguin
**Chaetoceros dichaeta* Ehrenb.
Chaetoceros cf. *dichaeta* Ehrenb.
Chaetoceros hyalochaete (Ehr.) Gran
Chaetoceros cf. *neglectum* Karsten
Chaetoceros cf. *neogracile* Van Landingham
Chaetoceros phaeoceros (Ehr.) Gran
Chaetoceros seychellarum Karsten var. *australe* Manguin
Chaetoceros spp.
Charcotia australis (Kartsen) M. Pera
**Cocconeis costata* Gregory
Cocconeis fasciolata (Ehrenberg) Brown
Cocconeis imperatrix A.S.
**Corethron criophilum* Castracane
Coscinodiscus bouvet Karsten
Coscinodiscus furcatus Karsten
Coscinodiscus gracilis Karsten
**Coscinodiscus excentricus* Ehrenberg
**Coscinodiscus oculatus iridis* Ehrenb.
Coscinodiscus tumidus Janisch.

Coscinodiscus spp.
Cylindrotheca closterium (Ehrenberg) Reimann & Lewin
Dactyliosolen tenuijunctus Manguin
Denticulopsis spp.
Eucampia antarctica (Castr.) Manguin
Eucampia balaustium Castr.
Fragilaria curta V. Heurck
Fragilariopsis angulata Hasle
Fragilariopsis curta (Van Heurck) Hustedt
Fragilariopsis cylindrus (Grun.) Hasle
Fragilariopsis kerguelensis (O'Meara) Hustedt = *F. antarctica* (Castr.) Hustedt
Fragilariopsis obliquecostata (V. Heur.) Hasle
Fragilariopsis ritscheri (Hust.) Hasle
Fragilariopsis rhombica (O'Meara) Hustedt
Fragilariopsis separanda (Hust,) Hasle
Fragilariopsis cf. *sublinearis* (V. Heur.) Hasle
Fragilariopsis vanheurckii Hasle
Fragilariopsis sp. 1 (8µm)
Fragilariopsis spp.
Gomphonema minuscula Krasske
Gryosigma wansbeckii (Donkin) Cleve
Grammatophora cf. *charcotii* M. Per.
Licmophora spp.
Melosira adeliae Mangin
Melosira sp.
Navicula directa (Wm. Smith) Ralfs
Navicula glaciei V. Heurck
Navicula trompii Cleve. var. *major* Heid. & Kolbe
Navicula spp.
Naviculcea sp. (20µm)
Nitzschia lecointei V. Heurck
Nitzschia closterium (Ehrenb.) W. Sm. = *Cylindrotheca closterium* (Ehrenb.) Reim & Lewin
Nitzschia cf. *promare* Medlin
Nitzschia cf. *subcurvata* Hasle
Nitzschia sp. *(bilobatae* sec.*)*
Nitzschia spp.
Odontella litigiosa (V. Heurck) Hoban
Odontella weissflogii (Jan.) Grunow
Odontella sp.
Paralia spp.
Pennate diatoms >20µm
Pinnularia quadratarea (A. Schmidt) Cleve
Pleurosigma directum Grunow
Pleurosigma sp.
Porosira glacilis (Grun.) Joerg.
Porosira pseudodenticulataum (Hust.) Jouse
Proboscia alata (Brigt.(Sundström)
Pseudonitzschia barkleyi (Hust.) Manguin
Pseudonitzschia seriata Cleve

Pseudonitzschia turgiduloides Brightwell
Pseudonitzschia spp.
Rhizosolenia cunii Karsten
**Rhizosolenia hebetata* Bailey
**Rhizosolenia styliformis* Brightwell
Rhizosolenia truncata Karsten
Rhizosolenia spp.
Stellarima microtrias (Ehr.) Hasle & Sims
Stephanopyxis spp. (Pliocene)
Synedra tabulata (Agardh) Kutzing
Thalassiosira antarctica Comber
Thalassiosira cf. *antarctica* Comber
**Thalassiosira decipiens* (Grun.) Jørg.
**Thalassiosira gracilis* (Karst.) Hust.
Thalassiosira gracilis var. *expecta* (V. Land.) Fryx & Has.
**Thalassiosira gravida* Cleve
Thalassiosira inura Gers.
Thalassiosira lentiginosa (Jan.) Fryx,
**Thalassiosira oestrupii* Halse
Thalassiosira oliverana (O'Mear.) Sour.
Thalassiosira torokino Brady
**Thalassiosira tumida* (Castracane) Hasle
Thalassiosira sp. 43µm
Thalassiosira spp.
**Thalassiothrix antarctica* (Schim.) Karsten
Trachymeis aspersa (Ehrenberg) Cleve
**Trigonium* cf. *arctcum* Brightwell
Tropidoneis fusiformis Manguin
Undetermined diatoms spp.

CYANOPHYCEAE
Numerous in the Ross Sea (Acosta-Pomar et al., 2000)

DINOPHYCEAE
Amphidinium sp.
Dinophysis cf. *antarctica* Balech
Dinophysis sp. 1
Dinophysis sp. 2
Gymnodiniaceae < 20µm
Gymnodiniaceae > 20µm
Gymnodiniaceae > 100µm
Gymnodinium cf. *baccatum* Balech
Gymnodinium cf. *flavum* Kofoid & Swezy
Gymnodinium cf. *guttula* Balech
Gyrodinium lachryma (Meun.) Kofoid & Swezy
Gymnodiniium soyai Hada
Gyrodinium spp. > 20µm
Gyrodinium glaciale Hada
**Gyrodinium lachryma* (Meunier) Kofoid & Swezy
Gryodiniium sp. 1
Gyrodinium sp. 2

Naked dinoflagellates < 20µm
Naked dinoflagellates > 20µm
Oxytoxum criophilum Balech
Peridinium charcotii Balech
Peridinium curtum Balech
**Peridinium depressum* Balech
Peridinium obovatum Wood
**Peridinium pallidum* Osten.
**Peridinium pellucidum* (Bergh) Schütt
Peridinium turbinatum Manguin
Prorocentrum cf. *antarcticum* (Hada) Balech
Protoperidinium adeliense (Balech) Balech
Protoperidinium archiovatum (Balech) Balech
Protoperidinium bellulum (Balech) Balech
Protoperidinium concavum (Mangin) Balech
Protoperidinium defectum (Balech) Balech
Protoperidinium elegantissimum (Balech) Balech
Protoperidinium incertum (Balech) Balech
Protoperidinium macrapicatum (Balech) Balech
Protoperidinium mediocre (Balech) Balech
Protoperidinium melo (Balech) Balech
Protoperidinium peritum (Balech) Balech
Protoperidinium pseudoantarcticum (Balech) Balech
Protoperidinium radius Balech
Protoperidinium raphanum (Balech) Balech
Protoperidinium cf. *rosaseum* (Balech) Balech
Protoperidinium cf. *unipes* (Balech) Balech
Protoperidinium sp.
Thecate dinoflagellates < 20µm

PRYMNESIOPHYCEAE
Phaeocystis cf. *antarctica* Karsten

CHRYSOPHYCEAE
Dictyocha speculum Ehrenberg

Other flagellates [Chryptophyceae; Xanthophyceae; Chlorophyceae]
Cryptophycea sp. 1
Cryptophyceans spp.
Phytoflagellate sp. 7µm
Phytoflagellate sp. 10µm
Phytoflagellate sp. <10µm
Phytoflagellate sp. <20µm
Undetermined 20µm (*Halosphaera* rosettes?)

Table 4.1.1.2. List of recorded microalgal taxa from the tide crack at White Island. (from Rawlence et al., 1987)

BACILLARIOPHYCAEA
Fragilaria sp.
Nitzschia cylindrus (Grun.)
Nitzschia curta (Van Heurck)
Nitzschia obliquecostata (Van Heurck)
Synedra tabulata (Ag.) Ktz. var. *australis* (Manguin 1960)

PRASINOPHYCEAE
Pyraminmonas sp.

Table 4.1.1.3. Algal taxa observed in forty samples of sea ice from Wood Bay. Those present in sea ice, and those in ice during formation are identified separately.

Taxa	**Sea ice**	**During ice formation**
BACILLARIOPHYCEAE		
Achnanthes brevipes Agardh	+	+
Actinocyclus actinochilus (Ehrenberg) Simonsen		
Actinocylcus cholnokyi Van Landigham	-	+
Amphipleura rutilans (Trentepohl) Cleve	+	-
Asteromphalus heptactis (Brèbisson) Ralfs	-	+
Asteromphalus sp.	+	+
Auricola compacta (Hustedt) Medlin	+	-
Chaetoceros atlanticus Cleve	+	+
Chaetoceros dichaeta Ehrenberg	+	-
Chaetoceros sp.	+	+
Cocconeis fasciolata (Ehrenberg) Brown	-	+
Corethron criophilum Castracane	-	+
Coscinodiscus tabularis (Grunow) Fryxell & Sims	+	+
Coscinodiscus sp.	+	+
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	+	+
Entomoneis kufferathii Mangin	+	-
Eucampia antarctica (Castracane) Mangin	+	+
Fragilariopsis curta (Van Heurck) Hustedt	+	+
Fragilariopsis obliquecostata (Grunow) Kreiger	+	+
Fragilariopsis rhombica (O'Meara) Hustedt	+	+
Fragilariopsis ritcherii (Hustedt) Hasle	+	+
Fragilariopsis separanda (Hustedt) Hasle	+	-
Fragilariopsis sublinearis Hasle	+	-
Fragilariopsis spp.	+	+
Navicula cancellata Donkin	+	-
Navicula directa (Wm Smith) Ralfs	+	-
Navicula glaciei Van Heurck	+	-
Navicula spp.	+	+
Nitzschia arctica Cleve	+	-
Nitzschia neglecta Hustedt	+	-
Nitzschia stellata Mangin	+	-
Nitzschia spp.	+	+
Nitzschiella subcurvata Hasle	+	+
Odontella sp.	+	-
Pinnularia quadratarea (A Schmidt) Cleve	+	-
Pleurosigma directum Grunow	+	+
Pleurosigma sp.	+	-
Porosira glacialis (Grunow) Jorgensen	+	-

Taxa	**Sea ice**	**During ice formation**
Proboscia alata (Brightwell) Sundstrom	+	-
Pseudonitzschia seriata (Coleve) Peragallo	+	+
Pseudonitzschia turgiduloides Hasle	-	+
Rhizosolenia styliformis Brightwell	+	-
Rhizosolenia truncata (Kaarsten) Nothig & Ligowski	+	-
Rhizosolenia spp.	+	+
Stellarima microtrias (Ehrenberg) Hasle & Sims	-	+
Synedra tabulata (Agardh) Kützing	-	+
Synedra sp.	+	+
Thalassiosira tumida (Janisch) Hasle	-	+
Thalassiosira sp.	+	+
Tropidoneis sp.	+	-
XANTHOPHYCEAE		
Pseudopleurochloris antaractica Andreoli *et al.*	+	+
DICTYOCHOPHYCEAE		
Dictyocha speculum Ehrenberg	+	+
DINOPHYCEAE		
Amphidinium hadai Balech	-	+
Amphidinium sp.	-	+
Dinophysis tenuivelata *Balech*	-	+
Gyrodinium spp.	-	+
Polarella glacialis Montresor *et al.*	+	+
Protoperidinium applanatum (Mangin) Balech	-	+
Protoperidinium archiovatum (Balech) Balech	-	+
Protoperidinium bipes (Paulsen) Balech	-	+
Protoperidinium charcoti (Balech) Balech	-	+
Protoperidinium incertum (Balech) Balech	-	+
Protoperidinium incognitum (Balech) Balech	-	+
Protoperidinium mediocre (Balech) Balech	-	+
HAPTOPHYCEAE		
Phaeocystis sp.	-	+
PRASINOPHYCEAE		
Mantioniella antaractica Marchant	-	+
Pyramimonas gelidicola McFadden	-	+

Table 4.3.1.1. List of microzooplankton taxa recorded or inferred as being found in the Ross Sea.

HETEROTROPHIC/MIXOTROPHIC DINOFLAGELLATES (from Monti & Umani, 2000; Andreoli et al., 1995)

Amphidinium hadai Balech
Gymnodinium cf. *baccatum* Balech
Gymnodinium cf. *flavum* Kofoid & Swezy
Gymnodinium cf. *guttula* Balech
Gyrodinium lachryma (Meun.) Kofoid & Swezy
Gymnodiniium soyai Hada
Gyrodinium glaciale Hada
Gyrodinium lachryma (Meunier) Kofoid & Swezy
Protoperidinium affine (Balech) Balech
Protoperidinium antarcticum (Schim.) Balech
Protoperidinium applanatum (Mangin) Balech
Protoperidinium defectum (Balech) Balech
Protoperidinium cf. *pseudoantarcticum* (Balech) Balech
Gyrodinium lachryma

CILIATES (from Umani et al., 1992; Monti & Umani, 2000)

TINTINNIDS
Codonellopsis gausii (Laackmann)
Codonellopsis glacialis (Laackmann)
Codonellopsis sp. (Laackmann)
Laackmanniella naviculaefera (Laackmann)
Laackmanniella prolongata (Laackmann)
Laackmanniella sp. (Laackmann)
Coxliella frigida (Laackmann)
Coxliella sp. (Brandt)
Cymatocylis conica (Laackmann)
Cymatocylis convallaria (Laackmann)
Cymatocylis drygalskii (Laackmann)
Cymatocylis ecaudata (Kofoid & Campbell)
Cymatocylis flava (Laackmann)
Cymatocylis folliculus (Kofoid & Campbell)
Cymatocylis glans (Kofoid & Campbell)
Cymatocylis nobilis (Laackmann)
Cymatocylis subconica (Kofoid & Campbell)
Cymatocylis vanhoffeni (Laackmann)
Cymatocylis sp. (Laackmann)
Ptychocylis sp. (Brandt)
Salpingella sp. (Jørgensen)

HOLOTRICHA
Enchelys
Prorodon
Lacrymaria
Litonotus
Chaenea

OLIGOTRICHA
Strombidium
Laboea
Patronella
Lohmaniella
Leegardiella

HYPOTRICHA
Cytharoides balechi (Tuffrau)
Euplotes

RADIOLARIA (inferred from Hays, 1965; Petrushevskaya, 1971; Reshetnjak, 1971; Monti & Umani, 2000; with records from core tops (Hays 1965)). * Records from Balleny Islands sediments (Petruchevskaya, 1968).

**Antarctissa denticulata* (Ehr.)
**Antarctissa strelkovi* Petrushevsk.
**Artostrobus annulatus* (Bailey)
Aulographonium mediterraneum (Borgert)
Aulospathis variabilis triodon Haecker
Cadium marinum Bailey
Cadium melo (Cleve)
**Cenosphaera cristata?* Haeckel
**Cornutella* spp.
**Cromyechinus antarctica* (Dreyer)
**Cycladophora davisiana* Ehrenberg
Challengeria naresi (J. Murray)
Dictyocephalus papillosus (Ehr.)
Dictyophimus gracilipes Bailey
**Diploplegma aquatica?* (Popofsky)
**Echinomma delicatulum* (Dogel)
Euphysetta amphicodon Haeckel
Euphysetta elegans Borgert
Heliotholus histricosa Jorgensen
Lamprocyclas maritalis Haeckel
Lithamphora furcaspiculata Popof.
Lithelius nautiloides Popofsky
**Lithelius riedeli* Petrushevskaya
**Lithocampe furcaspicalata* Popofsky
Lithomelissa borealis (Ehr.)
**Lithomelissa* spp.
**Lithomitra arachnea* (Ehr.)
Peromelissa denticulata Ehrenberg
**Phorticium clevei* (Joergensen)

Porospathis holostoma (Cleve)
Protocystis bicuspis Schroeder
Protocystis microplectus Haecker
Protocystis swerei (J. Murray)
**Saccospyris antarctica* Haecker
**Saccospyris conithorax* Petrushevskaya
**Semantis micropora* Popofsky
Spongodiscus favus Ehr. *maxima* Pop.
**Spongodiscus osculosus* (Dreyer)
Spongoplegma antarctcum Haeckel
**Spongotrochus glacilais* Popofsky
**Spongotrocus setosus?* (Dreyer)
**Spongurus pulomaticus* Riedel
Sticholonche zanclea
Stylatractus neptunus Haeckel
**Stylatractus* sp.
Theocalyptra davisiana (Ehrenberg)
**Theocalyptra bicornis* (Popofsky)
**Tholospira* sp.
Triceraspyris antarctica (Haecker)

FORAMINIFERA (from Heron-Allen & Earland, 1922; Pflum, 1966, Kennett, 1968; Ward, 1984; Asioli & Langone, 1997)
Globigerina bulloides D'Orbigny, 1826
Globigerina dubia
Globigerina cretacea
Globigerina helicina
Globigerinoides ruber (d'Orbigny, 1839)
Globigerinoides conglobatus (Brady, 1879)
Globoquadrina conglomerata (Schwager, 1866)
Globorotalia inflata (d'Orbigny, 1839)
Neogloboquadrina dutertrei (d.Orbigny, 1839)
Neogloboquadrina pachyderma (Ehrenberg, 1861)
Turborotalia quinqueloba (Natland, 1938)

ACANTHARIA (inferred from Berstein et al., 1999)
Acanthometra pellucida
Acanthometra prismatica
Acanthometra tetracopa
Acanthoplegma krohni
Coleaspis obscura
Gigartacon abcisus
Gigartacon denticulatus
Gigartacon muelleri
Hexalaspis heliodiscus
Lychnaspis minima
Phractopelta dorataspis
Phyllostaurus echinoides
Stauracon pallidus

Table 4.3.2.1 Heterotrophic protozoa from ice edge sites in McMurdo Sound and from Cape Armitage after Stoeckner et al. (1993).

Taxon	Ice edge sites	Cape Armitage
FLAGELLATES		
Cryothecomonas armigera	Yes	Yes
Crothecomonas sp.	Yes	
DINOFLAGELLATES		
Gymnodinium sp	Yes	Yes
Polykiros sp	Yes	Yes
Gyrodinium sp	Yes	Yes
Protoperidinium sp	Yes	
CILIATES		
Strombilidium sp	Yes	
Strombidium spp	Yes	
Mesodinium rubrum	Yes	Yes
Didinium spp	Yes	
Spiroprorodon sp.	Yes	
Aspidisca sp.	Yes	
Euplotes sp.	Yes	
Scuticociliate	Yes	

Table 4.4.1.1.1. List of zooplankton taxa recorded or inferred as being found in the Ross Sea.

COELENTERATA

HYDROZOA (from Browne, 1910; Larson & Harbison, 1990)
Benthocodon hyalinus Larson & Harbison, 1990
Catablema weldoni Browne, 1910
Cosmetirella simplex Browne, 1910
Cosmetira frigida Browne, 1910
Diplulmaris antarctica Maas, 1908
Diplulmaris? gigantea Browne, 1910
Eleutheria hodgsoni Browne, 1910
Koellikeria maasi (Browne, 1910)
Laodicea pulchra Browne, 1902
Lucernaria vanhoeffeni Browne, 1910
Leuckartiara browni Larson & Harbison, 1990
Margelopsis australis Browne, 1910
Mitrocomella frigida (Browne, 1910)
Pantachogon scotti Browne, 1910
Perigonimus sp.
Ptychogena antarctica Browne, 1907
Sibogita borchgrevinki Browne, 1910
Solmundella bitentaculata (Quoy & Gaimard, 1833)
Solmundella mediterranea (Muller, 1851)

SIPHONOPHORA (from Hopkins, 1987)
Dimophyes arctica
Dyphes antarctica
Pyrostephos vanhoeffeni

SCYPHOZOA (from Browne, 1910; Larson, 1986; Larson & Harbison, 1990)
Atolla chuni Vanhoffen, 1902
Atolla gigantea Maas, 1897
Atolla wyvillii Haeckel, 1880
Desmonema gaudichaudi (Mass, 1908)
Desmonema glaciale Larson, 1986
Diplulmaris antarctica Mass, 1908
Periphyella dodecabostrycha (Brandt, 1838)
Periphylla periphylla (Peron & Leseur, 1809)
Poralia rufescens Vanhoffen, 1902
Stygiomedusa gigantea (Browne, 1810)

CTENOPHORA (inferred from O'Sullivan, 1986)
Bathyctenidae chuni (Moser),
Beroe cucumis Fabricius, 1780
Beroe compacta Moser,
Beroe forskalii Milne Edwards, 1841
Callianira antarctica Chun, 1897
Callianira cristata Moser
Cryptocoda gerlachei Leloup

Lyrocteis flavopallidus Robilliard & Dayton,
Pleurobrachia pileus (Muller, 1776)

CHAETOGNATHA (from Fowler, 1907; Burfield, 1930; David, 1965; Alvarino et al., 1983b; Lutschinger, 1993)
Eukrohnia bathyantarctica David, 1958
Eukrohnia bathypelagica Alvarino, 1962
Eukrohnia hamata (Moebius, 1875)
Pseudosagitta gazellae (Ritter-Zahony, 1909) = ?Flaccisagitta hexaptera (D'Orbigny, 1843) [see Lutschinger, 1993]
Pseudosagitta maxima (Conant, 1896)
?*Serratosagitta serratodentata* (Krohn, 1853)
?Serratosagitta tasmanica Thompson, 1947 [see Alvarino et al. 1983a]
Solidosagitta marri (David, 1956?) =?Sagitta planctonis Steinhaus, 1896 [see Lutschinger, 1993]

ANNELIDA
POLYCHAETA (from Benham, 1929)
Callizona bongraini Gravier, 1911
Maupasia caeca
Pelagobia longicirrata Sagitella kowalewskii Wagner, 1872
Tomopteris carpenteri Quatrefages, 1865
Tomopteris septentrionalis Quatrefages, 1865
Tomopteris cavallii Rosa, 1908
Vanadis antarctica

ARTHROPODA CRUSTACEA
COPEPODA (from Wolfenden, 1908; Farran, 1929; Bradford, 1971; Sertorio et al., 2000; Sertorio & Markhaseva, in prep.; Park, 1979, 1980, 1982, 1983, 1992; Fontaine, 1988; http://www.nmnh.si.edu/iz/usap/) **E** = epipelagic; **M**= mesopelagic; **B** = bathypelagic; **BP** = benthopelagic; **†** = endemic.
CALANOIDA
Aetideopsis antarctica (Wolfenden, 1908) **M BP?**
Aetideopsis minor (Wolfenden, 1911) **MB BP?**
Aetideus australis Vervoort, 1957 **M**
Amallothrix arcuata (Sars, 1920) **M** = ? *Scolecithricella robusta* (T. Scott, 1893)
Amallothrix dentipes (Vervoort, 1951) **M**
Amallothrix polaris (Wolfenden, 1911) **M**
Amallothrix valida (Farran, 1908) **MB**
Arietellidae sp.
Calanoides acutus (Giesbrecht, 1902) **EM**
Calanus propinquus Brady, 1883 **EM**
Candacia maxima Vervoort, 1957 **MB**
Candacia falcifera Farran, 1929 **MB**
Cephalophanes frigidus Wolfenden, 1911
Chiridiella megadactyla Bradford, 1971 **M**
Cornucalanus antarcticus Brodsky & Zvereva, 1950 **B** = *C. robustus* Vervoort, 1957
Ctenocalanus citer Giesbrecht, 1888 **E**
Euaugaptilus antarcticus Wolfenden, 1911 **B**
Euaugaptilus magnus (Wolfenden, 1904) **B**
Euaugaptilus nodifrons (Sars, 1905) **B**

Euchirella rostromagna Wolfenden, 1911 **M**
Farrania frigida (Wolfenden, 1911) **MB**
Gaetanus antarcticus Wolfenden, 1905 **M**
Gaetanus brevispinus (Sars, 1900) **M**
Gaetanus tenuispinus (Sars, 1900) **B**
Haloptilus ocellatus Wolfenden, 1905 **M**
Haloptilus oxycephalus (Giesbrecht, 1889) **MB**
Heterorhabdus austrinus Giesbrecht, 1902 **M**
Heterorhabdus farrani Brady, 1918 **MB**
Heterorhabdus pustilifer Farran, 1929 **M**
Heterostylites longicornis (Giesbrecht, 1888) **M**
Heterostylites major (Dahl, 1894) **MB**
Landrumius antarcticus Parks, 1983 **B**
Lophothrix humilifrons Sars, 1905 **MB**
Lophothrix simplex Wolfenden, 1911 **M**
Lucicutia curta Farran, 1905 **M**
Lucicutia macrocera Sars, 1920 **MB**
Lucicutia magna Wolfenden, 1903 **MB**
Lucicutia ovalis (Giesbrecht, 1889) **MB**
Lucicutia wolfendeni Sewell, 1932 **B**
Metridia curticauda Giesbrecht, 1889 **MB**
Metridia gerlachei Giesbrecht, 1902 **EM**
Metridia princeps Giesbrecht, 1892 **MB**
Micropygmaeus pusillus Sars, 1903 **EMB**
Microcalanus pygmaeus (Sars, 1900) **EMB**
Mimocalanus cultrifer Farran, 1908 **MB**
Mimocalanus inflatus Davis, 1949 **B**
Mixtocalanus altera (Farran, 1929) **M**
Mixtocalanus vervoorti (Park, 1982) **M** = *Scaphocalanus subbrevicornis,* Bradford, 1971
Onchoclanaus magnus (Wolfenden, 1906) **MB**
Onchocalanus wolfendeni Vervoort, 1950 **MB**
Pachyptilus pacificus Johnson, 1936 **MB?**
Paraheterorhabdus farrani (Brady, 1918) **M**
Paralabidocera antarctica (I.C. Thompson, 1898) **E**
Pareuchaeta abbreviata (Park, 1978)
Pareuchaeta antarctica (Giesbrecht, 1902) **EMB**
Pareuchaeta biconvexa (Park, 1978) **B**
Pareuchaeta biloba Farran, 1929 **B**
Pareuchaeta dactylifera (Park, 1978) **B**
Pareuchaeta eltaninae (Park, 1978) **MB**
Pareuchaeta erebi Farran, 1929 **EM†**
Pareuchaeta farrani (With, 1915) **MB**
Pareuchaeta longissima (Park, 1978) **B**
Pareuchaeta parvula (Park, 1978) **B**
Pareuchaeta pseudotonsa (Fontaine, 1967) **B**
Pareuchaeta rasa Farran, 1929 **MB**
Pareuchaeta regalis (Grice & Hulsemann, 1968) **B**
Pareuchaeta similis Wolfenden, 1908 **EMB**
Pareuchaeta tycodesma (Park, 1978) **MB†**
Pleuromamma sp.

Pseudoamallothrix cenotelis Park, 1980 **M**
Pseudoamallothrix emarginata (Farran, 1905) **MB**
Pseudoamallothrix incisa (Farran, 1929) **M**
Pseudoamallothrix ovata (Farran, 1905) **M**
Pseudochirella spectabilis (Sars, 1900) **M** = *Euchirella elongata* Wolfenden, 1905
Pseudochirella hirsuta (Wolfenden, 1905) **MB**
Pseudochirella elongata (Wolfenden, 1905) **M**
Racovitzanus antarcticus Giesbrecht, 1902 **E**
Rhincalanus gigas Brady, 1883 **EM**
Scaphocalanus antarcticus Park, 1982 **MB** = *S. affinis,* Farran, 1929
Scaphocalanus echinatus (Farran, 1908) **MB**
Scaphocalanus farrani Park, 1982 **MB** = *S. brevicornis,* Farran, 1929
Scaphocalanus parantarcticus Park, 1982 **BM**
Scaphocalanus subbrevicornis (Wolfenden, 1911) **M**
Scolecithricella abyssalis Giesbrecht, 1888 **M**
Scolecithricella glacialis (Giesbecht, 1902) **E**
Spinocalanus abyssalis Giesbrecht, 1888 **MB**
Spinocalanus antarcticus Wolfenden, 1906 **M**
Spinoclanaus horridus Wolfenden, 1911 **MB**
Spinocalanus magnus (Wolfenden, 1904) **MB**
Spinocalanus spinipes Brodsky, 1950 **MB**
Spinocalanus spinosus Farran, 1908 **M**
Spinocalanus sp.
Stephos antarcticum **E BP** under ice
Stephos longipes **E BP** under ice
Temorites brevis Sars, 1900 **M**
Tharybis magna Bradford, 1983 **BP** Under Ross Ice Shelf
Undinella acuta Vaupel-Klein, 1970 **M**
Xanthocalanus antarcticus Wolfenden, 1908 **MB**
Xanthocalanus harpagatus Bradford, 1983 **BP** Under Ross Ice Shelf

CYCLOPOIDA
Oithona frigida Giesbrecht, 1902 **E**
Oithona similis Claus, 1866 **E**

HARPACTICOIDA (from Bradford & Wells, 1983; Knox et al., 1996)
Harpacticus furcifer Giesbrecht, 1902

POECILOSTOMATOIDA (inferred from Heron & Bradford-Grieve, 1995)
Conaea rapax Giesbrecht, 1891 **M**
Oncaea antarctica Heron, 1977 **EM**
"Oncaea" curvata Giesbrecht, 1902 **EM**
Oncaea englishi Heron, 1977 **EMB**
Oncaea inflexa Heron, 1977 **EM**
Oncaea lacinia Heron, English & Damkaer, 1984 **EMB**
Oncaea mediterranea (Claus, 1863) **EM**
Oncaea prolata Heron, 1977 **EMB**

OSTRACODA (from Brady, 1907; McKenzie et al., 1990; Benassi et al., 1992; McKenzie et al., 2000)
Alacia belgicae (Mueller, 1906)

Alacia hettacra (Mueller, 1906)
Boroecia antipoda (Mueller, 1906)
Conchoecia innominata Brady, 1907
Conchoecia gr. *magna* (Claus, 1874) [may be *Loricoecia loricata*]
Conchoecissa symmetrica (Mueller, 1906)
Cypridina glacialis Brady, 1907
Gigantocypris muelleri Skogsberg, 1920
Metaconchoecia isocheira (Mueller, 1906)
Metaconchoecia skogsbergi (Iles, 1953)
Paraconchoecia cf. *brachyaskos* (Mueller, 1906)
Paraconchoecia elegans (Sars, 1865)
Philomedes antarctica Brady, 1907
Philomedes assimilis Brady, 1907
Philomedes orbicularis Brady, 1907
Pseudoconchaecia serrulata (Claus, 1874)
Spinoecia obtusata (Sars, 1866)
Xestolebris reniformis Brady, 1907

AMPHIPODA (from Walker, 1907)
Epimeriella macronyx
Eusirus propeperdentatus
Eusirus tridentatus
Vibilia propinqua Stebbing, 1888
Cyllopus magellanicus Dana, 1852
Hyperia macrocephala
Hyperia medusarum (Mueller, 1776) as *H. gaudichaudii*
Hyperiella macronyx (Walker, 1906)
Hyperiella dilatata Stebbing, 1888
Orchomene plebs
Orchomene rossi

MYSIDACEA (from Tattersall, 1908; Crescenti et al., 1994; Tattersall, 1965)
Antarctomysis maxima (Holt & Tattersall, 1906)
Antarctomysis ohlini Hansen, 1908
Boreomysis brucei Tattersall, 1913
Caesaromysis hispida Ortmann, 1893
Dactylambliops hodgsoni Holt & Tattersall, 1906
Euchaetomera zurstrasseni (Illig, 1906)
Hansenomysis antarctica Holt & Tattersall, 1906
Pseudomma belgicae Holt & Tattersall, 1906
Mysidetes posthon Holt & Tattersall, 1906

EUPHAUSIACEA (from Tattersall, 1908)
Euphausia superba Dana, 1852
Euphausia crystallorophias Holt & Tattersall, 1906
Euphausia triacantha Holt & Tattersall, 1906
Thysanoessa macrura Sars, 1883

DECAPODA (from Carli & Pane, 2000)
Pelagic larvae
Acanthephyra pelagica (Risso, 1816)
Chorismus antarcticus (Pfeffer, 1887)
Notocrangon antarcticus (Pfeffer, 1887)

NATANTIA (inferred from Yaldwyn, 1965)
Hymenodora gracilis Smith, 1886
Nematocarcinus lanceopes Bate, 1888
Pasiphaea longispina Lenz & strunk, 1914
Pasiphaea scotiae (Stebbing, 1914)
Petalidium foliaceum Bate, 1888

MOLLUSCA
GASTROPODA (from Powell, 1965)
Lamellariopsis
Marseniposis conica

PTEROPODA (from Chen, 1971; Powell, 1965)
Limacina antarctica (Woodward, 1854)
Limacina helicina (Phipps, 1774)
Clio pyramidata forma *sulcata*
Clione limacinba antarctica Smith, 1902
Spongiobranchata australis D'Orbigny, 1836
Thilea procera Strebel

UROCHORDATA
Salpidae From Garstang (1933), Herdman (1910)
Dolioloides resistibile (Neumann, 1913)
Salpa hexagona Quoy & Gaim, xxxx
?*Folia gigas* Garstang & Georgeson, 1935

APPENDICULARIA (inferred from Esnal 1999)
Fritillaria antarctica Lohmann, 1905
Fritillaria borealis Lohmann, 1896
Fritillaria pellucida (Busch, 1851)
Oikopleura drygalskii Lohmann & Buckmann, 1926
Oikopleura gaussica Lohmann, 1905
Pelagopleura austrlis (Buckmann, 1923)
Pelagopleura magna (Lohmann, 1826)

LARVAL FISH (from Vacchi et al. 2000)

Nototheniidae:
Dissostichus mawsoni Norman
Notothenia coriiceps Richardson
Pleurogramma antarcticum Boulenger
Trematomus bernacchii Boulanger
Trematomus eulepidotus Regan
Trematomus hansoni Boulanger
Trematomus lepidorhinus Pappenheim

Trematomus loennbergii Regan
Trematomus newnesi Boulanger
Trematomus nicolai Boulenger
Trematomus pennellii Regan
Trematomus scotti Boulenger
Pagothenia borchgrevinki Boulenger

Bathydraconidae:
Cygnodraco mawsoni Waite
Gymnodraco acuticeps Boulenger
Prionodraco evansii regan

Channichthyidae
Chaenodraco wilsoni Regan
Chionodraco hamatus Lonnberg
Chionodraco myersi DeWhitt & Tyler
Crydraco sp. Dollo
Neopagetopsis ionah Nybelin
Pagetopsis macropteris Boulenger

Artedidraconidae
Artedidarco loennbergii Roule
Histiodraco velifer Regan
Pogonphryne scotti regan

Liparidae
Paraliparis sp.

MESOPELAGIC FISH (see Table 6.1)

Table 4.4.2.1. List of taxa recorded in the White Island tide-crack and adjacent ice hole, and under the ice in McMurdo Sound (from Bradford, 1981; Waghorn & Knox 1988; Knox et al. 1996).

ANNELIDA
Polychaeta larvae

CRUSTACEA
OSTRACODA
Conchoecia beligicae

COPEPODA
CALANOIDA
Calanoides acutus (Giesbrecht, 1902) **EM**
Calanus propinquus Brady, 1883 **EM**
Ctenocalanus citer Giesbrecht, 1888 **E**
Pareuchaeta sp.
Metridia gerlachei Giesbrecht, 1902 **EM**
Microcalanus pygmaeus (Sars, 1900) **EMB**
Paralabidocera grandispina Waghorn, 1979 **E†**
Pareuchaeta antarctica (Giesbrecht, 1902) **EMB**
Pareuchaeta erebi Farran, 1929 **EM†** McMurdo Sound
Pareuchaeta similis Wolfenden, 1908 **EMB**
Pareuchaeta tycodesma (Park, 1978) **EB**
Pseudocyclopia sp. **BP**
Racovitzanus antarcticus Giesbrecht, 1902 **E**
Stephos longipes **E BP** under ice

CYCLOPOIDA
Oithona similis Claus, 1866 **E**
Pseudocyclopina belgica Giesbrecht, 1902

HARPACTICOIDA
Harpacticus furcatus Lang, 1936
Harpacticus furcifer Giesbrecht, 1902
Microsetella sp.
Pseudodiosaccus sp.
Tisbe gracilipes T. Scott, 1912
Tisbe prolata Waghorn, 1979 †
Tisbe racovitzai (Giesbrecht, 1902)

POECILOSTOMATOIDA
Oncaea curvata Giesbrecht, 1902 **EM**

AMPHIPODA
Hyperiella macronyx
Orchomene rossi
Orchomene plebs
Probolisca ovata
EUPHAUSIACEA

Euphausia crystallorophias
Thysanoessa macrura

CHAETOGNATHA
Sagitta sp.

PTEROPODA
Clione limacina antarctica
Limacina antarctica

FISH
Prionodraco evansi
Pleurogramme antarctcum

Table 4.4.3.1. List of taxa recorded under the Ross Shelf at Ross Ice Shelf Project station J-9 (from Azam et al. 1979; Bruchhausen et al. 1979; Lipps et al. 1979; Stockton, 1982; Bradford & Wells, 1983).

BACTERIA

DIATOMS
Fragilariopsis sp.
Pleurosigma sp.

DINOFLAGELLATE
Peridinium depressum

CRUSTACEA

COPEPODA
CALANOIDA
Xanthocalanus harpagatus Bradford & Wells, 1983
Tharybis magna Bradford & Wells, 1983
CYCLOPOIDA
Nauplii of *Oithona*
HARPACTICOIDA
Tisbe spinulosa Bradford & Wells, 1983
Tisbe prolata Waghorn, 1979
Longipedia weberi A. Scott, 1909

ISOPODA
Serolis trilobitoides

AMPHIPODA
Orchomene plebs
Orchomene rossi
Cyphocaris sp.
Uristes sp.

MYSIDACEA
Antarctomysis maxima

FISH
Trematomus cf. *loennbergii*
?Gymnodraco acuticeps

Table 4.4.4.1. Copepods found in the pack ice of the Bellingshausen and Amundsen Seas (after Schnack-Schiel et al., 1998).

- Calanoida
  - Stephidae
    - *Stephos longipes*
- Cyclopoida
  - Oithonidae
    - *Oithona similis*
- Poecilostomatioida
  - Oncaeidae
    - *Oncaea curvata*
- Harpacticoida
  - Tisbidae
    - *Drescheriella glacialis* Dahms and Dieckmann
  - Harpacticidae
    - *Harpacticus furcifer* Giesbrecht
  - Ectinosomatidae
    - *Microsetella norvegica* (Boeck 1864)

Table 5.1.3.2.1. Zonation and diversity of rocky bottom benthos in Terra Nova Bay, Ross Sea (from Gambi & Mazzella 1991). Values are numbers m^{-2}; *, mean wet weight (g). A more recent publication (Gambi *et al.* 1994) shows wide variation in densities of many species within some depths.

Species	**Group**	**0.5 m**	**2 m**	**6 m**	**12 m**	**16 m**
Diatom zone						
Diatoms	Diatoms	abundant				
Cyanobacteria	Bacteria	abundant				
Paramoera walkeri	Amphipoda	**6338**	2044	3119	19	6
***Iridaea cordata* zone**						
*Iridaea cordata**	Algae	0	**1,845**	**60**	0	13
Laevilittorina antarctica	Gastropoda	19	**70,625**	462	2856	106
Munna antarctica	Isopoda		**1688**	1219	775	75
Harmothoe brevipalpa	Polychaeta		**650**	419	550	107
Powellisetia deserta	Gastropoda		200	**1619**	1075	194
Austrosignum sp.	Isopoda		1200	**1381**	175	50
Indet. gen et sp. 1	Amphipoda		75	**400**	356	125
Onoba gelida	Gastropoda		56	**306**	150	94
Paramunna rostrata	Isopoda		138	**206**	181	
***Phyllophora antarctica* zone**						
*Phyllophora antarctica**	Algae	0	150	100	**472**	**153**
Nototanais dimorphus	Tanaidacea		5000	5000	**6250**	2544
Hochstetteria sublaevis	Bivalvia		75	319	**869**	6
Pionosyllis cf. *comosa*	Polychaeta		131	106	**575**	69
Indet. gen et sp. 2	Amphipoda			343	**513**	25
Onoba turqueti	Gastropoda		50	25	**181**	88
Total density		**6356**	**82,025**	**15,181**	**14,813**	**3,581**
Total species		**2**	**20**	**20**	**26**	**21**

Table 5.1.3.3.1.1. Densities and diversities of soft-bottom benthos either side of McMurdo Sound and at other Ross Sea locations.

Location	**Total density m^{-2}**	**No. species**	**No. samples**	**Mesh size (mm)**	**Source**
North of McMurdo Sound					
Ross Sea (74° 58'S, 170° 48'E, 500 m)	1,960	-	6	0.5	Dayton & Oliver, 1977
Cape Hallett (100-250 m)	7,755	147	4	1.0	Lowry, 1976
West McMurdo Sound (Antarctic coast)					
Garwood Valley (30 m)	2,184	-	3	0.5	Dayton & Oliver, 1977
Ferrar Glacier (30 m)	6,027	-	3	0.5	Dayton & Oliver, 1977
New Harbour (30-40 m)	10,036	50	3	0.5	Dayton & Oliver, 1977
East McMurdo Sound (Ross Island)					
McMurdo Station jetty (20 m)	118,712	-	10	0.5	Dayton & Oliver, 1977
Cape Armitage (sediment, 20 m)	155,572	37	2	0.5	Dayton & Oliver, 1977
Cape Armitage (sponge mat, 30 m)	145,781	-	2	0.5	Dayton & Oliver, 1977
Cape Bird (35-55 m)	85,105	72	4	1.0	Lowry, 1976

Table 5.5.1. Benthic biota of the Ross Sea region based on published reports in the taxonomic literature and some unpublished records. Note, names used are current for echinoderms, polychaetes, nemertines, sponges, bryozoans, molluscs, amphipods, isopods; the remainder have not been checked for synonyms.

Phylum/Class	Class/Order	Genus	Species	Authority
Rhodophyta		*Ballia*	*callitricha*	J. Agardh.
		Ballia	*sertularoides*	
		Clathromorphum	*lemoineanum*	Mendoza & Cabioch
		Delesseria	*quercifolia*	Bory, 1828
		Erythrotricha	*carnea*	(Dillwyn) J. Agardh
		Gainia	*mollis*	Moe
		Graciliaria	*dumontioides*	Harv. Ex Dickie
		Graciliaria	*simplex*	A. & E.S. Gepp
		Hildenbrandia	*lecannelliere*	Hariot
		Iridaea	*cordata*	(Tourner) Bory
		Iridaea	*micans*	Bory, 1828
		Iridaea	*obovata*	Kutzing
		Leptosomia	*simplex*	(A & ES Gepp) Kylin
		Phycodrys	*antarctica*	(Skottsberg) Skottsberg
		Phyllophora	*antarctica*	A & ES Gepp
		Plocamium	*cartilagineum*	(Linnaeus) Dixon
		Plocamium	*coccineum*	(Hudson) Lyngbye
		Spongoclonium	*orthocladum*	Gepp & Gepp
Heterokontophyta	Phaeophyceae	*Desmarestia*	*aculeata?*	Lam.
		Desmarestia	*harveyana*	Gepp, 1905
		Desmarestia	*menziesii*	J. Agardh.
		Desmarestia	*rossi*	Hook & Harv.
		Desmarestia	*willii*	
		Ectocarpus	*geminatus*	Hook & Harv.
		Geminocarpus	*geminatus*	
		Lessonia	*grandifolia*	Gepp, 1905
		Petroderma	*maculiforme*	
		Phyllogigas	*grandifolia*	Skottsb.
		Zonaria	sp.	
Chlorophyta	Chlorophyceae	*Lola*	*irregularis*	Zaneveld
		Monostroma	*hariotii*	Gain
		Prasiola	*crispa*	(Lightfoot) Meneghini
		Ulothrix	*flacca*	(Dillwyn) Touret
Protozoa	Foraminiferida	*Adercotryma*	*glomerata*	(Brady, 1878)
		Alveolophragmium	*wiesneri*	
		Ammodiscus	*cf. anguillae*	Hoglund, 1947
		Ammodiscus	*charoides*	(Jones & Parker, 1860)
		Ammodiscus	*gordialis*	(Jones & Parker, 1860)
		Ammodiscus	*incertus*	(d'Orbigny, 1839)
		Ammodiscus	*shoneanus*	(Siddall, 1878)
		Ammodiscus	spp.	
		Ammoflintina	n.sp.	unknown
		Ammoglobigerina	*globigeriniformis*	(Parker & Jones, 1865)
		Ammomarginulina	*ensis*	Wiesner, 1931
		Ammomorginulina	*foliacea*	
		Ammopemphix	spp.	Wiesner, 1931
		Angulogerina	*anugulosa*	
		Articulina	*funalis*	Brady, 1884
		Astrammina	*rara*	Rhumbler, 1931
		Astrammina	*sphaerica*	(Heron-Allen & Earland, 1932)
		Astrononion	*antarcticum*	Parr,1950
		Astrononion	*echoisi*	Kennett, 1967
		Astrononion	n.sp.	
		Astrorhiza	*arenaria*	Norman, 1876
		Astrorhiza	*limicola*	Sandahl, 1857
		Astrorhiza	*triangularis*	Earland
		Aveolophragmium	*subglobosum*	
		Bathysiphon	*argenteus*	Heron-Allen & Earland, 1913
		Bathysiphon	*capillaris*	de Folin, 1886
		Bathysiphon	cf. *filiformis*	Sars, 1872
		Bathysiphon	*crassatina*	(Brady)
		Bathysiphon	*discreta*	(Brady, 1884)
		Bathysiphon	*filiformis*	M. Sars
		Bathysiphon	*rufum*	de Folin, 1887
		Bathysiphon	sp.	unknown
		Bathysiphon	*hirudinea*	(Heron-Allen & Earland, 1932)
		Bifarina	*porrecta*	Brady, 1879
		Biloculina	*bulloides*	d'Orbigny, 1826

Biloculina	*depressa var. murrhyna*	Schwager, 1866
Biloculina	*elongata*	d'Orbigny, 1826
Biloculina	*irregularis*	d'Orbigny, 1839
Biloculina	*ringens*	(Larmarck, 1804)
Biloculina	*sphaera*	d'Orbigny, 1839
Bolivina	*decussata*	Brady, 1879
Bolivina	*dilatata*	Reuss, 1849-50
Bolivina	*pseudopunctata*	Hoglund, 1947
Bolivina	*punctata*	d'Orbigny, 1839
Bolivina	*punctata var. aren+E104acea*	Heron-Allen & Earland, 1922
Bolivina	*pygmaea*	Brady, 1884
Bolivina	*robusta*	Brady, 1879
Bolivina	spp.	
Bolivina	*textilarioides var. spinescens*	Cushman, 1910
Botellina	cf. *labyrinthica*	Brady 1881
Botellina	*goesii*	Earland, 1934
Botellina	*labyrinthica*	Brady, 1881
Brizalina	*decussata*	(Brady, 1884)
Brizalina	*seminuda*	(Cushman, 1911)
Bulimina	*aculeata*	d'Orbigny, 1826
Bulimina	*chapmani*	Heron-Allen & Earland, 1922
Bulimina	*echinata*	d'Orbigny, 1826
Bulimina	*elegantissima*	d'Orbigny, 1839
Bulimina	*marginata*	d'Orbigny, 1826
Bulimina	*pupoides*	d'Orbigny, 1846
Bulimina	spp.	
Bulimina	*subteres*	Brady, 1879
Buliminella	*cochlea*	Wiesner, 1931
Buliminella	*elegantissima*	d'Orbigny, 1839
Cassidulina	*bradyi var. elongata*	Sidebottom, 1904
Cassidulina	*calabra*	(Seguenza, 1879-80)
Cassidulina	cf *porrectus*	
Cassidulina	*crassa*	d'Orbigny, 1839
Cassidulina	*laevigata*	d'Orbigny, 1826
Cassidulina	*neocarinata*	
Cassidulina	*oblonga*	Reuss, 1849-50
Cassidulina	*parkeriana*	Brady, 1879
Cassidulina	*porrectus*	
Cassidulina	*subglobossa*	Brady, 1879
Cassidulina	*subglobossa* var. *tuberculata*	Heron-Allen & Earland, 1922
Cassidulinoides	*porrectus*	(Heron-Allen & Earland, 1932)
Cassidulinoides	spp.	
Cassudilinoides	*parkerianus*	(Brady, 1884)
Ceratobulimina	*arctica*	
Chilostomella	spp.	
Cibicides	*bradii*	(Tolmachoff, 1934)
Cibicides	cf. *lobatulus*	
Cibicides	cf. *refulgens*	
Cibicides	*grossepunctatus*	Earland, 1934
Cibicides	*lobatulus*	(Walker & Jacob, 1798)
Cibicides	*refulgens*	Montfort, 1808
Cibicides	spp	
Cibicides	*subhaidingerii*	
Cibicidoides	*dispars*	(d'Orbigny, 1839)
Clavulina	*communis*	d'Orbigny, 1826
Clavulina	*obscura*	Chaster
Clavulina	*parisiensis*	d'Orbigny, 1826
Conotrochammina	*bullata*	(Hoglund, 1947)
Cornuspira	*foliacea*	(Philippi, 1844)
Cornuspira	*involvens*	(Reuss, 1849-50)
Cornuspira	*selseyensis*	Heron-Allen & Earland, 1905
Cornuspira	spp	
Cornuspiroides	*rotundus*	Schmeidl & Mackensen, 1993
Cribrostomoides	*jeffreysi*	(Williamson, 1858)
Cribrostomoides	spp	
Cribrostomoides	*subglobosus*	(Sars, 1869)
Cribrostomoides	*wiesneri*	
Cristellaria	*acutauricularis*	(Fitchel & Moll, 1798)
Cristellaria	*articulata*	(Reuss, 1863-4)
Cristellaria	*convergens*	Bornemann, 1855
Cristellaria	*crepidula*	(Fitchel & Moll, 1798)
Cristellaria	*cultrata*	(Monfort, 1808-10)
Cristellaria	*gibba*	d'Orbigny, 1839

Cristellaria	*paucisepta*	Reuss, 1852
Cristellaria	*rotulata*	(Lamarck, 1804)
Crithionina	*granum*	Goes,1894
Crithionina	*lens*	Goes, 1896
Crithionina	*mamilla*	Goes, 1894
Crithionina	*pisum*	Goes, 1896
Crithionina	*pisum hispida*	Flint, 1899
Crithionina	*rugosa*	Goes, 1896
Cruciloculina	*triangularis*	d'Orbigny, 1839
Cyclammina	*cancellata*	Brady, 1879
Cyclammina	*orbicularis*	Brady, 1879
Cyclammina	*pusilla*	Brady, 1884
Cyclammina	*tasmanica*	Parr
Cyclogyra	*antarctica*	(Rhumbler, 1931)
Cyclogyra	*corticata*	(Chapman & Parr, 1937)
Cyclogyra	*involvens*	(Reuss, 1850)
Cyclogyra	*lacunosa*	(Brady, 1884)
Delosina	*sutilis*	Earland, 1934
Delosina	*wiesneri*	Earland, 1934
Dendronina	*arborescens var. antarctica*	Heron-Allen & Earland, 1922
Dendronina	*aborescens*	Heron-Allen & Earland, 1922
Dendronina	*limosa*	
Dendrophyra	*indivisa*	(Heron-Allen & Earland)
Dentalia	*communis*	(d'Orbigny, 1826)
Dentalina	*communis larva*	(Earland)
Dentalina	sp.	unknown
Dentalina	*translucens*	
Deuterammina	*glabra*	(Heron-Allen & Earland, 1932)
Discopulvinulina	sp.	
Discopulvinulina	*subcomplanata*	(Parr, 1950)
Discorbina	*bertheloti*	(d'Orbigny, 1839)
Discorbina	*chasteri*	Heron-Allen & Earland, 1914
Discorbina	*globularis*	(d'Orbigny, 1826)
Discorbina	*mediterranensis*	(d'Orbigny, 1826)
Discorbina	*parisiensis*	(d'Orbigny, 1826)
Discorbina	*peruviana*	(d'Orbigny, 1839)
Discorbina	*praegeri*	Heron-Allen & Earland, 1913
Discorbina	*pulvinoides*	Cushman, 1910
Discorbina	*rosacea*	(d'Orbigny, 1826)
Discorbina	*turbo*	(d'Orbigny, 1826)
Discorbina	*vilardeboana*	(d'Orbigny, 1839)
Discorbina	*wilsoni*	Heron-Allen & Earland, 1922
Discorbinella	*araucana*	(d'Orbigny, 1839)
Discorbis	cf. *peruviana*	(d'Orbigny)
Eggerella	*bradyi*	(Cushman, 1911)
Eggerella	cf *bradyi*	(Cushman, 1911)
Eggerella	*superba*	Earland, 1934
Ehrenbergia	*glabra*	
Ehrenbergia	*pupa*	(d'Orbigny, 1839)
Ehrenbergiana	*hystrix var. glabra*	Heron-Allen & Earland, 1922
Ehrenbergiana	*serrata*	Reuss, 1849-50
Ehrenbergiana	*glabra*	Heron-Allen and Earland, 1922
Elphidiella	sp.	
Entolingulina	*bicarinata*	Sidebottom, 1907
Entolingulina	*biloculi*	(Wright, 1911)
Epinoides	cf. *punctatulus*	
Epinoides	*tumidulus*	
Epistominella	*exigua*	(Brady,1884)
Epistominella	spp.	
Epistominella	*vitrea*	Parker, 1953
Eponides	n.sp.	
Eponides	*weddellensis*	
Eponides	spp.	
Fissurina	aff. *kerguelensis*	Parr
Fissurina	*alveolata*	
Fissurina	*bisulcata*	(Heron-Allen and Earland, 1932)
Fissurina	cf. *clypeatomarginata*	(Rhymer-Jones, 1874)
Fissurina	cf. *quadricostulata*	(Ruess, 1870)
Fissurina	cf. *reniformis*	(Sidebottom, 1913)
Fissurina	cf. *trigonomarginata*	(Parker & Jones, 1865)
Fissurina	cf. *wrightiana*	(Brady)
Fissurina	*cornigera*	(Buchner, 1940)
Fissurina	*cushmani*	

Fissurina	*fissicarinata*	
Fissurina	*foliformis*	(Buchner, 1940)
Fissurina	*marginata*	(Montagu, 1803)
Fissurina	*marginata fissa*	(Heron-Allen & Earland, 1922)
Fissurina	*mennellae*	(Buchner, 1940)
Fissurina	*nelsoni*	(Heron-Allen and Earland, 1922)
Fissurina	*piriformis*	
Fissurina	*semimarginata*	(Reuss, 1870)
Fissurina	*spathiformis*	(Buchner, 1940)
Fissurina	*subformosa*	Parr, 1950
Fissurina	*subtilis*	(Buchner, 1940)
Fissurina	*texta*	(Wiesner, 1931)
Fissurina	*tingellifera*	(Parker & Jones, 1865)
Fissurina	*trigono-marginata*	(Buchner, 1940)
Frondicularia	*pygmaea*	Sidebottom, 1904
Frondicularia	*spathulata*	Brady, 1879
Fursenkoina	*earlandi*	(Parr, 1950)
Fursenkoina	*davisi*	(Chapman & Parr, 1937)
Fursenkoina	*earlandi*	(Cushman, 1936)
Fursenkoina	*fusiformis*	(Williamson, 1858)
Fursenkoina	*schreibersiana*	(Czjzek, 1848)
Fursenkoina	*davisi*	(Chapman and Parr, 1937)
Fursenkoina	*earlandi*	(Parr, 1950)
Fursenkoina	*fusiformis*	
Gaudryina	*filiformis*	Berthelin, 1880
Gaudryina	*minuta*	Earland
Gaudryina	*scabra*	Brady, 1870
Gaudryina	*siphonella*	Reuss, 1851
Glandulina	*antarctica*	Parr, 1950
Glandulina	*laevigata*	(d'Orbigny, 1826)
Globigerina	*bulloides*	d'Orbigny, 1826
Globigerina	*conglobata*	Brady, 1879
Globigerina	*cretacea*	d'Orbigny, 1840
Globigerina	*dubia*	Egger, 1857
Globigerina	*dutertrei*	d'Orbigny, 1839
Globigerina	*helicina*	d'Orbigny, 1826
Globigerina	*inflata*	d'Orbigny, 1839
Globigerina	*megastoma*	Earland
Globigerina	*pachyderma*	(Ehrenberg, 1873)
Globigerina	*rubra*	d'Orbigny, 1839
Globigerina	*rubra, var. elevata*	d'Orbigny, 1840
Globigerina	*pachyderma*	
Globigerinoides	*conglobatus*	(Brady, 1879)
Globigerinoides	*ruber*	(d'Orbigny, 1839)
Globocassidulina	*biora*	(Crespin,1960)
Globocassidulina	cf. *biora*	(Crespin, 1960)
Globocassidulina	*crassa*	(d'Orbigny, 1839)
Globocassidulina	*crassa rossensis*	
Globocassidulina	n. sp.	
Globocassidulina	n.sp. A	unknown
Globocassidulina	*pacifica*	Cushman, 1925)
Globocassidulina	*parkerianus*	
Globocassidulina	*rossensia*	Kennett, 1967
Globocassidulina	*subglobosa*	(Brady, 1881)
Globocassidulina	*tuberculata*	(Heron-Allen and Earland, 1922)
Globoquadrina	*conglomerata*	(Schwager, 1866)
Globorotalia	*inflata*	(d'Orbigny, 1839)
Globulotuba	cf. *entosoleniformis*	Collins, 1958
Glomospira	*charoides*	
Glomospira	*gordialis*	(Jones and Parker, 1860)
Gordiospira	*fragilis*	Heron-Allen and Earland, 1932
Gromia	*oviformis*	Dujardin, 1835
Gyroidina	*neosoldanii*	Brotzen, 1936
Gyroidina	sp.	
Haplophragmium	*agglutinans*	d'Orbigny, 1846)
Haplophragmium	*anceps*	Brady, 1884
Haplophragmium	*canariense*	(d'Orbigny, 1839)
Haplophragmium	*canariense var. variabilis*	Heron-Allen & Earland, 1916
Haplophragmium	*crassimargo*	Norman, 1892
Haplophragmium	*foliaceum*	Brady, 1879
Haplophragmium	*fontinense*	Terquem, 1867
Haplophragmium	*globigeriniforme*	(Parker & Jones, 1865)
Haplophragmium	*glomeratum*	Brady, 1878

Haplophragmium	*latidorsatum*	(Bornemann, 1855)
Haplophragmium	*nanum*	Brady, 1879
Haplophragmium	*pseudospirale*	(Williamson, 1858)
Haplophragmium	*rotulatum*	Brady, 1879
Haplophragmium	*scitulum*	Brady, 1879
Haplophragmium	*sphaeriloculum*	(Cushman, 1910)
Haplophragmium	*sphaeroidiniforme*	Brady, 1884
Haplophragmium	*tenuimargo*	Brady, 1882
Haplophragmoides	*canariensis*	
Haplophragmoides	cf. *sphaeriloculus*	Cushman, 1917
Haplophragmoides	*rotulatum*	(Brady, 1884)
Haplophragmoides	spp	
Hemisphaerammina	*bradyi*	Loeblich & Tappen 1957
Hemisphaerammina	*depressa*	(Heron-Allen & Earland)
Hemisphaerammina	*limosa*	(Earland)
Heronallenia	*wilsoni*	
Heronallenia	cf. *kempi*	(Heron-Allen & Earland, 1929)
Heronallenia	*kempii*	Chapman & Parr, 1931
Heronallenia	*wilsoni*	(Heron-Allen and Earland, 1922)
Hippocrepinella	*alba*	
Hippocrepinella	*hirudinea*	
Hoeglundina	*elegans*	(d'Orbigny)
Hormosina	*globulifera*	Brady, 1879
Hormosina	*ovicula*	Brady, 1884
Hormosina	*ovicula gracilis*	
Hormosinella	*distans*	(Brady, 1881)
Hormosinella	*ovicula gracilis*	(Earland, 1933)
Hyperammina	*arborescens*	Brady, 1881
Hyperammina	*cylindrica*	Parr, 1950
Hyperammina	*elongata*	Brady, 1878
Hyperammina	*elongata* var. *laevigata*	Wright, 1891
Hyperammina	*friabilis*	Brady, 1884
Hyperammina	*laevigata*	Wright 1891
Hyperammina	*malovensia*	Heron-Allen & Earland, 1932
Hyperammina	*novaezealandiae*	Heron-Allen & Earland
Hyperammina	*ramosa*	Brady, 1879
Hyperammina	spp	
Hyperammina	*subnodosa*	Brady, 1884
Hyperammina	*vagans*	Brady, 1879
Involutina	*anguillae*	
Iridia	*diaphana*	Heron-Allen & Earland, 1905
Islandiella	*porrecta*	(Heron-Allen and Earland, 1932)
Jaculella	*acuta*	
Jaculella	*obtusa*	Brady, 1892
Karreriella	*bardyi*	(Cushman)
Karreriella	*pusilla*	Parr
Lagena	*acuta*	(Ruess, 1858)
Lagena	*alveolata*	Brady, 1884
Lagena	*alveolata* E362 *substiata*	Brady, 1879
Lagena	*annectens*	Burrows & Holland, 1866
Lagena	*apiculata*	(Reuss, 1851)
Lagena	*aspera*	Reuss, 1861
Lagena	*auriculata*	Brady, 1879
Lagena	*bicarinata*	(Terquem, 1882)
Lagena	*bicarinata* var. *spinigera*	Heron-Allen & Earland, 1922
Lagena	*botelliformis*	Brady, 1879
Lagena	*caeris*	
Lagena	*catenulata*	Ruess, 1862
Lagena	cf. *striatopunctata*	Parker and Jones, 1865
Lagena	*clathrata*	Brady, 1884
Lagena	*costata*	(Williamson, 1858)
Lagena	*danica*	Madsen, 1895
Lagena	*desmophora*	Rymer Jones, 1872
Lagena	*distoma*	Parker and Jones, 1865
Lagena	*elongata*	(Ehrenberg, 1844)
Lagena	*exsculpta*	Brady, 1879
Lagena	*fasciata* var. *faba*	Balkwill & Millett, 1884
Lagena	*fieldiana*	
Lagena	*fimbriata*	Brady, 1879
Lagena	*fimbriata* var. *occlusa*	Sidebottom, 1912
Lagena	*forficula*	Heron-Allen & Earland, 1913
Lagena	*formosa*	Schwager, 1866
Lagena	*formosa* var. *comata*	Brady, 1884

Lagena	*foveolata*	Reuss, 1862
Lagena	*foveolata* var. *paradoxa*	Sidebottom, 1912
Lagena	*foveolata, var. spinipes*	Sidebottom, 1912
Lagena	*globosa*	(Walker & Boys, 1874)
Lagena	*gracilis*	Williamson 1848
Lagena	*gracillima*	(Seguenza, 1862)
Lagena	*heronalleni*	Earland, 1934
Lagena	*hexagona*	(Williamson, 1848)
Lagena	*hispida*	Reuss, 1858
Lagena	*laevigata*	(Ruess, 1849-50)
Lagena	*laevis*	(Montagu, 1803)
Lagena	*lagenoides* var. *nuda*	Chapman, 1909
Lagena	*lagenoides* var. *tenuistriata*	Brady, 1879
Lagena	*laureata*	
Lagena	*lineata*	(Williamson, 1848)
Lagena	*longispina*	Brady, 1879
Lagena	*lyelli*	(Seguenza, 1862)
Lagena	*lucida*	(Williamson, 1858)
Lagena	*marginata*	(Walker & Boys, 1784)
Lagena	*marginata* var. *fissa*	Heron-Allen & Earland, 1922
Lagena	*marginata* var. *raricostata*	Sidebottom, 1912
Lagena	*marginata* var. *semimarginata*	Ruess, 1870
Lagena	*marginato-perforata*	Seguenza, 1879-1880
Lagena	*melo*	
Lagena	*mendionalis*	Wiesner, 1931
Lagena	*multicosta*	(Karrer, 1877)
Lagena	*nebulosa*	Cushman, 1923
Lagena	*orbignyana*	(Seguenza, 1862)
Lagena	*orbignyana* var. *concertrica*	Sidebottom, 1912
Lagena	*orbignyana* var. *coronata*	Sidebottom, 1912
Lagena	*orbignyana* var. *unicostata*	Sidebottom, 1912
Lagena	*orbignyana* var. *walleriana*	Wright, 1886
Lagena	*protea*	Chaster, 1892
Lagena	*quadrangularis*	Brady, 1884
Lagena	*quinquelatera*	Brady, 1879
Lagena	*reniformis*	Sidebottom, 1912
Lagena	*reticulata*	(Macgillivary, 1843)
Lagena	*schkichti*	(Silvestri, 1902)
Lagena	*scottii*	Heron-Allen & Earland, 1922
Lagena	*semistriata*	Williamson, 1848
Lagena	*spumosa*	Millett, 1898
Lagena	*squamosa*	(Montagu, 1803-8)
Lagena	*squamosasulcata*	Heron-Allen & Earland, 1922
Lagena	*staphyllearia*	(Schwager, 1866)
Lagena	*stelligera*	Brady, 1879
Lagena	*stelligera* var. *excentrica*	Sidebottom, 1912
Lagena	*stelligera* var. *nelsoni*	Heron-Allen & Earland, 1922
Lagena	*striata*	(d'Orbigny, 1839)
Lagena	*striatopunctata*	Parker & Jones, 1865
Lagena	*subacuticosta*	Parr, 1950
Lagena	*subformosa*	(Parr, 1950)
Lagena	*sulcata*	(Walker & Jacob)
Lagena	*sulcata spicata*	Cushman & McCulloch, 1950
Lagena	*texta*	Wiesner, 1931
Lagena	*unguiculata*	Brady, 1879
Lagena	*ventricosa*	Silvestri, 1903
Lagena	*wiesneri*	
Lagenammina	*atlantica*	(Cushmann, 1944)
Lagenammina	*difflugiformis*	(Brady, 1879)
Lagenammina	*lonicollis*	(Wiesner)
Laryngosigma	*hyalascidia*	Loeblich & Tappen, 1953
Laryngosigma	*williamsoni*	(Terquem, 1878)
Lenticulina	*antarctica*	Parr, 1950
Lenticulina	*asterizans*	Parr, 1950
Lenticulina	*gibba*	(d'Orbigny, 1839)
Lingulina	*biloculi*	Wright, 1910-11
Lingulina	*vitrea*	d'Orbigny, 1826
Marginulina	*glabra*	d'Orbigny, 1826
Marsipella	*cylindrica*	Brady, 1882
Marsipella	*elongata*	
Martinottella	*nodulosa*	
Martinottiella	*antarctica*	(Parr, 1950)
Miliammina	*arenacea*	(Chapman, 1916)

Miliammina	*earlandi*	Loeblich & Tappen, 1955
Miliammina	*lata*	Heron-Allen & Earland, 1930
Miliammina	*obliqua*	Heron-Allen & Earland, 1930
Miliolina	*auberiana*	(d'Orbigny 1839)
Miliolina	*bosciana*	(d'Orbigny, 1839)
Miliolina	*bucculenta*	Brady, 1884
Miliolina	*calcarata*	Heron-Allen & Earland, 1922
Miliolina	*circularis*	(Bornemann, 1855)
Miliolina	*contorta*	(d'Orbigny, 1846)
Miliolina	*labiosa*	(d'Orbigny, 1839)
Miliolina	*oblonga*	(Montagu, 1803)
Miliolina	*oblonga var. arenacea*	Chapman, 1914
Miliolina	*pygmaea*	(Reuss, 1849-50)
Miliolina	*seminulum*	(Linne, 1767)
Miliolina	*tricarinata*	(d'Orbigny, 1826)
Miliolina	*trigonula*	(Lamarck, 1804)
Miliolina	*venusta*	(Karrer, 1869)
Miliolinella	*#REF!*	
Miliolinella	*chukchiensis*	Loeblich and Tappan,1953
Miliolinella	*circularis*	(Bornemann, 1855)
Miliolinella	n. sp.	unknown
Miliolinella	*subrotunda*	(Montagu, 1803)
Neoglabratella	*wiesneri*	(Parr, 1950)
Neogloboquadrina	*dutertrei*	(d'Orbigny, 1839)
Neogloboquadrina	*pachyderma*	(Ehrenberg, 1861)
Nodosaria	*calomorpha*	Reuss, 1865-6
Nodosaria	*communis*	d'Orbigny
Nodosaria	*laevigata*	d'Orbigny, 1826
Nodosaria	*mariae*	d'Orbigny, 1846
Nodosaria	*mucronata*	(Neugeboren, 1856)
Nodosaria	*pauperata*	(d'Orbigny, 1846)
Nodosaria	*raphanistrum*	(Linne, 1767)
Nodosaria	*rotundata*	(Reuss, 1849-50)
Nodulina	*dentaliniformis*	(Brady, 1884)
Nodulina	*subdentaliniformis*	Parr 1950
Nonion	*barleeanum*	
Nonion	*germanicus*	
Nonion	*iridea*	Heron-Allen & Earland, 1932
Nonionella	*bradyi*	(Chapman, 1916)
Nonionellina	*antarctica*	
Nonionina	*asterizans*	(Fichtel & Moll, 1798)
Nonionina	*communis*	d'Orbigny, 1826
Nonionina	*depressula*	(Walker & Jacob, 1798)
Nonionina	*pompilioides*	(Fichtel & Moll, 1798)
Nonionina	*scapha*	(Fichtel & Moll, 1798)
Nonionina	*stelligera*	d'Orbigny, 1839
Nonionina	*turgida*	(Williamson, 1858)
Nonionina	*turgida, var. arenacea*	Heron-Allen & Earland, 1922
Nonionina	*umbilicatula*	(Montagu, 1803-8)
Notodendrodes	*antarctikos*	DeLaca, Lipps & Hessler, 1980
Notodendrodes	*cf. antarctikos*	DeLaca, Lipps & Hessler, 1980
Oculosiphon	*linearis*	
Oolina	*apiculata*	
Oolina	*apiopleura*	(Loeblich & Tappan, 1953)
Oolina	*borealis*	Loeblich & Tappan, 1954
Oolina	*botelliformis*	(Brady, 1884)
Oolina	*catenulata*	(Ruess, 1863)
Oolina	*caudigera*	(Wiesner, 1931)
Oolina	*felsinea*	(Fornasini, 1901)
Oolina	*globosa*	(Montagu)
Oolina	*heteromorpha*	
Oolina	*hexagona*	
Oolina	*lineata*	(Williamson, 1848)
Oolina	*melo*	
Oolina	*pseudocatenulata*	
Oolina	*squamososulcata*	(Heron-Allen & Earland, 1922)
Oolina	*striatoppunctata*	
Oolina	*vilardeboana*	d'Orbigny, 1839
Operculina	*ammonoides*	(Gronovius, 1781)
Orbulina	*universa*	d'Orbigny, 1839
Oridorsalis	*tener*	(Brady)
Oridorsalis	*umbonatus*	
Osangularia	*umbonifera*	

Parafissurina	cf. *Fissurina wilsoni*	(Heron-Allen and Earland, date unkno
Parafissurina	cf. *laevigata*	(Ruess, 1850)
Parafissurina	cf. *ventricosa*	(Silvestri, 1904)
Parafissurina	*curta*	Parr, 1950
Parafissurina	*dorbignyana*	
Parafissurina	*fusiformis*	Wiesner, 1931
Parafissurina	*fusuliformis*	Loeblich & Tappen, 1953
Parafissurina	*lata*	(Wiesner, 1931)
Parafissurina	*lateralis*	(Cushman, 1913)
Parafissurina	*marginata*	
Parafissurina	n.sp. A	unknown
Parafissurina	n.sp. A	
Parafissurina	n.sp. B	unknown
Parafissurina	*pseudoorbignyana* var. *typica*	Buchner, 1940
Parafissurina	*pustulata*	(Buchner, 1940)
Parafissurina	sp.	
Parafissurina	*staphylearia*	(Buchner, 1940)
Parafissurina	*subcarinata*	Parr, 1950
Parafissurina	*tricarinata*	Parr, 1950
Parafissurina	*valida*	(Matthes, 1939)
Parafissurina	*wiesneri*	Parr, 1950
Patellina	*antarctica*	Parr, 1950
Patellina	*corrugata*	Williamson, 1858
Patellinoides	*depressa*	Heron-Allen & Earland, 1932
Pelosina	*bicaudata*	(Parr, 1950)
Pelosina	*cylindrica*	Brady, 1884
Pelosina	*rotundata*	Brady, 1879
Pelosina	*variabilis*	Brady, 1879
Pelosphaera	*cornuta*	Heron-Allen & Earland
Placopsilina	*cenomana*	d'Orbigny, 1850
Placopsilina	*kingsleyi*	Siddall, 1886
Planispirinoides	*bucculentus*	(Brady, 1884)
Planispirinoides	*bucculeuta placentiformis*	(Brady, 1884)
Planorbulina	*medditerranensis*	d'Orbigny, 1826
Polymorphina	*angusta*	Egger, 1857
Polymorphina	*communis*	d'Orbigny, 1826
Polymorphina	*compresa*	d'Orbigny, 1846
Polymorphina	*gibba*	d'Orbigny, 1826
Polymorphina	*lanceolata*	Reuss, 1851
Polymorphina	*ovata*	d'Orbigny, 1846
Polymorphina	*problema*	d'Orbigny, 1826
Polymorphina	*rotundata*	(Bornemann, 1855)
Polymorphina	*sororia*	Reuss, 1863
Polystomella	*faba*	(Fichtel & Moll, 1798)
Polystomella	*striatopunctata*	(Fichtel & Moll, 1798)
Polystomella	*striatopunctata* var. *selseyensis*	Heron-Allen & Earland, 1908
Portatrochammina	*antarctica*	(Parr, 1950)
Portatrochammina	*cf bipolaris*	
Portatrochammina	*eltaninae*	Echols, 1971
Portotrochammina	*wiesneri*	(Parr)
Psammophax	*consociata*	Rhumbler, 1931
Psammosiphonella	*discreta*	
Psammosphaera	*fusca*	Schulze, 1875
Psammosphaera	*parva*	Flint, 1899
Psammosphaera	cf. *rustica*	Heron-Allen and Earland, 1912
Psammosphaera	*rustica*	Heron-Allen & Earland, 1912
Pseudobolivina	*antarctica*	
Pseudobulimina	*chapmani*	(Heron-Allen and Earland, 1922)
Pseudonodosaria	sp.	unknown
Pseudonodosinella	*nodulosa*	(Brady, 1879)
Pseudowebbinella	*goesi*	(Hoglund, 1947)
Pullenia	*bulloides*	(d'Orbigny, 1846)
Pullenia	*quinqueloba*	(Reuss, 1851)
Pullenia	*sphaeroides*	(d'Orbigny, 19\826)
Pullenia	*subcarinata*	d'Orbigny, 1939
Pulvinulina	*brongniartii*	(d'Orbigny, 1826)
Pulvinulina	*crassa*	(d'Orbigny, 1840)
Pulvinulina	*elegans*	(d'Orbigny, 1826)
Pulvinulina	*exigua*	Brady, 1884
Pulvinulina	*haueri*	(d'Orbigny, 1846)
Pulvinulina	*karsteni*	(Reuss, 1855)
Pulvinulina	*oblonga*	(Williamson,xxxx)
Pulvinulina	*partschiana*	(d'Orbigny, 1846)

Pulvinulina	*pauperata*	Parker & Jones, 1865
Pulvinulina	*repanda*	(Fitchtel & Moll, 1798)
Pulvinulina	*umbonata*	(Reuss, 1851)
Pyrgo	cf. *murrhina*	(Schwager, 1866)
Pyrgo	*depressa*	(d'Orbigny, 1826)
Pyrgo	*elongata*	(d'Orbigny, 1826)
Pyrgo	*inornata*	(d'Orbigny)
Pyrgo	*oblonga*	
Pyrgo	*patagonica*	(d'Orbigny)
Pyrgo	*pisum*	(Schlumberger, 1891)
Pyrgo	*ringens*	(Lamarck, 1804)
Pyrgo	spp.	
Pyrgo	*subsphaerica*	(d'Orbigny, 1826)
Pyrgo	*williamsoni*	(Silvestri, 1923)
Pyrgoella	*sphaera*	(d'Orbigny, 1839)
Quinqueloculina	cf. *sigmoilinoides*	Vella, date unknown
Quinqueloculina	*seminulum*	
Recurvoides	*contortus*	Earland, 1934
Reophax	*advena*	Cushman, 1919
Reophax	*ampullacea*	Brady, 1879
Reophax	*bacillaris*	Brady, 1879
Reophax	*bilocularis*	Flint 1899
Reophax	cf. *difflugiformis*	
Reophax	*cushmani*	Heron-Allen & Earland, 1932
Reophax	*cylindrica*	Brady, 1884
Reophax	*dentaliniformis*	Brady, 1879
Reophax	*difflugiformis*	Brady, 1879
Reophax	*distans*	Brady, 1884
Reophax	*fusiformis*	(Williamson, 1858)
Reophax	*goesii*	(Earland, 1934)
Reophax	*longiscatiformis*	Chapman, 1914
Reophax	*nodulosa*	Brady, 1879
Reophax	*ovicula*	
Reophax	*pauciloculatus*	Rhumbler, 1931
Reophax	*piluller*	Brady, 1881
Reophax	*pseudodistans* E641 *tenuis*	Parr, 1950
Reophax	*sabulosus*	Brady
Reophax	*scorpiurus*	Montfort, 1808
Reophax	*scorpiurua*	de Monfort, 1808
Reophax	*spiculifera*	Brady, 1879
Reophax	*spiculior*	Brady 1879
Reophax	*subdentaliniformis*	Parr, 1950
Reophax	*subfusiformis*	Earland
Reophax	*turbo*	
Rhabdammina	*abyssorum*	M. Sars, 1868
Rhabdammina	cf. *linearis*	Brady
Rhabdammina	*discreta*	Brady, 1881
Rhabdammina	*linearis*	Brady, 1879
Rhabdamminella	*cylindrica*	
Rhizammina	*algaeformis*	Brady, 1879
Rhizammina	cf. *algaeformis*	
Rhizammina	*indivisa*	
Robertinoides	*wiesneri*	(Parr, 1950)
Robulus	*asterizans*	Parr, 1950
Robulus	sp.	unknown
Rosalina	*bradyi*	
Rosalina	*globularis*	d'Orbigny, 1826
Rotolia	*beccarii*	(Linne, 1767)
Rotolia	*perlucida*	Heron-Allen & Earland, 1913
Rotolia	*soldanii*	d'Orbigny, 1826
Rotolia	*soldanii* var. *arenacea*	Heron-Allen & Earland, 1922
Rupertina	*stabilis*	(Wallich, 1877)
Saccammina	*atlantica*	(Cushman, 1944)
Saccammina	cf. *fragilis*	le Calvez
Saccammina	cf. *tubulata*	Rhumbler
Saccammina	sp.	
Saccammina	*sphaerica*	G.O Sars,1872
Saccorhiza	*ramosa*	(Brady, 1879)
Schackoinella	*antarctica*	Ward & Quilty, sp. nov.
Scutuloris	*hornibrooki*	(Vella, 1957)
Scutuloris	*serra*	(Crespin, 1960)
Seabrookia	*earlandi*	Wright, 1891
Sigmoilina	*obesa*	

Sigmoilina	*umbonata*	Heron-Allen & Earland, 1922
Sigmorphina	*subulata*	
Siphotextularia	*obesa*	Parr
Soroaphaera	sp.	
Sphaeroidina	*bulloides*	d'Orbigny, 1826)
Spirillina	*decorata*	Brady, 1884
Spirillina	*dimidiata*	Wiesner, 1931
Spirillina	*limbata*	Brady, 1879
Spirillina	*multispira*	Parr, 1950
Spirillina	*obconica*	Brady, 1879
Spirillina	*obconica* var. *carinata*	Halkyard, 1889
Spirillina	*radiosa*	Parr, 1950
Spirillina	*spinulosa*	Chapman & Parr, 1937
Spirillina	*tuberculata*	Brady, 1879
Spirillina	*vivipara*	Ehrenberg, 1841
Spirillina	*wrightii*	Heron-Allen & Earland, 1930
Spiroplecta	*annectens*	(Parker & Jones, 1859)
Spiroplecta	*biformis*	(Parker & Jones, 1859)
Spiroplectammina	*filiformis*	Earland, 1933
Spiroplectammina	*subcylindrica*	Earland
Stainforthia	*complanata*	(Egger, 1893)
Stainforthia	*concava*	(Hoglund, 1947)
Technitella	*legumen*	Norman 1878
Textularia	*antarctica*	(Wiesner, 1931)
Textularia	cf. *agglutinans*	d'Orbigny
Textularia	*concava* var. *heterostoma*	Fornasini, 1883
Textularia	*earlandi*	Parker, 1951
Textularia	*tenuissma*	
Textularia	*wiesneri*	
Tholosina	*bulla*	(Brady, 1879)
Tholosina	*laevis*	Rhumbler
Tholosina	*vesicularis*	
Thurammina	*albicans*	Brady, 1884
Thurammina	*cariosa*	Flint, 1899
Thurammina	cf. *compressa*	Brady, 1897
Thurammina	*compressa*	Brady
Thurammina	*corrugata*	Earland
Thurammina	*papillata*	Brady, 1879
Thurammina	*papillata* var. *albicans*	Brady, 1879
Thurammina	*papillata* var. *favosa*	Flint, 1899
Thurammina	*papillata* var. *haeusleri*	Heron-Allen & Earland, 1912
Thurammina	*protea*	Earland, 1933
Tolypammina	*vagans*	(Brady, 1879)
Trifarina	*angulosa*	
Trifarina	*angulosa* morph "*asperula*"	
Trifarina	*earlandi*	(Parr, 1950)
Trifarina	*pauperata*	(Heron-Allen & Earland, 1932)
Triloculina	*oblonga*	(Montagu, 1803)
Triloculina	*rotunda*	
Triloculina	*tricarinata*	
Triloculina	*trigonula*	
Trochammina	*alternans*	Earland
Trochammina	*antarctica*	Parr, 1950
Trochammina	cf. *nana*	
Trochammina	cf. *ochracea*	(Williamson)
Trochammina	*cornica*	Earland, 1934
Trochammina	*gaboensis*	Parr, 1950
Trochammina	*galeata*	Brady, 1879
Trochammina	*geboensis*	
Trochammina	*glabra*	
Trochammina	*grisea*	
Trochammina	*inconspicua*	Earland
Trochammina	*inflata*	(Montagu, 1808)
Trochammina	*intermedia*	
Trochammina	*nana*	
Trochammina	*nitida*	Brady, 1879
Trochammina	*ochracea*	(Williamson, 1858)
Trochammina	*pauciloculata*	Brady, 1879
Trochammina	*robertsoni*	Brady, 1879
Trochammina	*rossensis*	
Trochammina	*rotaliformis*	Wright, 1885
Trochammina	*sorosa*	Parr
Trochammina	*squamata*	Jones and Parker, 1860

	Trochammina	*tricamerata*	Earland, 1934
	Trochammina	*trullissata*	Brady, 1879
	Trochammina	*wiesneri*	
	Truncatulina	*akneriana*	(d'Orbigny, 1846)
	Truncatulina	*dutemplei*	(d'Orbigny, 1846)
	Truncatulina	*haidingerii*	(d'Orbigny, 1846)
	Truncatulina	*lobatula*	(Walker & Jacob, 1798)
	Truncatulina	*lobatula* var. *arenacea*	Heron-Allen & Earland, 1922
	Truncatulina	*pygmaea*	(Hantken, 1875)
	Truncatulina	*reflugens*	(Montfort, 1808-10)
	Truncatulina	*robertsoniana*	Brady, 1879
	Truncatulina	*tenera*	Brady, 1884
	Truncatulina	*tumidula*	(d'Orbigny, 1846)
	Truncatulina	*ungeriana*	(d'Orbigny, 1846)
	Truncatulina	*variablis*	d'Orbigny, 1826
	Truncatulina	*wuellerstorfi*	(Schwager, 1866)
	Tubinella	*funalis*	(Brady, 1884)
	Turritellella	*shoneana*	(Siddall, 1878)
	Uvigerina	*angulosa*	Williamson, 1858
	Uvigerina	*asperula*	Czjzek, 1848
	Uvigerina	*bassensis*	Parr
	Uvigerina	*canariensis*	d'Orbigny, 1839
	Uvigerina	*pygmaea*	d'Orbigny, 1826
	Uvigerina	*aculeata*	d'Orbigny, 1846
	Vaginulina	*legumen*	(Linne, 1788)
	Vaginulina	*subelegans*	Parr, 1950
	Vanhoeffenella	*gaussi*	Rhumbler, 1905
	Verneuilina	*minuta*	
	Verneuilina	*propinqua*	Brady, 1884
	Verneuilina	*pusilla*	Goes, 1894
	Verneuilina	*pygmaea*	(Egger, 1857)
	Verneuilina	*minuta*	Wiesner, 1931
	Vernuilina	*advena*	Cushman, 1922
	Vernuilina	*minuta*	Wiesner, 1931
	Virgulina	*schreibersianna*	Czjzek, 1848
	Virgulina	*subsquamosa*	Egger, 1857
	Webbina	*clavata*	(Jones & Parker, 1860)
Ctenophora	*Lyrocteis*	*flavopallidus*	Robilliard & Dayton, 1972
Porifera	*Acanthorhabdus*	*fragilis*	Burton, 1929
	Achramorpha	*glacialis*	Jenkin, 1908
	Achramorpha	*grandinis*	Jenkin, 1908
	Achramorpha	*nivalis*	Jenkin, 1908
	Achramorpha	*truncata*	Topsent, 1908
	Adocia	*cucurbitiformis*	Kirkpatrick, 1907
	Adocia	*glacialis*	Ridley & Dendy, 1886
	Adocia	*tenella*	Ridley & Dendy, 1886
	Amphilectus	*rugosa* var. *major*	Hentschel, 1914
	Anaulosoma	*schulzii*	Kirkpatrick, 1907
	Anchinoe	*latrunculioides*	Ridley & Dendy, 1886
	Anoxycalyx	*ijimai*	Kirkpatrick, 1907
	Aplysina	*minima*	Hentschel, 1914
	Artemesina	*apollinis*	Ridley & Dendy, 1887
	Artemisina	*plumosa*	Hentschel, 1914
	Artemisina	*tubulosa*	Koltun, 1964
	Asbestopluma	*belgicae*	Topsent, 1902
	Atergia	*acanthoxa*	Koltun, 1964
	Aulorossella	*levis*	Kirkpatrick, 1907
	Aulorossella	*longstaffi*	Kirkpatrick, 1907
	Aulorossella	*pilosa*	Kirkpatrick, 1907
	Axinella	*supratumescens*	Topsent, 1907
	Axociella	*flabellata*	Topsent, 1917
	Axociella	*nudificata*	Kirkpatrick, 1907
	Calyx	*arcuarius*	Topsent, 1913
	Calyx	*stipitatus*	Topsent, 1916
	Cercidochela	*lankesteri*	Kirkpatrick, 1907
	Chalina	*altera*	Topsent, 1901
	Chalina	*dancoi*	Topsent, 1901
	Chalina	*penicillata*	Topsent, 1908
	Chalina	*topsenti*	Thiele, 1905
	Chalina	*virens*	Topsent, 1908
	Chondrocladia	*clavata*	Ridley & Dendy, 1886
	Chondropsis	*chaliniformis*	Carter, 1886
	Cinachyra	*antactica*	Carter, 1872

Cinachyra	*barbata*	Sollas, 1886
Cinachyra	*vertex*	Lendenfeld, 1907
Cinachyra	*vertex* var. *monticularis*	Lendenfeld, 1907
Cladochalina	*dendyi*	Burton, 1929
Cladothenea	*andriashevi*	Koltun, 1964
Clathria	*pauper*	Brondsted, 1924
Clathria	*toxipraedita*	Topsent, 1913
Clathrina	*coriacea*	Haeckel, 1872
Clathrina	*primordialis*	Haeckel, 1872
Craniella	*leptoderma*	Sollas, 1888
Craniella	*sagitta* var. *microsigma*	Lendenfeld, 1907
Craniella	*sagitta* var. *pachyrrhabdus*	Lendenfeld, 1907
Dendrilla	*membranosa*	Pallas, 1776
Dermatreton	*charteceum*	Jenkin, 1908
Dermatreton	*hodgsoni*	Jenkin, 1908
Desmacella	*vestibularis*	Wilson, '904
Desmacidon	*doryphora*	Brondsted, '924
Desmacidon	*fruticosa*	Montagu, 1818
Desmacidon	*kerguelenensis* var. *antarctica*	Ridley & Dendy, 1887
Desmacidon	*kerguelenensis* var. *cactoides*	Kirkpatrick, 1908
Desmacidon	*maeandrina*	Kirkpatrick, 1907
Desmacidon	*spinigera*	Kirkpatrick, 1908
Ectodoryx	*nobilis*	Ridley & Dendy, 1886
Ectodoryx	*ramilobosa*	Topsent, 1916
Ectyodoryx	*antactica*	Hentschel, 1914
Ectyodoryx	*minuta*	Calcinai & Pansini, 2000
Ectyomyxilla	*hentscheli*	Burton, 1929
Ectyomyxilla	*keruelensis*	Hentschel, 1914
Esperiopsis	*informis*	Stephens, 1915
Esperiopsis	*villosa*	Carter, 1874
Eurypon	*miniaceum*	Thiele, 1905
Gelliodes	*benedeni*	Topsent,1901
Gelliodes	*spongiosus*	Topsent, 1916
Gellius	*bidens*	Topsent, 1901
Gellius	*cucurbitiformis*	Kirkpatrick, 1907
Gellius	*fimbriatus*	Kirkpatrick, 1907
Gellius	*glacialis* var. *nivea*	Ridley & Dendy, 1887
Gellius	*phakellioides*	Kirkpatrick, 1907
Gellius	*pilosus*	Kirkpatrick, 1907
Gellius	*rudis*	Topsent, 1901
Gellius	*tenella*	
Geodinella	*vestigifera*	Dendy, 1924
Grantia	*chartacea*	Jenkin, 1908
Grantia	*cirrata*	Jenkin, 1908
Grantia	*hirsuta*	Topsent, 1907
Grantia	*tenuis*	Urban, 1908
Grantiopsis	*cylindrica*	Dendy, 1892
Guitarra	*fimbriata*	Carter, 1874
Gymnorossella	*inermis*	Topsent, 1916
Halichondria	*panicea*	Pallas, 1766
Halichondria	*variabilis*	Ridley, 1884
Haliclona	*dancoi*	Topsent, 1902
Haliclona	*penicillata*	Topsent, 1908
Halisarca	*dujardini* var. *magellanica*	Topsent, 1901
Hemiastrella	*digitata*	Burton, 1929
Hircinia	*variabilis*	Schulze, 1879
Homaxinella	*balfourensis*	Ridley & Dendy, 1887
Homaxinella	*flagelliformis*	Ridley & Dendy, 1886
Homaxinella	*supratumescens*	Topsent, 1907
Hoplakithara	*dendyi*	Kirkpatrick, 1907
Hyalascus	*hodgsoni*	Kirkpatrick, 1907
Hymedesmia	*areolata*	Thiele, 1905
Hymedesmia	*exigua*	Kirkpatrick, 1907
Hymedesmia	*rufa*	Kirkpatrick, 1907
Hymedesmia	*unguifera*	Burton, 1929
Hypodictyon	*longstaffi*	Jenkin, 1908
Inflatella	*belli*	Kirkpatrick, 1907
Inflatella	*coelosphaeroides*	Koltun, 1964
Inflatella	*latrunculioides*	(Ridley & Dendy, 1886)
Iophon	*flabellodigitatus*	Kirkpatrick, 1907
Iophon	*radiatus*	Topsent, 1902
Iophon	*spatulatus*	Kirkpatrick, 1907
Iophon	*terranovae*	Calcinai & Pansini, 2000

Iophon	*unicornis*	Topsent, 1907
Iophonopsis	*radiatus*	Topsent, 1901
Isodictya	*antarctica*	Kirkpatrick, 1908
Isodictya	*cactoides*	Kirkpatrick, 1908
Isodictya	*cavicornuta*	Dendy, 1924
Isodictya	*conulosa*	Ridley & Dendy, 1886
Isodictya	*crinacea*	Topsent, 1916
Isodictya	*delicata megachela*	Burton, 1934
Isodictya	*erinacea*	Topsent, 1916
Isodictya	*kirkpatricki*	Topsent, 1916
Isodictya	*obliquidens*	(Hentschel, 1914)
Isodictya	*setifer*	Topsent, 1901
Isodictya	*spinigera*	Kirkpatrick, 1907
Isodictya	*verrucosa*	Topsent, 1913
Jaspis	*novae-zealaniae*	Dendy, 1924
Joyeuxia	*belli*	Kirkpatrick, 1907
Kirkpatrickia	*coulmani*	Kirkpatrick, 1907
Kirkpatrickia	*variolosa*	Kirkpatrick, 1907
Latrunculia	*apicalis*	
Latrunculia	*apicalis var. basalis*	Ridley & Dendy, 1887
Latrunculia	*apicalis var. biformis*	Ridley & Dendy, 1887
Latrunculia	*lendenfeldi*	Hentschel, 1914
Leucandra	*brumalis*	Jenkin, 1908
Leucandra	*cirrata*	Jenkin, 1908
Leucandra	*frigida*	Jenkin, 1908
Leucandra	*gelatinosa*	Jenkin, 1908
Leucandra	*hiberna*	Jenkin, 1908
Leucandra	*primigentia*	Jenkin, 1908
Leucetta	*leptoraphis*	Jenkin, 1908
Leucettusa	*lancifer*	Dendy, 1924
Leuconia	*frigida*	Jenkin, 1908
Leuconia	*joubini*	Topsent, 1907
Leuconia	*levis*	Polejaeff, 1884
Leucosolenia	*botryoides*	Ellis & Solander, 1786
Leucosolenia	*complicata*	Minchin, 1904
Leucosolenia	*coriacea*	Montagu, 1918
Leucosolenia	*discoveryi*	Jenkin, 1908
Leucosolenia	*minchini*	Jenkin, 1908
Lissodendoryx	*flabellata*	Burton, 1929
Lissodendoryx	*innominata*	Burton, 1929
Lissodendoryx	*spongiosa*	Ridley & Dendy, 1887
Lissomyxilla	*hanitschi*	Kirkpatrick, 1907
Megapogon	*crispatus*	Jenkin, 1908
Megapogon	*cruciferus*	Polejaeff, 1883
Megapogon	*pollicaris*	Jenkin, 1908
Megapogon	*raripilus*	Jenkin, 1908
Megapogon	*villosus*	Jenkin, 1908
Megepogon	*villosus*	Jenkin, 1908
Microxina	*benedeni*	Topsent, 1901
Microxina	*charcoti*	Topsent, 1916
Microxina	*lanceolata*	Calcinai & Pansini, 2000
Microxina	*sarai*	Calcinai & Pansini, 2000
Monosyringa	*brondstedi*	Burton, 1929
Mycale	*acerata*	Kirkpatrick, 1907
Mycale	*fibrosa*	Boury-Esnault & Van Beveren, 1982
Mycale	*gaussiana*	Hentschel, 1914
Mycale	*magellanica*	Ridley, 1881
Mycale	*pellita*	Topsent, 1908
Mycale	*profunda*	Koltun, 1964
Mycale	*tridens*	Hentschel, 1914
Myxilla	*asigmata*	Topsent, 1902
Myxilla	*decepta*	Kirkpatrick, 1907
Myxilla	*elongata*	Topsent, 1917
Myxilla	*mollis*	Ridley & Dendy, 1886
Myxodoryx	*hanitschi*	Kirkpatrick, 1907
Oceanapia	*tantula*	Kirkpatrick, 1907
Ophlitaspongia	*nidificata*	Kirkpatrick, 1907
Pachypellina	*pedunculata*	(Ridley & Dendy, 1887)
Paratedania	*tarantula*	Kirkpatrick, 1907
Penares	*tylotaster*	Dendy, 1924
Petrosia	*fistulata*	Kirkpatrick, 1907
Phorbas	*glaberrima*	Topsent, 1917
Plakina	*monolopha*	Schulze, 1880

		Plakina	*trilopha*	Schulze, 1880
		Plocamia	*gaussiana*	Hentschel, 1914
		Plumocolumella	*cribriporosa*	Burton, 1929
		Plumocolumella	*moeandrina*	Kirkpatrick, 1907
		Polymastia	*invaginata*	Kirkpatrick, 1907
		Proteleia	*burtoni*	Koltun, 1964
		Pseudanchionoe	*toxiferum*	Topsent, 1913
		Pseudosuberites	*antacticus*	Carter, 1876
		Pseudosuberites	*exalbicans*	Topsent, 1913
		Pseudosuberites	*hyalinus*	Ridley & Dendy, 1887
		Pseudosuberites	*nudus*	Koltun, 1964
		Pseudosuberites	*sulcatus*	Thiele, 1905
		Pyloderma	*latrunculioides*	Ridley & Dendy, 1887
		Reniera	*dancoi*	Topsent, 1902
		Reniera	*scotti*	Kirkpatrick, 1907
		Rhabderemia	*coralloides*	Dendy, 1924
		Rhizaxinella	*australiensis*	Hentschel, 1909
		Rossella	*antarctica*	Carter, 1872
		Rossella	*antarctica* subsp. *antarctica*	Schulze & Kirkpatrick, 1910
		Rossella	*hexactinophila*	Kirkpatrick, 1907
		Rossella	*nuda*	Topsent, 1901
		Rossella	*podogrosa*	Kirkpatrick, 1907
		Rossella	*racovitzae*	Topsent, 1901
		Rossella	*villosa*	Burton, 1929
		Scolymastra	*joubini*	Topsent, 1916
		Sigmaxinyssa	*phakellioides*	Kirkpatrick, 1907
		Sphaerotylus	*antarcticus*	Kirkpatrick, 1907
		Sphaerotylus	*capitatus*	Sollas, 1888
		Sphaerotylus	*schoenus*	Kirkpatrick, 1908
		Spongelia	*oculata*	Burton, 1929
		Stelletta	*crater*	Dendy, 1924
		Stelletta	*maori*	Dendy, 1924
		Stelletta	*purpurea*	Ridley, 1884
		Streptoconus	*australis*	Jenkin, 1908
		Stylocordyla	*borealis*	Loven, 1868
		Stylocordyla	*borealis* var. *acuata*	Loven, 1868
		Suberella	*topsenti*	Burton, 1929
		Suberites	*caminatus*	Ridley & Dendy, 1887
		Suberites	*caminatus* var. *papillatus*	Ridley & Dendy, 1887
		Suberites	*microstomus* var. *stellatus*	Ridley & Dendy, 1887
		Suberites	*monitiniger*	Carter
		Subertes	*papillatus*	Kirkpatrick, 1908
		Tedania	*charcoti*	Topsent, 1907
		Tedania	*coulmani*	Kirkpatrick, 1907
		Tedania	*oxeata*	Topsent, 1916
		Tedania	*tantula*	Kirkpatrick, 1907
		Tedania	*variolosa*	Kirkpatrick, 1907
		Tenthrenodes	*antacticus*	Jenkin, 1908
		Tenthrenodes	*scotti*	Jenkin, 1908
		Tetilla	*leptoderma*	Sollas, 1886
		Tetilla	*metaclada*	Lendenfeld, 1907
Hydrozoa	Hydroida	*Billardia*	*subrufa*	(Jaderhohn, 1904)
		Campanulina	*belgicae*	Hartlaub, 1904
		Campanulina	*hicksoni*	Totton, 1930
		Catablema	*weldoni*	Browne, 1910
		Cosmetira	*frigida*	Browne, 1910
		Cosmetirella	*simplex*	Browne, 1910
		Eleutheria	*hodgsoni*	Browne, 1910
		Errina	*fissurata*	Gray
		Errina	*gracilis*	Marenzeller
		Errina	*kerguelensis*	Broch
		Errina	*labiata*	Moseley
		Errina	*laterofolia*	Eguchi
		Errina	sp.	
		Eudendrium	*antarcticum*	Totton, 1930
		Gravelya	*antarctica*	(Hickson & Gravely, 1907)
		Halecium	*antarcticum*	Totton, 1930
		Hebella	*plana*	Ritchie, 1907
		Hydronema	*angustum*	(Hartlaub, 1904)
		Koellikeria	*maasi*	Browne, 1910
		Lafoea	*gaussica*	Vanhoffen, 1910
		Lafoea	*gracillima*	(Alder, 1856)
		Margelopsis	*australis*	Browne, 1910

		Ophiodissa	*arborea*	(Allman, 1888)
		Oswaldella	*antarctica*	(Jaderholm, 1904)
		Perigonimus	sp.	
		Ptychogena	*antarctica*	Browne, 1907
		Reticularia	*antarctica*	(Hartlaub, 1904)
		Schizotricha	*unifurcata*	Allman, 1883
		Sertularella	*elongata*	Jaderholm, 1904
		Sertularella	*spiralis*	Hickson & Gravely, 1907
		Sibogita	*borchgrevinki*	Browne, 1910
		Staurotheca	*antarctica*	
		Staurotheca	*dichotoma*	Allman, 1888
		Stegella	*grandis*	(Hickson & Gravely, 1907)
		Symplectoscyphus	*glacialis*	(Jaderholm, 1904)
		Symplectoscyphus	*plectilis*	(Hickson & Gravely, 1907)
		Symplectoscyphus	*vanhoeffeni*	Totton, 1930
	Actinulida	*Cystiactis*	*antarctica*	
		Paractis	*polaris*	Clubb, 1908
		Paractis	*papaver*	
		Rhodactinia	*crassicornis*	
	Antipatharia	*Bathypathes*	*patula*	Brook
		Schizopathes	*crassa*	Brook
	Ceriantharia	*Cerianthus*	sp.	
	Stolonifera	*Trachythela*	sp.	
	Alcyonacea	*Anthomastus*	sp.	
		Clavulina	*frankliniana*	Molander
	Gorgonacea	*Ainigmaptilon*	*antarcticum*	(Molander)
		Anthothela	sp.	
		Ascolepis	*lepidota*	Bayer, MS
		Callozostron	*horridum*	Kukenthal
		Chrysogorgia	sp.	
		Echinisis	sp.	
		Fannyella	*lepidota*	(Bayer)
		Fannyella	*rossi*	Gray
		Fannyella	sp.	
		Lepidisis ?	sp.	
		Narella	*gaussi*	(Kukenthal)
		Ophidiogorgia	*paradoxa*	
		Ophidiogorgia	sp.	
		Paragorgia	sp.	
		Parastenella	*sipnosa cf.*	(Wright & Studer)
		Primnoella	*gracilis*	Molander
		Primnoella	*gracilis cf.*	Molander
		Primnoella	sp.	
		Primnoisis	sp.	
		Thorarella	sp.	
		Thouarella	*abies*	Broch
		Thouarella	*spinosa*	(Thomson & Rennet)
	Pennatulacea	*Umbellula*	*lindahli*	Kolliker, 1874
		Umbellula	*magniflora*	Kolliker, 1880
	Actiniaria	*Actinernus*	*elongatus*	(Hertwig)
		Actinostola	*crassicornis*	(Hertwig)
		Artemidactis	*victrix*	Stephenson, 1918
		Aulactinia	*sulcata*	(Clubb)
		Bolocera	*keguelensis*	Studer
		Capnea	*georgiana*	(Carlgren)
		Cymbactis	*selaginella*	Stephenson, 1918
		Dactylanthus	*antarcticus*	(Clubb)
		Edwardsia	sp.	
		Epiactus	*georgiana*	Carlgren
		Flabellum	*impensum*	Squires
		Gardineria	*antarcrtica*	Gardiner, 1929
		Gardineria	*lilliei*	Gardiner, 1929
		Glyphoperidium	*bursa*	Roule
		Halocampoides	*aspersa*	Stephenson, 1918
		Hormathia	*lacunifera*	(Stephenson)
		Hormosoma	*scotti*	Stephenson, 1918
		Isosicyonis	*alba*	(Studer)
		Leptopenus	*antarcticus*	Cairns, 1989
		Leptoteichus	*insignis*	Stephenson, 1918
		Lilliella	*lacunifera*	Stephenson, 1918
		Liponema	*multiporum*	Hertwig
		Stomphia	*selaginella*	(Stephenson)
Platyhelminthes	Trematoda	*Allocreadium*	*fowleri*	Leiper & Atkinson, 1914

		Allotetranchoides	*rhigophilae*	Dillon & Hargis, 1967
		Aponurus	*bowersi*	Leiper & Atkinson, 1914
		Gyrodactylus	*centronoti*	Dillon & Hargis, 1967
		Gyrodactylus	*rhigophilae*	Dillon & Hargis, 1967
		Gyrodactylus	*wilkesi*	Dillon & Hargis, 1967
		Hemiurus	*oatesi*	Leiper & Atkinson, 1914
		Lepodora	*garrardi*	Leiper & Atkinson, 1914
		Neopavlovskioides	*dissostichi*	Dillon & Hargis, 1967
		Ogmogaster	*plicatus*	(Creplin, 1829)
		Pavlovskioides	*antarcticus*	Bychowsky, Gussev & Nagibina, 1965
		Pavlovskioides	*trematomi*	Dillon & Hargis, 1967
		Pavlovskioides	*wilkesensis*	Dillon & Hargis, 1967
		Podocotyle	*pennelli*	Leiper & Atkinson, 1914
	Cestoda	*Anomotaenia*	*zederi*	(Baird)
		Anthobothrium	*wyatti*	Leiper & Atkinson, 1914
		Dibothriocephalus	*antarcticus*	(Baird, 1853)
		Dibothriocephalus	*archeri*	Leiper & Atkinson, 1914
		Dibothriocephalus	*lashleyi*	Leiper & Atkinson, 1914
		Dibothriocephalus	*mobilis*	Rennie & Reid, 1912
		Dibothriocephalus	*scotti*	Shipley, 1907
		Dibothriocephalus	*wilsoni*	Shipley, 1907
		Diphyllobothrium	*perfoliatum*	Railliet & Henry, 1912
		Diphyllobothrium	*rufum*	Leiper & Atkinson, 1914
		Tetrabothrius	*cylindraceus*	Rud., 1819
		Tetrabothrius	*wrighti*	Leiper & Atkinson, 1914
Nemertea		*Amphiporus*	*moseleyi*	Hubrecht, 1887
		Amphiporus	*multihastatus*	Joubin, 1910
		Antarctolineus	*scotti*	Baylis, 1915
		Baseodiscus	*antarcticus*	Baylis, 1915
		Parborlasia	*corrugatus*	(McIntosh, 1876)
		Tetrastemma	*unilineatum*	(Joubin, 1910)
Nematoda		*Antarcticonema*	*comicapitatum*	Timm, 1978
		Desmoscolex	*amaurus*	Lorenzen, 1972
		Desmoscolex	*articulatus*	Timm, 1978
		Desmoscolex	*frigidus*	Timm, 1978
		Desmoscolex	*gerlachi*	Timm, 1972
		Desmoscolex	*labiosus*	Lorenzen, 1969
		Desmoscolex	*max*	Timm, 1971
		Greeffiella	*antarctica*	Timm, 1978
		Kathleena	*osculata*	(Rud. 1802)
		Kathleena	*radiata*	(v. Linstow, 1906)
		Kathleena	*rectangulata*	(v. Linstow, 1906)
		Leptosomatum	*setosum*	v. Linstow, 1896
		Quadricoma	*avicapitata*	Timm, 1978
		Quadricoma	*curvicauda*	Timm, 1978
		Quadricoma	*pontica*	Filipjev, 1923
		Tricoma	aff. *maxima*	(Schepotieff, 1907) Allgen, 1944
		Tricoma	*nematoides*	(Greeff, 1869) Stauffer, 1925
		Tricoma	*septentrionalis*	Timm, 1978
		Usarpnema	*auriculatum*	Timm, 1978
Acanthocephala		*Corynosoma*	*hamanni*	(v. Linstow, 1906)
		Echinorhynchus	*campbelli*	Leiper & Atkinson, 1914
		Echinorhynchus	*debenhami*	Leiper & Atkinson, 1914
		Echinorhynchus	*rennicki*	Leiper & Atkinson, 1914
Annelida	Polychaeta	*Achinothria*	*pycnobranchiata*	(McIntosh, 1885)
		Aedicira	*belgicae*	(Fauvel, 1936)
		Aglaophamus	*macroura*	(Schmarda, 1861)
		Aglaophamus	*trissophyllus*	(Grube, 1877)
		Aglaophamus	*virginis*	(Kinberg, 1866)
		Amage	*sculpta*	Ehlers, 1908
		Ammotrypane	*syringopyge*	Ehlers, 1901
		Ampharete	*kerguelensis*	McIntosh, 1885
		Amphicteis	*gunneri*	(Sars, 1835)
		Amphicteis	*gunneri antarctica*	Hessle, 1917
		Amphitrite	*cirrata*	(Müller, 1771)
		Amphitrite	*kerguelensis*	McIntosh, 1876
		Amythas	*membranifera*	Benham, 1921
		Anaitides	*adarensis*	(Benham, 1927)
		Anaitides	*bowersi*	(Benham, 1927)
		Anaitides	*longipes*	(Kinberg, 1866)
		Anaitides	*madeirensis*	(Langerhans, 1880)
		Anobothrus	*patagonicus*	(Kinberg, 1867)
		Aphelochaeta	*cincinnatus*	(Ehlers, 1908)

Aphelochaeta	*epitoca*	(Monro, 1930)
Aphrodita	*rossi*	Knox & Cameron, 1998
Asychis	*amphiglypta*	(Ehlers, 1897)
Augeneria	*tentaculata*	Monro, 1930
Austrolaenilla	*antarctica*	Bergström, 1916
Austrolaenilla	*hastulifera*	(Fauvel, 1936)
Austrophyllum	*charcoti*	(Gravier, 1911)
Autolytus	*charcoti*	Gravier, 1906
Autolytus	*longstaffi*	Ehlers, 1912
Autolytus	*maclearanus*	McIntosh, 1885
Axionice	*godfroyi*	(Gravier, 1911)
Axionice	*spinifera*	(Ehlers, 1908)
Axiothella	*quadrimaculata*	Augener
Barrukia	*cristata*	(Willey, 1902
Barrukia	*curviseta*	(Monro, 1930)
Callizona	*bongraini*	Gravier, 1911
Capitella	*capitata*	(Fabricius, 1780)
Chitinopomoides	*wilsoni*	Benham, 1927
Cirratulus	*cirratus*	(Müller, 1776)
Clymenella	*antarctica*	Knox & Cameron, 1998
Eteone	*aurantiaca*	Schmarda
Euchone	*pallida*	Ehlers, 1908
Euclymene	*grossa*	(Baird, 1873)
Eucranta	*mollis*	(McIntosh, 1876)
Eulagisca	*corrientis*	McIntosh, 1885
Eulagisca	*gigantea*	Monro, 1939
Eulalia	*magalhaensis*	Kinberg, 1865
Eulalia	*picta*	Kinberg, 1865
Eunice	*narconi*	Baird, 1869
Eunice	*pennata*	(Müller, 1776)
Eunoe	*abyssorum*	McIntosh, 1885
Eunoe	*opalina*	McIntosh, 1885
Euphrosine	*armadilloides*	Ehlers, 1900
Euphrosine	*echidna*	Kudenov, 1993
Euphrosinella	*cirratoformis*	(Averincev, 1972)
Euphrosinopsis	*antipoda*	Kudenov, 1993
Eurysyllis	*ehlersi*	Benham, 1927
Eusyllis	*kerguelensis*	McIntosh, 1885
Exogone	*anomalochaeta*	Benham, 1921
Exogone	*heterosetosa*	McIntosh, 1885
Exogone	*miniscula*	Hartman
Flabelligera	*mundata*	Gravier, 1907
Galathowenia	*scotiae*	(Hartman, 1978)
Galathowenia	*longicollaris*	(Hartmann-Schröder & Rosenfeldt, 19
Galathowenia	*scotiae*	Hartman, 1978
Galathowenia	*wilsoni*	(Blake, 1984)
Glycera	*capitata*	Ørsted
Gorekia	*crassicirris*	(Willey, 1902)
Grubianella	*antarctica*	McIntosh, 1885
Gyptis	*incompta*	Ehlers, 1913
Haploscoloplos	*kerguelensis*	(McIntosh, 1885)
Harmothoe	*spinosa*	Kinberg, 1855
Harmothoe	*crosetensis*	(McIntosh, 1885)
Harmothoe	*ernesti*	Augener, 1931
Harmothoe	*exanthema bergstomi*	Monro, 1936
Harmothoe	*ferox*	(Baird, 1865)
Harmothoe	*hartmanae*	Uschakov, 1962
Harmothoe	*lagiscoides*	Willey, 1902
Harmothoe	*magellanica*	(McIntosh, 1885)
Harmothoe	*spinosa*	Kinberg, 1855
Harmothoe	*tuberosa*	Ehlers, 1912
Harmothoe	*crosetensis*	(McIntosh, 1885)
Harmothoe	*spinosa*	Kinberg, 1855
Hauchiella	*tribullata*	(McIntosh, 1869)
Hermadion	*ferox*	Baird, 1865
Hermadion	*magalhaensis*	Kinberg, 1855
Ilyphagus	*coronatus*	Monro, 1939
Isocirrus	*yungi*	Gravier, 1911
Jasmineira	*caeca*	Ehlers, 1913
Kebuita	*minuta*	Hartman, 1967
Laena	*arenilega*	Ehlers, 1913
Laetmonice	*producta*	Grube, 1877
Lanicides	*bilobata*	(Grube, 1877)

Laonice	*antarcticae*	Hartman, 1953
Laonice	*cirrata*	(Sars)
Laonice	*weddellia*	Hartman, 1978
Leaena	*abranchiata antarctica*	McIntosh, 1885
Leaena	*collaris*	Hessle, 1917
Leaena	*wandelensis*	Gravier, 1906
Leitoscoloplos	*kerguelensis minutus*	(Hartman, 1953)
Leitoscoloplos	*mawsoni*	Benham, 1921
Leodora	*perrieri*	(Caullery & Mesnil, 1897)
Levinsenia	*gracilis*	(Tauber, 1879)
Lumbrineris	*kerguelensis*	(Grube, 1878)
Lumbrineris	*magalhaensis*	(Kinberg, 1865)
Lumbrineris	*tetraura*	(Schmarda, 1861)
Lysilla	*loveni macintoshi*	Gravier, 1907
Maldane	*sarsi*	Malmgren
Maldane	*sarsi antarctica*	Arwidsson, 1911
Maldanella	*antarctica*	McIntosh, 1885
Maldanella	*grossa*	(Baird, 1873)
Maupasia	*caeca*	Viguier, 1886
Melinnoides	*nelsoni*	Benham, 1927
Metalaeospira	*armiger*	Vine, 1977
Myriochele	*antarctica*	Cantone, 2001
Myriochele	*heeri*	Malmgren, 1867
Myriochele	*terranovensis*	Cantone & Di Pietro, 1998
Myrioglobula	*antarctica*	Hartman, 1967
Myxicola	*sulcata*	Ehlers, 1912
Myzostoma	*antarcticum*	v. Stummer-Traunfels, 1908
Myzostoma	*cysticola*	v. Graff, 1884
Neanthes	*kerguelensis*	(McIntosh, 1885)
Neosabellides	*elongatus*	(Ehlers, 1912)
Nereis	*loxechini*	Kinberg, 1865
Nerinopsis	*hystricosa*	Ehlers, 1912
Nicolea	*chilensis*	(Schmarda, 1861)
Nicomache	*lumbricalis*	(Fabricius, 1780)
Nicon	*ehlersi*	Hartman, 1953
Nothria	*abyssia*	Kucheruk, 1978
Nothria	*anoculata*	Orensanz, 1974
Notomastus	*latericeus*	Sars, 1851
Notomastus	*lineatus*	Claparde, 1870
Notoproctus	*oculatus antarcticus*	Arwidsson, 1911
Octobranchus	*phyllocomus*	Hartman, 1952
Oligobregma	*collare*	(Levenstein, 1975)
Oligobregma	*notiale*	Blake, 1981
Oncoscolex	*dicranochaetus*	Schmarda, 1861
Ophelina	*gymnopyge*	(Ehlers, 1908)
Ophelina	*syringopyge*	(Ehlers, 1901)
Ophiodromus	*comatus*	(Ehlers, 1912)
Ophyrotrocha	*notialis*	(Ehlers, 1908)
Orbinia	*marginata macleani*	(Benham, 1921)
Oriopsis	*limbata*	(Ehlers, 1897)
Paradexiospira	*falklandica*	Pixell, 1913
Paradiopatra	*ehlersi*	(McIntosh, 1885)
Paramphinome	*australis*	Monro, 1930
Paraninoe	*antarctica*	(Monro, 1930)
Paraonis	*belgicae*	Fauvel, 1936
Paraonis	*gracilis*	(Tauber)
Pelagobia	*longicirrata*	Greef, 1879
Pelagobia	*viguieri*	Gravier, 1911
Perkinsiana	*antarctica*	(Kinberg, 1867)
Perkinsinia	*borsibrunoi*	Giangrande & Gambi, 1997
Perkinsinia	*littoralis*	(Hartman, 1967)
Perkinsinia	*milae*	Giangrande & Gambi, 1997
Pherusa	*kerguelarum*	(Grube, 1878)
Phyllocomus	*crocea*	Grube, 1877
Phyllodoce	*patagonica*	(Kinberg, 1865)
Pionosyllis	*comosa*	Gravier, 1907
Pionosyllis	*maxima*	Monro, 1930
Pionosyllis	*stylifera*	Ehlers, 1913
Pista	*corrientis*	McIntosh, 1885
Pista	*cristata*	(Müller, 1776)
Pista	*godfroyi*	(Gravier, 1911)
Pista	*mirabilis*	McIntosh, 1885
Pista	*spinifera*	Ehlers, 1908

		Polycirrus	*kerguelensis*	(McIntosh, 1885)
		Polycirrus	*antarcticus*	(Willey, 1902)
		Polyeunoa	*laevis*	McIntosh, 1885
		Polynoe	*antarctica*	Kinberg, 1858
		Potamethus	*scotiae*	(Pixell, 1913)
		Potamilla	*antarctica*	(Kinberg, 1867)
		Praxillella	*kerguelensis*	(McIntosh, 1885)
		Praxillella	*praetermissa antarctica*	Cantone, 1995
		Proclea	*glabrolimbata*	Hessle, 1917
		Proclea	*graffii*	(Langerhans, 1884)
		Pseudoscalibregma	*bransfieldium*	(Hartman, 1967)
		Pseudoscalibregma	*usarpium*	Blake, 1981
		Pterocirrus	*macleani*	Benham, 1921
		Rhodine	*loveni*	Malmgren, 1865
		Rhynchonerella	*bongraini*	(Gravier)
		Sabella	*oatesiana*	Benham, 1927
		Sagitella	*kowalewskii*	Wagner, 1872
		Scalibregma	*inflatum*	Rathke, 1843
		Sclerocheilus	*antarcticus*	Ashworth, 1915
		Scolelepis	*chilensis*	(Hartman-Schröder, 1962)
		Scolelepis	*eltaninae*	Blake, 1983
		Scolelepis	*eltaninae nudipalpa*	Cantone, 2001
		Scoloplos	*marginatus*	(Ehlers, 1897)
		Serpula	*loveni*	(Kinberg, 1867)
		Serpula	*narconensis*	Baird, 1865
		Serpula	*vermicularis*	Linnaeus, 1767
		Spio	*obtusa*	Ehlers
		Spiophanes	*kroyeri*	Grube, 1860
		Spiophanes	*tcherniai*	Fauvel, 1951
		Steggoa	*hunteri*	(Benham, 1921)
		Steggoa	*magalhaensis*	McIntosh, 1885
		Streblosoma	*bairdi antarctica*	Monro, 1936
		Syllides	*articulosus*	Ehlers, 1897
		Syllidia	*inermis*	(Ehlers, 1912)
		Syllis	*amica*	Quatrefages
		Terebella	*ehlersi*	Gravier, 1907
		Terebella	*flabellum*	Baird, 1865
		Tharyx	*cincinnatus*	(Ehlers, 1908)
		Thelepides	*koehleri*	Gravier, 1911
		Thelepides	*venustus*	Levenstein, 1964
		Thelepus	*cincinnatus*	(Fabricius, 1780)
		Traviopsis	*levinseni*	Southern, 1910
		Travisia	*kerguelensis*	McIntosh, 1885
		Travisiopsis	*levinseni*	Southern, 1910
		Trichobranchus	*glacialis antarcticus*	Hessle, 1917
		Trypanosyllis	*gigantea*	(McIntosh, 1885)
		Typhloscolex	*mulleri*	Busch, 1851
		Typosyllis	*armillaris*	(Müller, 1771)
		Typosyllis	*brachychaeta*	(Schmarda)
		Typosyllis	*brachycola*	(Ehlers, 1897)
		Typosyllis	*pennelli*	Knox & Cameron, 1998
		Typosyllis	*prolixa*	(Ehlers, 1901)
		Typosyllis	*hyalina*	Grube, 1863
		Vanadis	*antarctica*	(McIntosh, 1885)
	Clitellata	*Glyptonotobdella*	*antarctica*	Sawyer & White
		Grania	*acanthochaeta*	Rota & Erséus , 1996
		Grania	*algida*	Rota & Erséus , 1996
		Grania	*angustinasus*	Rota & Erséus , 1996
		Grania	*antarctica*	Rota & Erséus , 1996
		Grania	*carchinii*	Rota & Erséus , 1996
		Grania	*hirsuticauda*	Rota & Erséus , 1996
		Megaliobdella	*szidati*	Meyer & Burreson, 1990
		Moorebdellina	*rugosa*	
		Platybdella	*levigata*	(Harding, 1922)
		Polygordius	*antarcticus*	Rota & Carchini, 1999
		Rossidrilus	*terraenovae*	Erséus & Rota, 1996
		Stibarobdella	*biannulata*	(Moore)
		Stibarobdella	*tasmanica*	(Hickman, 1947)
		Torodrilus	*gelidus*	Erséus & Rota, 1996
Mollusca	Gastropoda	*Acirsa*	*antarctica*	(Smith, 1907)
		Acteon	*antarcticus*	Thiele, 1912
		Admete	sp.	
		Admete	*delicatula*	Smith, 1907

Aforia	*magnifica*	(Strebel, 1908)
Amouropsis	*rossiana*	Smith, 1907
Amouropsis	*grisea*	(Von Martens, 1878)
Anatoma	*amoena*	(Thiele, 1912)
Anatoma	*euglypta*	(Pelseneer, 1903)
Antarctodomus	*thielei*	(Powell, 1958)
Antarctoneptunea	*aurora*	(Hedley, 1916)
Antimargarita	*dulcis*	(Smith, 1907)
Antimargarita	*thielei*	(Hedley, 1916)
Asperiscala	*eltanini*	Dell, 1990
Balcis	*convexa*	(Smith, E.A., 1907)
Balcis	sp.	
Balcis	*subantarctica*	(Strebel, 1908)
Bathybembix	*delicatula*	Dell, 1990
Bathydomus	*obtectus*	Thiele, 1912
Belalora	aff. *thielei*	Powell, 1951
Belalora	*striatula*	(Thiele, 1912)
Belaturricula	*antarctica*	Dell, 1990
Brookula	*antarctica*	Dell, 1990
Brookula	*rossiana*	Dell, 1990
Brookula	sp.	
Bulbus	*benthicolus*	Dall, 1990
Bullinella	*gelida*	Smith, 1907
Calliotropis	*lateumbilicata*	Dell, 1990
Calliotropis	*pelseneeri rossiana*	Dell, 1990
Capulus	*subcompressus*	Dell, R.K.
Cerithiopsilla	*antarctica*	(Smith, E.A., 1907)
Chlandidota	*lamyi*	Dell, 1990
Chlanidota	cf. *lamyi*	Dell, 1990
Chlanidota	sp.	
Chlanidota	*vestita*	(Martens, 1878)
Cirsonella	*extrema*	Thiele, 1912
Conerbela	*antarctica*	(Strebel, 1908)
Cylichna	*gelida*	(Smith, 1907)
Eatoniella	*demissa*	(Smith, 1915)
Eatoniella	*glacialis*	(Smith, E.A., 1907)
Eatoniella	*kerguelensis regularis*	(Smith, 1915)
Eulima	*convexa*	Smith, 1907
Euphrosine	*monroi*	Kudenov, 1993
Falsilunata	cf. *xantha*	(Watson, 1881)
Falsilunata	*delicatula*	(Smith, 1902)
Falsilunata	*fartilis*	(Watson, 1881)
Falsilunatia	*delicatula*	(Smith, E.A., 1875)
Falsimargarita	*gemma*	(Smith, 1915)
Falsimargarita	*thielei*	(Hedley, 1916)
Harpovoluta	*charcoti*	(Lamy. 1910)
Hemiaclis	*incolorata*	(Thiele, 1912)
Iothia	*coppingeri*	(Smith, E.A., 1881)
Kerguelenatica	*bioperculata*	Dell, 1990
Laevilitorina	*antarctica*	(Smith, E.A., 1902)
Laevilitorina	*labioflecta*	Dell, 1990
Lepeta (Pilidium)	*antarctica*	Smith, 1907
Lepetella	*postapicula*	Dell,1990
Leptocollonia	*innocens*	(Thiele, 1912)
Leucosyrunx	*badenpowelli*	Dell, 1990
Liotella	*endeavourensis*	Dell, 1990
Lissotesta	*liratula*	(Pelseneer, 1903)
Lissotesta	*mammillata*	(Thiele, 1912)
Lissotesta	*minutissima*	(Smith, E.A., 1907)
Lissotesta	*strebeli*	(Thiele, 1912)
Lissotesta	*liratula*	(Pelseneer, 1903)
Lophiotoma	*pseudoannulata*	Dell, 1990
Lorabela	*davisi*	(Hedley, 1916)
Lorabela	*plicatula*	(Thiele, 1912)
Lovenella	*antarctica*	Smith, 1907
Margarella	*antarctica*	(Lamy, 1905)
Margarella	*refulgens*	(Smith, E.A., 1907)
Margarites	*crebrilirulata*	(Smith, 1907)
Margarites	*refulgens*	(Smith, 1907)
Marginella	*hyalina*	Thiele, 1912
Marseniopsis	*conica*	(Smith, E.A., 1902)
Marseniopsis	*mollis*	(Smith, 1902)
Melanella	*convexa*	(Smith, 1907)

Melanella	*exulata*	(Smith, 1915)
Meteuthria	*multituberculata rossiana*	Dell, 1990
Meteuthria	*rossiana*	Dell, 1990
Meteuthria	sp.	
Microdiscula	*vanhoeffeni*	Thiele, 1912
Murdochella	*antarctica*	Dell. 1990
Natica	cf. *prasina*	Watson, 1881
Natica (Neverita)	*delicatula*	Smith, 1902
Neactaeonina	*edentula*	(Watson, 1883)
Neobuccinum	*eatoni*	(Smith, 1875)
Neobuccinum	*tenerum*	Smith, 1907
Neoconcha	*vestita*	Smith, 1907
Newnesia	*antarctica*	Smith, 1902
Nothoadmete	*antarctica*	(Strebel, 1908)
Nothoadmete	*consobrina*	(Powell, 1951)
Nothoadmete	*delicatula*	(Smith, 1907)
Notoficula	*bouveti*	(Thiele, 1912)
Onoba	*gelida*	(Smith, E.A., 1907)
Onoba	*kergueleni*	(Smith, E.A., 1875)
Onoba	sp.	
Onoba	*subantarctica*	(Hedley, 1916)
Onoba	*turqueti*	(Lamy, 1905)
Onoba	*wilkesiana*	(Hedley, 1916)
Paradmete	*curta*	Strebel, 1908
Paradmete	*fragillima*	(Watson, 1882)
Pareuthria	*innocens*	(Smith, 1907)
Pareuthria	*plicatula*	Thiele, 1912
Pareuthria	*valdiviae*	Thiele, 1925
Parmaphoridea	*mawsoni*	(Powell, 1958
Philine	*apertissima*	Smith, 1902
Pleurotomella	aff. *enderbyensis*	Powell
Pleurotomella	cf. *annulata*	Thiele, 1912
Pleurotomella	*endeavourensis*	Dell, 1990
Pleurotomella	*frigida*	(Thiele, 1912)
Pleurotomella	*simillima*	Thiele, 1912
Pleurotomella	*rossi*	Dell, 1990
Pontiothauma	*hedleyi*	Dell, 1990
Powellisetia	*deserta*	(Smith, E.A., 1907)
Probuccinum	*costatum*	Thiele, 1912
Probuccinum	*tenerum*	(Smith, E.A. 1907)
Prolacuna	*indecora*	(Thiele, 1912)
Prolacuna	*macmurdensis*	(Hedley, 1911)
Proneptunea	*rossiana*	Dell, 1990
Prosipho	*cancellatus*	Smith, E.A. 1915
Prosipho	*contrarius*	Thiele, 1912
Prosipho	*elongatus*	Thiele, 1912
Prosipho	*glacialis*	Thiele, 1912
Prosipho	*hedleyi*	Powell, 1958
Prosipho	*hunteri*	Hedley, 1916
Prosipho	*mundus*	Smith, E.A., 1915
Prosipho	*priestleyi*	(Hedley, 1916)
Prosipho	*pusillus*	Thiele, 1912
Prosipho	*similis*	Thiele, 1912
Prosipho	sp. A	
Prosipho	*spiralis*	Thiele, 1912
Prosipho	*tuberculatus*	Smith, 1915
Pucturella	*noachina*	(Linnaeus, 1771)
Puncturella	sp.	
Puncturella	*spirigera*	Thiele, 1912
Retusa	*frigida*	Hedley, 1916
Rissola	*adarensis*	Smith, 1907
Rissola	*deserta*	Smith, 1907
Rissola	*fraudulenta*	Smith, 1907
Rissola	*gelida*	Smith, 1907
Rissola	*glacialis*	Smith, 1907
Sassia	*kampyla*	
Scala	*antarctica*	Smith, 1907
Sinuber	*microstriatum*	Dell, 1990
Sinuber	*sculptum sculptum*	(Martens, 1878)
Skenella	*paludinoides*	(Smith, 1902)
Solariella	*antarctica*	Powell, 1958
Stilapex	cf. *polaris*	(Hedley, 1916)
Streptocionella	*pluralis*	Dell, 1990

	Submargarita	*macknighti*	Dell, 1990
	Submargarita	*unifilosa*	Thiele, 1912
	Thesbia?	*innocens*	Smith, 1907
	Toledonia	*elata*	Thiele, 1912
	Toledonia	*globosa*	Dedley, 1916
	Toledonia	*limnaeformis*	(Smith, E.A., 1879)
	Toledonia	*major*	(Hedley, 1911)
	Toledonia	*punctata*	Thiele, 1912
	Toledonia	sp.	
	Toledonia	*striata*	Thiele, 1912
	Tophon	*scotianus*	Powell, 1951
	Torellia	*antarctica*	Dell, R.K.
	Torellia	*comea*	Powell, 1951
	Torellia	*exilis*	(Powell, 1958)
	Torellia	*insignis*	Middendorff, 1849
	Torellia	*mirabilis*	(Smith, 1907)
	Torellia	*planispira*	(Smith, 1915)
	Torellia	*smithi*	Waren, Amaud & Cantera, 1986
	Trachysma	*tenue*	Thiele, 1912
	Tractolira	sp.	
	Trichoconcha	*mirabilis*	Smith, 1907
	Triphora	*delicatula*	(Thiele, 1912)
	Trochaclis	*antarctica*	Thiele, 1912
	Trophon	*coulmanensis*	Smith, 1907
	Trophon	*drygalskii*	Thiele, 1912
	Trophon	*longstaffi*	Smith, 1907
	Trophon	*minutus*	Strebel, 1907
	Trophon	*shackletoni shackletoni*	Hedley, 1911
	Turritellopsis	*latior*	Thiele, 1912
	Typhlodaphne	*innocentia*	Dell, 1990
	Valvatella	*crebrilirulata*	Smith, 1907
	Valvatella	*dulcis*	Smith, 1907
	Valvatella	*minutissima*	Smith, 1907
	Valvatella	*refulgens*	Smith, 1907
Nudibranchia	*Aegires*	*protectus*	Odhner, 1934
	Austrodoris	*granulatissima*	Vayssiere, 1917
	Austrodoris	*mcmurdensis*	Odhner, 1934
	Austrodoris	*nivium*	Odhner, 1934
	Austrodoris	*tomentosa*	Odhner, 1934
	Bathydoris	*hodgsoni*	Eliot, 1907
	Bathydoris	*inflata*	Eliot, 1907
	Bathydoris	*obliquata*	Odhner, 1934
	Cadlina	*affinis*	Odhner, 1934
	Cratena	sp.	
	Cuthonella	*antarctica*	Eliot, 1907
	Cuthonella	*modesta*	Eliot, 1907
	Cuthonella	*paradoxa*	Eliot, 1907
	Doto	*antarctica*	Eliot,
	Eubranchus	*adarensis*	Odhner, 1934
	Galvinella	*antarctica*	Eliot, 1907
	Notaeolida	*depressa*	Eliot, 1907
	Notaeolidia	*robsoni*	Odhner, 1934
	Telarma	*antarctica*	Odhner, 1934
	Tritonia	*challengeriana*	Bergh, 1884
	Tritoniella	*belli*	Eliot, 1907
	Tritoniella	*sinuata*	Eliot, 1907
Polyplacophora	*Callochiton*	*gaussi*	Thiele, 1908
	Leptochiton	*kerguelensis*	Haddon, 1886
	Notochiton	*mirandus*	Thiele
	Nuttalochiton	*mirandus*	(Thiele, 1906)
Aplacophora	*Proneomenia*	*discoveryi*	
	Solenogastre	sp.	
Bivalvia	*Adacnarca*	*limopsoides*	(Thiele, 1912)
	Adacnarca	*nitens*	Pelseneer, 1903
	Adacnarca	*wandelensis*	(Lamy, 1906)
	Adamussium	*colbecki*	(Smith, E.A., 1902)
	Anatina	*elliptica*	King & Broderip, xxxx
	Astarte	*antarctica*	Thiele, 1912
	Bathyarca	*sinuata*	Pelseneer, 1903
	Cardita	*astartoides*	Martens, xxxx
	Cuspidaria	*concentrica*	Thiele, 1912
	Cuspidaria	*infelix*	Thiele, 1912
	Cuspidaria	*kerguelensis*	Smith, 1885

		Cuspidaria	sp.	
		Cuspidaria	*tenella*	Smith, 1907
		Cyamiocardium	*denticulatum*	(Smith, E.A., 1907)
		Cyamiomactra	*laminifera*	(Lamy, 1906)
		Cyamium	*denticulatum*	Eliot, 1907
		Cyclocardium	*astartoides*	(Martens, 1878)
		Cyclopecten	*hexagonalis*	Powell, 1958
		Dacrydium	*albidum*	Pelseneer, 1903
		Diplodonta	*incerta*	Eliot, 1907
		Genaxinus	*debilis*	(Thiele, 1912)
		Kellia	*simulans*	Eliot, 1907
		Laternula	*elliptica*	(King & Broderip, 1831)
		Limatula	*hodgsoni*	(Smith, 1907)
		Limatula	*simillima*	Thiele, 1912
		Limopsis	*lilliei*	Smith, 1915
		Limopsis	*marionensis*	Smith, 1885
		Limopsis	*scabra*	Thiele, 1912
		Limulata	*sp.*	
		Lissarca	*notocadensis*	Melvill & Standen, 1907
		Lyonsia	*arcaeformis*	Martens, 1885
		Montacuta	*nimrodiana*	Hedley, 1911
		Mysella	*antarctica*	(Smith, 1907)
		Mysella	*charcoti*	(Lamy, 1906)
		Mysella	*gibbosa*	(Thiele, 1912)
		Nuculana	*inaequisculpta*	(Lamy, 1906)
		Pecten	*colbecki*	Smith, 1902
		Philobrya	*limoides*	Eliot, 1907
		Philobrya	*sublaevis*	(Pelseneer, 1903)
		Philobrya	*wandelensis*	Lamy, 1906
		Poromya	*adelaidis*	(Hedley, 1916)
		Portlandia	*antarctica*	(Thiele, 1912)
		Portlandia	*ecaudata*	(Pelseneer, 1903)
		Portlandia	*sabrina*	(Hedley, 1916)
		Propeleda	*longicaudata*	(Thiele, 1912)
		Pseudokellya	*cardiformis*	(Smith, 1885)
		Silicula	*rouchi*	Lamy, 1911
		Tellimya	*antarctica*	Eliot, 1907
		Thracia	*meridionalis*	Smith, 1885
		Thyasira	*bongraini*	(Lamy)
		Thyasira	*dearboni*	Nicol, 1965
		Yoldia	*eightsi*	(Couthouy, in Jay, 1939)
		Yoldiella	*antarctica*	(Thiele, 1912)
		Yoldiella	*ecaudata*	(Pelseneer, 1903)
		Yoldiella	*oblonga*	(Pelseneer, 1898)
		Yoldiella	*sabrina*	(Hedley, 1916)
	Scaphopoda	*Cadulus*	*dalli*	Odhner, 1931
		Cadulus	*dalli antarcticus*	Odhner, 1931
		Cadulus	*thielei*	Plate, 1908
		Fissidentalium	*majorinum*	Mabille & Rochebrune, 1889
		Siphonodentalium	*minimum*	Plate, 1908
Arthropoda	Arachnida	*Leptospathis*	*alberti antarctica*	
	Pycnogonida	*Achella*	*allopodes*	Fry & Hedgpeth, 1969
		Achelia	*communis*	(Bouvier, 1906)
		Achelia	*spicata*	(Hodgson, 1907)
		Ammothea	*calmani*	Gordon, 1932
		Ammothea	*caroleinensis*	Leach, 1814
		Ammothea	*clausi*	Pfeffer, 1889
		Ammothea	*fryi*	Child
		Ammothea	*glacialis*	(Hodgson, 1907)
		Ammothea	*gordonae*	Child, 1994
		Ammothea	*gigantea*	Gordon, 1932
		Ammothea	*longispina*	(Hodgson, 1907)
		Ammothea	*meridionalis*	Hodgson, 1915
		Ammothea	*minor*	(Hodgson, 1907)
		Austrodecus	*fagei*	Stock, 1957
		Austrodecus	*glaciale*	Hodgson, 1907
		Austrodecus	*macrum*	Child, 1994
		Austroraptus	*calcaratus*	Gordon, 1944
		Austroraptus	*juvenalis*	Calman, 1915
		Austroraptus	*polaris*	Hodgson, 1907
		Austroraptus	*praecox*	Calman, 1915
		Austroraptus	sp.	Fry & Hedgpeth, 1969
		Athernopycnon	*meridionalis*	

		Chaetonymphon	*australe*	
		Chaetonymphon	*australe var. austrinorum*	
		Chaetonymphon	*biarticulatum*	
		Chaetonymphon	*mendosum*	
		Chaetonymphon	*villosum*	
		Colossendeis	*australis*	
		Colossendeis	*megalonyx arundorostris*	Fry & Hedgpeth, 1969
		Colossendeis	*megalonyx megalonyx*	Fry & Hedgpeth, 1969
		Colossendeis	*robusta*	Hoek, 1881
		Colossendeis	*drakei*	Calman, 1915
		Colossendeis	*tortipalpus*	Gordon, 1932
		Colossendeis	*lilliei*	Calman, 1915
		Colossendeis	*scotti*	Calman, 1915
		Colossendeis	*wilsoni*	Calman, 1915
		Cilunculus	*cactoides*	Fry & Hedgpeth, 1969
		Decolopoda	*australis*	Eights, 1834
		Dodecolopoda	*mawsoni*	Calman & Gordon, 1933
		Ecleipsothremma	*spinosa*	(Hodgson, 1907)
		Endeis	*australis*	Hodgson, 1907
		Nymphon	*adareanum*	
		Nymphon	*australe*	Hodgson
		Nymphon	*frigidum*	
		Nymphon	*hiemale*	
		Nymphon	*lanare*	
		Nymphon	*longicoxa*	Hoek
		Nymphon	*tenuimanum*	Hodgson
		Pallenopsis	*glabra*	Mobius
		Pallenopsis	*hiemalis*	
		Pallenopsis	*pilosa*	(Hoek)
		Pallenopsis	*villosa*	
		Pantopipetta	*australis*	(Hodgson, 1914)
		Pentanymphon	*antarcticum*	Hodgson, xxxx
		Pentopycnon	*charcoti*	Bouvier, 1910
		Pseudopallene	*australis*	
		Pseudopallene	*cornigera*	Mobius, xxxx
		Pycnogonum	*gaini*	Bouvier, 1910
		Rhynchothorax	*australis*	
		Sericosura	*mitrata*	(Gordon, 1944)
		Thaumastopycnon	*striata*	(Mobius, 1902)
Crustacea/Maxillopoda	Ostracoda	*Conchoecia*	*innominata*	Brady, 1907
		Cypridina	*glacialis*	Brady, 1907
		Empoulsenia	*antarctica*	Kornicker
		Philomedes	*antarctica*	Brady, 1907
		Philomedes	*assimilis*	Brady
		Philomedes	*heptathrix*	Kornicker
		Philomedes	*orbicularis*	Brady, 1907
		Scleroconcha	*gallardoi*	Kornicker
		Xestolebris	*reniformis*	Brady, 1907
	Cirripedia	*Arcoscalpellum*	*bouvieri*	(Gruvel, 1906)
		Arcoscalpellum	*compactum*	(Borradaile, 1916)
		Arcoscalpellum	*triangulare*	(Hoek, 1883)
		Bathylasma	*coralliforme*	(Hoek, 1883)
		Litoscalpellum	*discoveryi*	(Gruvel, 1906)
Crustacea/Malacostraca	Mysidacea	*Amblyops*	*tattersalli*	Zimmer, 1914
		Antarctomysis	*maxima*	((Hansen in MS) (Holt and Tattersall),
		Antarctomysis	*ohlinii*	Hansen, 1908
		Boreomysis	*californica*	Ortman, 1894
		Boreomysis	*inermis*	(Willemoes-Suhm, 1874)
		Dactylamblyops	*hodgsoni*	Holt & Tattersall, 1905
		Euchaetomera	*zurstrasseni*	(Illig, 1906)
		Eucopia	*australis*	Dana, 1852
		Eucopia	*grimaldii*	Nouvel, 1942
		Hansenomysis	*antarctica*	Holt & Tattersall, 1906
		Mysidetes	*posthon*	Holt and Tattersall, 1906
		Mysidetes	sp.	
		Pseudomma	*belgicae*	Holt & Tattersall, 1906
	Cumacea	*Campylaspis*	*antarctica*	Calman, 1907
		Campylaspis	*verrucosa antarctica*	Sars, 1868
		Cumella	*australis*	Calman, 1907
		Cyclaspis	*gigas*	Zimmer, 1907
		Diastylis	*helleri*	Zimmer
		Diastylis	sp.	
		Eudorella	*gracilior*	Zimmer, 1907

	Eudorella	aff. *truncatula*	
	Eudorella	*splendida*	Zimmer
	Eudorella	*similis*	Calman 1907b
	Leptostylis	*crassicauda*	Zimmer
	Leucon	*antarctica*	Zimmer, 1907
	Leucon	*australis*	Calman 1907b
	Makrokylindrus	*inscriptus*	unknown
	Paralamprops	*rossi*	unknown
	Procampylaspis	*meridiana*	unknown
Tanaidacea	*Andrognathia*	*plumosa*	Sieg, 1983
	Cryptocopoides	*arcticus*	(Hansen, 1887)
	Leptognathia	*diversa*	Seig, 1983
	Nototanais	*antarcticus*	Hodgson, 1902
	Nototanais	*dimorphus*	(Beddard, 1886)
	Pseudoparatanais	*antarcticus*	Sieg, 1983
	Typhlotanais	*greenwichensis*	Shiino, 1970
	Typhlotanaoides	*insolitus*	Sieg, 1983
Isopoda	*Accalathura*	*gigantissima*	Kussakin, 1967
	Acutiserolis	*spinosa*	(Kussakin, 1967)
	Aega	*antarctica*	Hodgson, 1910
	Aega	*glacialis*	Tattersall, 1921
	Antarcturus	*furcatus*	(Studer, 1884)
	Antarcturus	*furcatus latispinus*	(Kussakin, 1967)
	Antarcturus	*horridus*	Tattersall, 1921
	Antarcturus	*polaris*	(Hodgson, 1902)
	Austrofilius	*furcatus*	Hodgson, 1910
	Austrosignum	*glaciale*	Hodgson, 1910
	Austrosignum	*grande*	Hodgson, 1910
	Caecognathia	*calva*	(Vanhöffen, 1914)
	Caecognathia	*hodgsoni*	(Vanhöffen, 1914)
	Caecognathia	*polaris*	(Hodgson, 1902)
	Chaetarcturus	*adareanus*	(Hodgson, 1902)
	Chaetarcturus	*franklini*	(Hodgson, 1902)
	Coulmannia	*australis*	Hodgson, 1910
	Coulmannia	*frigida*	Hodgson, 1910
	Cymodoce	*australis*	Hodgson, 1902
	Cymodocella	*tubicauda*	Pfeffer, 1887
	Dolichiscus	*gaussianus*	(Vanhöffen, 1914)
	Dolichiscus	*hiemalis*	(Hodgson, 1910)
	Dolichiscus	*meridionalis*	(Hodgson, 1910)
	Dolichiscus	*profundus*	Schultz, 1981
	Echinozone	*quadrispinosa*	(Beddard, 1886)
	Echinozone	*spinosa*	Hodgson, 1902
	Ectias	*turqueti*	Richardson, 1906
	Eisothistos	*antarcticus*	Vanhöffen, 1914
	Eunognathia	*gigas*	(Beddard, 1886)
	Frontoserolis	*acuminata*	(Sheppard, 1957)
	Glyptonotus	*antarcticus*	Eights, 1852
	Gnathia	*acuticauda*	Monod, 1926
	Ianthopsis	*bovallii*	(Studer, 1884)
	Leptanthura	*glacialis*	Hodgson, 1910
	Litarcturus	*lillei*	(Tattersall, 1921)
	Notasellus	*sarsii*	Pfeffer, 1887
	Notoxenus	*spinifer*	Hodgson, 1910
	Munna	*antarctica*	(Pfeffer, 1887)
	Munna	*neglecta*	Monod, 1931
	Natatolana	*albinota*	(Vanhöffen, 1914)
	Natatolana	*intermedia*	(Vanhöffen, 1914)
	Natatolana	*meridionalis*	(Hodgson, 1910)
	Paramunna	*glacialis*	(Hodgson, 1910)
	Paramunna	*rostrata*	(Hodgson, 1910)
	Paramunna	*serrata*	(Richardson, 1908)
	Paramunnopsis	*oceanica*	(Tattersall, 1905)
	Santia	*charcoti*	(Richardson, 1906)
	Serolis	*glacialis*	Tattersall, 1921
Amphipoda	*Abyssorchomene*	*nodimanus*	(Walker, 1903)
	Abyssorchomene	*plebs*	(Hurley, 1965)
	Abyssorchomene	*rossi*	(Walker, 1903)
	Abyssorchomene	*scotianensis*	(Andres, 1983)
	Abyssorchomene ?	sp.	
	Acanthonotozomella	*oatesi*	Barnard, 1930
	Aeginoides	*gaussi*	Schellenberg, 1926
	Ampelisca	*barnardi*	Nicholls, 1938

Ampelisca	*hemicryptops*	Barnard, 1930
Ampelisca	*macrocephala*	Liljeborg
Ampelisca	*richardsoni*	Karaman, 1975
Anchiphimedia	*dorsalis*	Barnard, 1930
Aristias	*antarcticus*	Walker, 1906
Atyloella	*quadridens*	(Barnard, 1930)
Atylopsis	*megalops*	Nicholls, 1938
Byblisoides	*juxtacornis*	Barnard, 1931
Caprellinoides	*spinosus*	Barnard, 1930
Caprellinoides	*mayeri*	(Pfeffer, 1888)
Cheirimedon	*crenatipalmatus*	Stebbing, 1888
Cheirimedon	*fougneri*	Walker, 1903
Cheirimedon	*similis*	Thurston, 1974
Cleonardo	*macrocephala*	Birstein & Vinogradov, 1955
Colomastix	*fissilingua*	Schellenberg, 1926
Cyphocaris	*richardi*	Chevreux, 1905
Cyphocaris	sp.	
Echiniphimedia	*echinata*	(Walker, 1906)
Echiniphimedia	*hodgsoni*	(Walker, 1906)
Echiniphimedia	*scotti*	Barnard, 1930
Epimeria	*inermis*	Walker, 1903
Epimeria	*macrodonta*	Walker, 1906
Epimeria	*punticulata*	Barnard, 1930
Epimeria	*rimicarinata*	Watling & Holman, 1980
Epimeria	*robusta*	Barnard, 1930
Epimeria	*similis*	Chevreux, 1912
Epimeriella	*macronyx*	Walker, 1906
Epimeriella	*walkeri*	Barnard, 1930
Euandandia	*gigantea*	(Stebbing, 1883)
Eusiroides	*stenopleura*	Barnard, 1932
Eusirus	*antarcticus*	Thomson, 1880
Eusirus	*microps*	Walker, 1906
Eusirus	*perdentatus*	Chevreux, 1912
Gammaropsis	*georgianus*	(Schellenberg, 1931)
Gammaropsis	*longicornis*	Walker, 1906
Gammaropsis	sp.	
Gitanopsis	*squamosa*	(Thomson, 1880)
Gnathiphimedia	*mandibularis*	Barnard, 1930
Gnathiphimedia	*sexdentata*	(Schellenberg, 1926)
Halice	*tenella*	Birstein & Vinogradov, 1962
Haplocheira	*barbimana*	(Thomson, 1879)
Haplocheira	sp.	
Heterophoxus	*videns*	Barnard, 1930
Hippomedon	*kergueleni*	(Miers, 1875)
Hippomedon	*macrocephala*	Bellan-Santini, 1972
Hippomedon	*major*	(Barnard, 1932)
Iphimedia	*pacifica*	Stebbing, 1883
Iphimediella	*cyclogena*	Barnard, 1930
Iphimediella	*georgei*	Watling & Holman, 1980
Iphimediella	*margueritei*	Chevreux, 1912
Iphimediella	*microdentata*	(Schellenbeg, 1926)
Iphimediella	*rigida*	Barnard, 1930
Jassa ?	*goniamera*	Walker, 1903
Kerguelenia	*antarctica*	Barnard, 1930
Leucothoe	*spinicarpa*	(Abildgaard, 1789)
Liljeborgia	cf. *georgiana*	Schellenberg,1931
Liljeborgia	*dubia*	(Haswell, 1880)
Maxilliphimedia	*longipes*	(Walker, 1906)
Melphidippa	*antarctica*	Schellenberg, 1926
Metaphoxus	sp.	
Monoculodes	cf. *abacus*	Barnard
Monoculodes	*scabriculosus*	Barnard, 1932
Monoculodes	sp.	
Neoxenodice	*cryophile*	Lowry, 1976
Oediceroides	*calmani*	Walker, 1906
Oediceroides	*newnesi*	(Walker, 1903)
Oradarea	*acuminata*	Thurston, 1974
Oradarea	*megalops*	(Nicholls, 1938)
Oradarea	*rossi*	Thurston, 1974
Oradarea	sp.	
Oradarea	*tricarinata*	Barnard, 1932
Oradarea	*unidentata*	Thurston, 1974
Oradarea	*walkeri*	Shoemaker, 1930

		Orchomene	sp.	
		Orchomenella	*chelipes*	(Walker, 1906)
		Orchomenella	*franklini*	(Walker, 1903)
		Orchomenella	*goniops*	(Walker, 1906)
		Orchomenella	*pinguides*	(Walker, 1903)
		Paramoera	*gregaria*	(Pfeffer, 1888)
		Paramoera	*walkeri*	(Stebbing, 1906)
		Paraphoxus ?	*pyripes*	Barnard, 1930
		Parashisturella	*carinata*	(Schellenberg, 1926
		Parepimeriella	sp.	
		Podoprionides	*incerta*	Walker, 1906
		Polycheria	*antarctica*	(Stebbing, 1875)
		Proboloides	*typica*	(Walker, 1906)
		Prolaphystius	*isopodops*	Barnard, 1930
		Prostebbingia	cf. *gracilis*	(Chevreux, 1912)
		Prostebbingia	*serrata*	Schellenberg, 1926
		Pseudharpinia	*vallini*	(Dahl, 1954)
		Pseudischyrocerus	*distichon*	(Barnard, 1930)
		Schraderia	cf. *dubia*	Thurston, 1974
		Schraderia	cf. *gracilis*	Pfeffer, 1888
		Schraderia	*gracilis*	Pfeffer, 1888
		Scopelocheiropsis	*abyssalis*	Schellenberg, 1926
		Seba	*antarctica*	Walker, 1906
		Stegosoladidus	*ingens*	Chevreux, 1906
		Syrrhoe	*tuberculata*	Dahl, 1954
		Syrrhoites	*anaticauda*	Barnard, 1930
		Thaumatelson	*herdmani*	Walker, 1906
		Torometopa	*antarctica*	(Walker, 1906)
		Torometopa	*perlata*	(Barnard, 1930)
		Tryphosella	*macropareia*	(Schellenberg, 1926
		Tryphosella	*murrayi*	(Walker, 1903)
		Uristes	*adarei*	(Walker, 1903)
		Uristes	*gigas*	Dana, 1852
		Uristes	sp.	
		Uristes	*stebbingi*	(Walker, 1903)
		Urothoe	sp.	
		Ventojassa	*georgiana*	(Schellenberg, 1931)
		Waldeckia	*arnaudi*	(Bellan-Santini, 1972)
		Waldeckia	*obesa*	(Chevreux, 1905)
	Decapoda	*Chorismus*	*antarcticus*	Pfeffer, 1887
		Crangon	*antarcticus*	Pfeffer, 1887
		Nematocarcinus	sp.	
		Notocrangon	*antarctica*	(Pfeffer, 1887)
		Paralomis	*spectabilis*	Hansen, 1908
		Pasiphaea	*scotiae*	(Stebbing, 1914)
		Pentalidium	*foliaceum*	Bate, 1881
Sipunculida		*Golfingia*	*andersonni*	(Theel, 1911)
		Golfingia	*margaritacea capsiformis*	(Baird, 1865)
		Golfingia	*ohlini*	(Theel, 1911)
		Golfingia	sp.	Lankester, 1885; Fisher, 1950
		Phascolosoma	*socium*	Lankester, 1908
Echiura		*Echiura*	*antarcticus*	Spengel, 1912
Priapulida		*Priapulus*	*tuberculatospinosus*	Baird, 1868
Bryozoa		*Acanthophragma*	*polaris*	Hayward, 1993
		Adelascopora	*jeqolqa*	Moyano, 1989
		Aimulosia	*antarctica*	(Powell, 1967)
		Aimulosia	*australis*	Jullien, 1888
		Alcyonidium	*flabelliforme*	Kirkpatrick, 1902
		Alcyonidium	sp.	
		Amastigia	*antarctica*	(Kluge, 1914)
		Amastigia	*cabereoides*	(Kluge, 1914)
		Amastigia	*gaussi*	(Kluge, 1914)
		Amastigia	*solida*	(Kluge, 1914)
		Amphiblestrum	*inermis*	(Kluge, 1914)
		Amphiblestrum	*rossi*	Hayward & Thorpe, 1989
		Annectocyma	*dichotoma*	(d'Orbigny, 1842)
		Antarcticaetos	*bubeccata*	(Rogick, 195
		Aplophragma	*hyalina*	(Waters, 1904)
		Arachnopusia	*aquilina*	Moyano, 1970
		Arachnopusia	*decipiens*	Hayward & Thorpe, 1989
		Arachnopusia	*ferox*	Hayward & Thorpe, 1988
		Arachnopusia	*gigantea*	(Kluge, 1914)
		Arachnopusia	*latiavicularis*	Moyano, 1970

Arachnopusia	n. sp.	
Arachnopusia	*tubula*	Hayward & Thorpe, 198
Aspericreta	*favulosa*	(Hayward & Thorpe, 1989)
Aspidostoma	*coronatum*	(Thornely, 1924)
Astochoporella	*cassidula*	Hayward & Thorpe, 1988
Austroflustra	*vulgaris*	(Kluge, 1914)
Beania	*erecta*	Waters, 1904
Beania	*scotti*	Hastings, 1943
Bicrisia	*edwardsiana*	(d'Orbigny, 1841)
Bostrychopora	*dentata*	(Waters, 1904)
Brettiopsis	*triplex*	(Hastings, 1943)
Buffonellaria	*frigida*	(Waters, 1904)
Buffonellodes	*antarctica*	Hayward, 1991
Bugula	*longissima*	Busk, 1884
Bugulella	*gracilis*	(Nichols, 1911)
Bugulella	*klugei*	(Hastings, 1943)
Caberea	*darwinii*	Busk, 1884
Camptoplites	*angustus*	(Kluge, 1914)
Camptoplites	*areolatus*	(Kluge, 1914)
Camptoplites	*bicornis*	(Busk, 1884)
Camptoplites	*giganteus*	(Kluge, 1914)
Camptoplites	*latus*	(Kluge, 1914)
Camptoplites	*lewaldi*	(Kluge, 1914)
Camptoplites	n. sp.	
Camptoplites	*rectilinearis*	Hastings, 1943
Camptoplites	*retiformis*	(Kluge, 1914)
Camptoplites	*tricornis*	(Waters, 1904)
Carbasea	*curva*	(Kluge, 1914)
Cellaria	*aurorae*	Livingstone, 1928
Cellaria	*coronata*	(Rogick, 1956)
Cellaria	*diversa*	Livingstone, 1928
Cellaria	*moniliorata*	Rogick, 1956
Cellaria	*sagittula*	Hayward & Ryland, 1993
Cellarinella	*margueritae*	Rogick, 1956
Cellarinella	*watersi*	Calvet, 1909
Cellarinella	*anomala*	Hayward & Ryland, 1991
Cellarinella	*edita*	Hayward & Ryland, 1991
Cellarinella	*foveolata*	Waters, 1904
Cellarinella	*latilaminata*	Moyano, 1974
Cellarinella	*laytoni*	Rogick, 1956
Cellarinella	n. sp.	
Cellarinella	*njegovanae*	Rogick, 1956
Cellarinella	*nodulata*	Waters, 1904
Cellarinella	*nutti*	Rogick, 1956
Cellarinella	*rogickae*	Moyano, 1965
Cellarinella	*rossi*	Rogick, 1956
Cellarinella	*virgula*	Hayward & Ryland, 1991
Cellarinelloides	*crassus*	Moyano, 1970
Celleporella	*antarctica*	Moyano & Gordon, 1980
Celleporella	*bougainvillei*	(d'Orbigny, 1842)
Celleporella	*dictyota*	Hayward, 1993
Celleporella	*discreta*	(Busk, 1854)
Chaperiopsis	*cervicornis*	(Busk, 1854)
Chaperiopsis	*quadrispinosa*	(Kluge, 1914)
Chondriovelum	*adeliensis*	(Livingstone, 1928
Cornucopina	*pectogemma*	(Goldstein, 1882)
Cornucopina	*lata*	(Kluge, 1914)
Cornucopina	*polymorpha*	(Kluge, 1914)
Crisia	*patagonica*	d'Orbigny, 1841
Dakariella	*concinna*	Hayward, 1993
Dakariella	*dabrowni*	(Rogick, 1962)
Dendroperistoma	*projecta*	(Waters, 1904)
Disporella	*canaliculata*	(Busk, 1876)
Ellisina	*antarctica*	Hastings, 1945
Ellisina	*constantia*	(Kluge, 1914)
Eminooecia	*carsonae*	(Rogick, 1957)
Entalophoroecia	*eburnea*	(d'Orbigny, 1842)
Escharella	*mamillata*	Hayward & Thorpe, 1989
Escharella	*watersi*	Hayward & Thorpe, 1989
Escharoides	*praestita*	(Waters, 1904)
Exallozoon	*simplicissimum*	(Kluge, 1914)
Exidmonea	*hula*	(Borg, 1944)
Exochella	*avicularis*	Hayward, 1991

Exochella	*elegans*	Hayward, 1991
Exochella	*hymanae*	(Rogick, 1956)
Exochella	*longirostris*	Jullien, 1888
Exochella	*rogickae*	Hayward, 1991
Exochella	*umbonata*	Hayward, 1991
Fenestrulina	*rugula*	Hayward & Ryland, 1990
Fenestrulina	*antarctica*	Hayward & Thorpe, 1989
Fenestrulina	*cervicornis*	Hayward & Ryland, 1990
Fenestrulina	*crystallina*	Hayward & Ryland, 1990
Fenestrulina	*exigua*	(Waters, 1904)
Fenestrulina	n. sp.	
Fenestrulina	*parvipora*	(Waters, 1904)
Fenestrulina	*proxima*	(Waters, 1904)
Figularia	*discors*	Hayward & Taylor, 1984
Filugaria	*spatulata*	(Calvert, 1909)
Harpecia	*spinossisima*	Calvert, 1904)
Hastingsia	*pygmaea*	Borg, 1944
Hastingsia	*irregularis*	Borg, 1944
Himantozoum	*antarcticum*	(Calvet, 1909)
Hippadenella	*inerma*	(Calvet, 1909)
Hippomonavella	*pellucidula*	(Calvet, 1904)
Hippothoa	*flagellum*	Manzoni, 1870
Hornera	*antarctica*	Waters, 1904
Hornera	*smitti*	Borg, 1944
Hornera	*americana*	d'Orbigny, 1842
Hornera	*falklandica*	Borg, 1944
Hornera	*lasarevi*	Androsova, 1968
Icelozoon	*lepralioides*	(Kluge, 1914)
Idmidronea	*antarctica*	Borg, 1944
Idmidronea	*magna*	Androsova, 1968
Inversiula	*nutrix*	Jullien, 1888
Isoschizoporella	*secunda*	Hayward & Taylor, 1984
Isoschizoporella	*similis*	Hayward & Thorpe, 1988
Isoschizoporella	*tricuspis*	(Calvet, 1909)
Isoschizoporella	*virgula*	Hayward & Thorpe, 1988
Isosecuriflustra	*angusta*	(Kluge, 1914)
Isosecuriflustra	*tenuis*	(Kluge, 1914)
Isosecuriflustra	*thysanica*	(Moyano, 1972)
Klugeflustra	*antarctica*	(Hastings, 1943)
Klugeflustra	*vanhoffeni*	(Kluge, 1914)
Klugella	*echinata*	(Kluge, 1914)
Klugerella	*antarctica*	(Kluge, 1914)
Kymella	*polaris*	(Waters, 1904)
Lacerna	*eatoni*	(Busk, 1876)
Lacerna	*hosteensis*	Jullien, 1888
Lacerna	*watersi*	Hayward & Thorpe, 1989
Lageneschara	*lyrulata*	(Calvet, 1909)
Lagenipora	sp.	
Larvapora	*mawsoni*	(Livingstone, 1928)
Melicerita	*obliqua*	(Thornely, 1924)
Melicerita	*latilaminata*	Rogick, 1956
Micropora	*brevissima*	Waters, 1904
Micropora	*notialis*	Hayward & Ryland, 1993
Microporella	*stenoporta*	Hayward & Taylor, 1984
Nematoflustra	*flagellata*	(Waters, 1904)
Neofungella	*claviformis*	(Waters, 1904)
Nevianipora	*rogickiana*	(Androsova, 1968)
Nimba	sp.	
Notoplites	*antarcticus*	(Waters, 1904)
Notoplites	*klugei*	(Hasenbank, 1932)
Notoplites	*drygalskii*	(Kluge, 1914)
Notoplites	*tenuis*	(Kluge, 1914)
Notoplites	*uniserialis*	Hastings, 1943
Notoplites	*vanhoffeni*	(Kluge, 1914)
Notoplites	*watersi*	(Kluge, 1914)
Orthoporidra	*compacta*	(Waters, 1904)
Orthoporidra	*brachyrhyncha*	Moyano, 1985
Orthoporidra	*stenorhyncha*	Moyano, 1985
Osthimosia	*mariae*	Hayward, 1992
Osthimosia	*milleporoides*	(Calvet, 1909)
Osthimosia	*bicornis*	(Busk, 1881)
Osthimosia	*clavata*	Waters, 1904
Osthimosia	*claviformis*	Hayward, 1993

		Osthimosia	*fusticula*	Hayward, 1992
		Osthimosia	*malingae*	Hayward, 1992
		Osthimosia	n. sp.	
		Osthimosia	*notialis*	Hayward, 1992
		Osthimosia	*phalacrocoraca*	Hayward, 1992
		Osthimosia	*rudicula*	Hayward, 1992
		Paracellaria	*wandeli*	(Calvet, 1909)
		Pelikopyxis	*inconstantia*	(Kluge, 1914)
		Pelikopyxis	*perlucida*	(Kluge, 1914)
		Pemmatoporella	*marginata*	(Calvet, 1909)
		Plesiothoa	*calculosa*	Hayward, 1993
		Polirhabdotos	*inclusum*	(Waters, 1904)
		Reteporella	*antarctica*	(Waters, 1904)
		Reteporella	*erugata*	Hayward, 1993
		Reteporella	*frigida*	(Waters, 1904)
		Reteporella	*gelida*	(Waters, 1904)
		Reteporella	*hippocrepis*	(Waters, 1904)
		Reteporella	*lepralioides*	(Waters, 1904)
		Reteporella	*longichila*	Hayward, 1993
		Reteporella	*parva*	Hayward, 1993
		Reteporella	*protecta*	(Waters, 1904)
		Rhamphosmittina	*bassleri*	(Rogick, 1956)
		Romancheina	*asymmetrica*	Moyano, 1975
		Romancheina	*barica*	(Rogick, 1955)
		Smittina	*antarctica*	(Waters, 1904)
		Smittina	*abditavicularis*	Rogick, 1956
		Smittina	*alticollarita*	Rogick, 1956
		Smittina	*anecdota*	Hayward & Thorpe, 1990
		Smittina	*ctenocondyla*	Hayward & Thorpe, 1990
		Smittina	*diffidentia*	Hayward & Thorpe, 1989
		Smittina	*directa*	(Waters, 1904)
		Smittina	*excertaviculata*	Rogick, 1956
		Smittina	*glebula*	Hayward & Thorpe, 1990
		Smittina	*incernicula*	Hayward & Thorpe, 1990
		Smittina	n. sp.	
		Smittina	*obicullata*	Rogick, 1956
		Smittina	*pileata*	(Waters, 1904)
		Smittinella	*rubrilingulata*	Rogick, 1956
		Smittoidea	*pugiuncula*	Hayward & Thorpe, 1989
		Smittoidea	*albula*	Hayward & Taylor, 1984
		Smittoidea	*conspicua*	(Waters, 1904)
		Smittoidea	*malleata*	Hayward & Thorpe, 1989
		Smittoidea	n. sp.	
		Smittoidea	*ornatipectoralis*	Rogick, 1956
		Spigaleos	*homeroides*	(Waters, 1904)
		Stomhypselosaria	*watersi*	Hayward & Thorpe, 1989
		Swanomia	*belgica*	Hayward & Ryland, 1993
		Swanomia	*brevimandibulata*	(Moyano, 1969)
		Swanomia	*membranacea*	(Thomely, 1924)
		Swanomia	sp.	
		Systenopora	*contracta*	Waters, 1904
		Telopora	*sarsii*	(Borg, 1944)
		Thrypticocirrus	*contortuplicata*	(Calvet, 1909)
		Thrypticocirrus	*phylactelloides*	(Calvet, 1909)
		Thrypticocirrus	*rogickae*	Hayward & Thorpe, 1988
		Toretocheilum	*absidatum*	Rogick, 1960
		Toretocheilum	*turbinatum*	Hayward, 1995
		Tracheloptyx	*antarctica*	Hayward, 1993
		Trilaminopora	*trinervis*	(Waters, 1904)
		Trilochites	*biformatus*	(Waters, 1904)
		Tubulipora	*gracillima*	Borg, 1944
		Tubulipora	*organisans*	d'Orbigny, 1842
		Tubulipora	sp.	
		Turritigera	*cribrata*	Hayward, 1993
		Valdemunitella	*lata*	(Kluge, 1914)
Entoprocta		*Barentsia*	*discreta*	(Busk, 1886)
Brachiopoda	Inarticulata	*Crania*	*lecointei*	Joubin, 1901
		Pelagodiscus	*atlanticus*	(King, 1868)
	Articulata	*Compsothyris*	*ballenyi*	Foster, 1974
		Compsothyris	*racovitzae*	(Joubin, 1901)
		Amphithyris	*hallettensis*	Thomson, 1918
		Compsothyris	sp.	Jackson, 1918
		Dyscolia	sp.	Fischer & Oehlert, 1891

		Eucalathis	*murrayi*	(Davidson, 1978)
		Fallax	*antarcticus*	Atkins, 1960
		Liothyrella	*blochmanni*	(Jackson, 1912)
		Liothyrella	*multiporosa*	Thomson, 1916
		Liothyrella	*scotti*	Thomson, 1916
		Liothyrella	sp.	Thomson, 1916
		Liothyrella	*uva antarctica*	(Blochmann, 1906)
		Macandrevia	*americana*	Dall, 1895
		Macandrevia	*vanhoeffeni*	Blochmann, 1906
		Magellania	*fragilis*	Smith, 1907
		Magellania	*joubini*	Blochmann, 1906
		Magellania	sp.	Bayle, 1880
		Magellania	*spinosa*	Bayle, 1880
		Manithyris	*rossi*	Foster, 1974
		Terebratella	sp.	King, 1850
Echinodermata	Asteroidea	*Acodontaster*	*capitatus*	(Koehler 1912)
		Acodontaster	*conspicuus*	(Koehler 1920)
		Acodontaster	*hodgsoni*	(Bell 1908)
		Acodontaster	sp.	
		Asterias	*longstaffi*	(Bell 1908)
		Bathybiaster	*loripes obesus*	Sladen, 1889
		Bathybiaster	*loripes*	Sladen 1889
		Crossaster	*canopus*	H.E.S. Clark 1963
		Cuenotaster	sp.	
		Cuenotaster	*involutus*	(Koehler 1912)
		Cycethra	*verrucosa*	(Philippi 1857)
		Diplasterias	*brucei*	(Koehler 1908)
		Henricia	*smilax*	(Koehler 1920)
		Kampylaster	*incurvatus*	Koehler 1920
		Labidiaster	*annulatus*	Sladen 1889
		Leptychaster	*flexuosus*	Koehler 1920
		Leptychaster	sp.	
		Lophaster	*gaini*	Koehler 1912
		Lophaster ?	sp.	
		Luidiaster	*gerlachi*	(Ludwig 1903)
		Lysasterias	*adelie*	(Koehler 1920)
		Lysasterias	*joffrei*	(Koehler 1920)
		Lysasterias	sp.	
		Macroptychaster	*accrescens*	(Koehler 1920)
		Notasterias	*armata*	Koehler 1911
		Notasterias	*stolophora*	Fisher 1940
		Odontaster	*penicillatus*	(Philippi, 1870)
		Odontaster	*meridionalis*	(Smith 1876)
		Odontaster	sp.	
		Odontaster	*validus*	Koehler, 1906
		Paralophaster	*antarcticus*	Koehler 1912
		Paralophaster	*godfroyi*	(Koehler 1912)
		Paralophaster	*lorioli*	(Koehler 1908)
		Pedicellaster	*hypernotius*	Sladen 1861
		Pergamaster	*incertus*	(Bell 1908)
		Pergamaster	*triseriatus*	H.E.S. Clark 1962
		Peribolaster	*macleani*	Koehler 1920
		Peribolaster	*powelli*	H.E.S. Clark 1963
		Perknaster	*densus*	Sladen 1889
		Perknaster	*fuscus*	Sladen 1889
		Perknaster	*sladeni*	(Perrier 1891)
		Porania	*antarctica glabra*	Sladen, 1889
		Porania	*antarctica*	Smith 1876
		Psalidaster	*mordax*	Fisher 1940
		Psilaster	*charcoti*	(Koehler 1906)
		Pteraster	*stellifer*	Sladen 1882
		Remaster ?	sp.	
		Rhopiella	*hirsuta*	(Koehler, 1920)
		Saliasterias	*brachiata*	Koehler 1920
		Solaster	*regularis*	Sladen 1889
		Spinulosa	sp.	
	Ophiuroidea	*Amphiodia*	*joubini*	(Koehler 1912)
		Amphiura	*algida*	Koehler 1911
		Amphiura	*belgicae*	Koehler 1900
		Amphiura	*joubini*	(Koehler 1912)
		Astrochlamys	*bruneus*	Koehler 1912
		Astrohamma	*tuberculatum*	(Koehler 1923)
		Astrotoma	*agassizi*	Lyman 1875

	Euvondrea	*floretta*	Fell 1961a
	Glaciacantha	*jason*	Fell 1961
	Gorgonocephalus	*chilensis*	(Philippi 1858)
	Ophiacantha	*vivipara*	Ljungman, 1870
	Ophiacantha	*pentactis*	Mortensen 1936
	Ophiacantha	*antarctica*	Koehler 1900
	Ophioceres	*incipiens*	Koehler 1922
	Ophiocten	*megaloplax*	Koehler 1900
	Ophiodaces	*inanis*	Koehler 1922
	Ophiogona	*doderleini*	(Koehler, 1901)
	Ophiomastus	*bispinosus*	Mortensen 1925
	Ophionotus	*taylori*	McKnight 1967
	Ophionotus	*victoriae*	Bell 1902
	Ophioperla	*koehleri*	(Bell, 1908)
	Ophioplocus	*incipiens*	(Koehler, 1922)
	Ophiopyren	*regularis*	Koehler 1900
	Ophiosparte	*gigas*	Koehler 1922
	Ophiosteira	*debitor*	Koehler, 1922
	Ophiosteira	*bullivanti*	Fell 1961a
	Ophiosteira	*echinulata*	Koehler 1922
	Ophiosteira	*antarctica*	Bell 1902
	Ophiosteira	*senouqui*	Koehler 1912
	Ophiura	*meridionalis*	(Lyman, 1879)
	Ophiura	*ambigua*	(Lyman 1878)
	Ophiura	*crassa*	Mortensen 1936
	Ophiura	*flexibilis*	(Koehler 1911)
	Ophiura	*umitakamaruae*	Seno & Irimura 1968
	Ophiuroglypha	*carinifera*	(Koehler 1901)
	Ophiurolepis	*brevirima*	Mortensen 1936
	Ophiurolepis	*martensi*	(Studer 1885)
	Ophiurolepis	*tuberosa*	(Mortensen 1936)
	Ophiurolepis	*gelida*	(Koehler 1900)
	Theodoria	*relegata*	(Koehler 1922)
	Theodoria	*wallini*	(Mortensen 1925)
	Toporkovia	*antarctica*	(Lyman 1882)
Echinoidea	*Amphipneustes ?*	sp.	
	Abatus	*agassizi*	(Pfeffer 1889)
	Abatus	*elongatus*	(Koehler 1908)
	Abatus	*ingens*	Koehler 1926
	Abatus	*nimrodi*	(Koehler 1911)
	Abatus	*philippi*	Loven 1871
	Abatus	*shackletoni*	Koehler 1911
	Abatus	sp.	
	Amphipneustes	*brevisternalis*	(Koehler 1926)
	Amphipneustes	*rostratus*	(Koehler 1926)
	Aporocidaris	*antarctica*	Mortensen, 1909
	Aporocidaris	*milleri*	(A.Agassiz 1898)
	Ctenocidaris	*gelberti*	(Koehler, 1912)
	Ctenocidaris	*gigantea*	(H.L. Clark 1925)
	Ctenocidaris	*perrieri*	Koehler, 1912
	Ctenocidaris	*speciosa*	Mortensen 1910
	Homalocidaris	*gigantea*	(H.L. Clark 1925)
	Notocidaris	*hastata*	Mortensen 1909
	Notocidaris	*lanceolata*	Chesher, unpub
	Notocidaris	*mortenseni*	(Koehler 1900)
	Notocidaris	*platyacantha*	H.L. Clark 1925
	Plexechinus	*nordenskjoldi*	Mortensen 1905
	Pourtalesia	sp	
	Rhynchocidaris	*triplopora*	Mortensen 1909
	Spatangoidea	sp.	
	Sterechinus	*antarcticus*	Koehler 1901
	Sterechinus	*dentifer*	Koehler 1926
	Sterechinus	*neumayeri*	(Meissner 1900)
	Sterechinus	sp.	
	Sterechinus	*diadema*	(Studer 1876)
	Tripylus	*abatoides*	(H.L. Clark 1925)
Holothuroidea	*Achlyonice*	*monactinica*	Oshima, 1915
	Bathyplotes	*moseleyi*	(Theel, 1886)
	Benthodytes	*plana*	Hansen, 1975
	Cucumaria	*ferrari*	(Bell)
	Cucumaria	*georgiana*	(Lampert)
	Echinopsolus	cf. *parvipes*	Massin
	Ekmocucumis	*steineni*	(Ludwig)

		Paracucumis	*antarctica*	Mortensen 1925
		Psolidium	*charcoti*	(Vaney)
		Psolidium	*gaini*	Vaney
		Psolidium	*incertum*	(Theel)
		Psolidium	*tenue*	Mortensen1925
		Psolus	*antarcticus*	(Philippi)
		Psolus	*arnaudi*	Cherbonnier
		Psychropotes	*longicauda*	Theel, 1882
		Scotoplanes	*globosa*	(Theel, 1879)
		Staurocucumis	*abyssorum*	(Theel)
		Staurocucumis	*liouvillei*	(Vaney)
		Taeniogyrus	*contortus*	(Ludwig)
		Trachythyone	sp.	
	Crinoidea	*Anisometra*	*frigida*	John 1939
		Anthometra	*adriani*	(Bell 1908)
		Eumorphometra	*fraseri*	John 1938
		Florometra	*mawsoni*	A.H. Clark 1937
		Florometra	sp.	
		Isometra	*graminea*	John 1938
		Isometra	*hordea*	John 1938
		Notocrinus	*virilis*	Mortensen 1917
		Pentametrocrinus	sp.	
		Phrixometra	*?rayneri*	John 1938
		Promachocrinus	*kerguelensis*	P.H. Carpenter 1888
		Solanometra	*antarctica*	(P.H. Carpenter 1888)
		Thaumatocrinus	*renovatus*	P.H. Carpenter 1884
Hemichordata	Cephalodiscida	*Cephalodiscus*	*hodgsoni*	Ridewood, 1907
		Cephalodiscus	*nigrescens*	Lankester, 1905
		Cephalodiscus	*densus*	Anderson, 1907
Chordata	Ascidiacea	*Aplidium*	*balleniae*	Monniot & Monniot
		Aplidium	*caeruleum*	(Sluiter, 1906)
		Aplidium	*cyaneum*	Monniot & Monniot
		Aplidium	*imbutum*	Monniot & Monniot
		Aplidium	*loricatum*	(Harant & Vernieres, 1938)
		Aplidium	*meridianum*	(Sluiter)
		Aplidium	*radiatum*	(Sluiter, 1906)
		Aplidium	*vastum*	(Sluiter, 1912)
		Aplidium	sp.	
		Arachnopusia	*aquilina*	
		Ascidia	*challengeri*	Herdman, 1882
		Bathyoncus	*mirabilis*	Herdman
		Bathypera	*splendens*	Michaelsen
		Caenagnesia	*bocki*	Arnback, 1938
		Caenagnesia	*schmitti*	
		Cibacaspa	*gulosa*	Monniot & Monniot, 1983
		Cnemidocarpa	*bythia*	Millar
		Cnemidocarpa	*drygalskii*	(Hartmeyer)
		Cnemidocarpa	*verrucosa*	(Lesson, 1830)
		Cnemidocarpa	sp.	
		Corella	*eumyota*	Traustedt
		Culeolus	*antarcticus*	Vinogradova
		Cystodytes	*antarcticus*	Sluiter
		Didemnum	*biglans*	(Sluiter, 1906)
		Didemnum	sp.	
		Distaplia	*colligans*	Sluiter, 1932
		Distaplia	*cylindrica*	(Lesson, 1830)
		Distaplia	*megathorax*	Monniot & Monniot, 1981
		Distaplia	sp.	
		Fasciculipora	*ramosa*	
		Ihlea	*magalhanica*	(Apstein)
		Molgula	*euplicata*	Herdman, 1923
		Molgula	*pedunculata*	Herdman, 1881
		Molgula	*robini*	Monniot & Monniot
		Molgula	sp.	
		Pareugyioides	*arnbackae*	(Millar, 1960)
		Polysyncraton	*chondrilla*	(Michaelsen, 1924)
		Polysyncraton	*trivolutum*	(Millar)
		Pyura	*bouvetensis*	(Michaelsen)
		Pyura	*challengeri*	Herdman
		Pyura	*discoveryi*	(Herdman, 1910)
		Pyura	*georgiana*	(Michaelsen, 1898)
		Pyura	*multiruga*	Monniot & Monniot, 1982
		Pyura	*setosa*	(Sluiter, 1914)

Pyura	*squamata*	Hartmeyer
Styela	*nordenskjoldi*	Michaelsen, 1898
Styela	*rotunda*	
Sycozoa	*georgiana*	(Michaelsen, 1907)
Sycozoa	*sigillinoides*	Lesson
Synoicum	*adareanum*	(Herdman)
Synoicum	sp.	
Tylobranchion	*speciosum*	Herdman, 1886

Table 5.5.2. Summary of the overall benthic biodiversity of the Ross Sea region, based on published and unpublished records of species occurrences.

Phylum/Class	Class/Order	Genera	Species
Rhodophyta		13	18
Phaeophyta		7	11
Chlorophyta		4	4
Protozoa	Foraminiferida	171	802
Ctenophora		1	1
Porifera		103	233
Hydrozoa	Hydroida	25	37
	Actinulida	3	4
	Antipatharia	2	2
	Ceriantharia	1	1
	Stolonifera	1	1
	Alcyonacea	2	2
	Gorgonacea	15	22
	Pennatulacea	1	2
	Actinaria	21	23
Platyhelminthes	Trematoda	10	14
	Cestoda	5	12
Nemertea		5	6
Nematoda		8	19
Acanthocephala		2	4
Annelida	Polychaeta	140	220
	Clitellata	9	15
Mollusca	Gastropoda	96	184
	Nudibranchia	13	22
	Polyplacophora	4	4
	Aplacophora	2	2
	Bivalvia	37	56
	Scaphopoda	3	5
Arthropoda	Arachnida	1	1
	Pycnogonida	21	61
Crustacea	Ostracoda	6	9
	Cirripedia	3	5
	Mysidacea	9	13
	Cumacea	10	16
	Tanaidacea	6	11
	Isopoda	30	48
	Amphipoda	66	120
	Decapoda	7	7
Sipunculida		2	5
Echiura		1	1
Priapulida		1	1
Bryozoa		99	231
Entoprocta		1	1
Brachipoda	Inarticulata	2	2
	Articulata	12	22
Echinodermata	Asteroidea	31	51
	Ophiuroidea	26	42
	Echinoidea	13	31

Table 6.1. List of fishes from the Ross Sea (south of 60° S, 160° E to 150° W out to 3000 m). Species not recorded but likely to occur in the Ross Sea area are also listed (*) and include widespread or circum-Antarctic species. Based on Gon & Heemstra (1990), Eastman & Hubold (1999), Andriashev & Stein (1998), Chernova & Eastman (2001), and Vacchi et al. (2001). Nomenclature and synonymies follow Eschmeyer (1998), Eastman & Eakin (2000), and Voskoboinikova (2000).

Pelagic and cryopelagic† species

GONOSTOMATIDAE
Cyclothone microdon (Günther, 1878)
Cyclothone pseudopallida Mukhacheva, 1964

SCOPELARCHIDAE
Benthabella elongata (Norman, 1937) *
B. macropinna Bussing & Bussing, 1966 *

PARALEPIDIDAE
Notolepis coatsi Dollo, 1908

ANOTOPTERIDAE
Anotopterus pharao Zugmayer, 1911 *

MYCTOPHIDAE
Electrona antarctica (Günther, 1878)
Gymnoscopelus braueri (Lönnberg, 1905)
Gymnoscopelus nicholsi (Gilbert, 1911)
Gymnoscopelus opisthopterus Fraser-Brunner, 1949 *
Krefftichthys anderssoni (Lönnberg, 1905)
Nannobranchium achirus (Andriashev, 1962)
Protomyctophum bolini (Fraser-Brunner, 1949)

ONEIRODIDAE
Oneirodes notius Pietsch, 1974

MELANOCETIDAE
Melanocetus rossi Balushkin & Fedorov, 1981

NOTOTHENIIDAE
Aethotaxis mitopteryx DeWitt, 1962
Gvozdarus svetovidovi Balushkin, 1989
Pagothenia borchgrevinki (Boulenger, 1902) †
P. brachysoma (Pappenheim, 1912) †
Pleuragramma antarcticum Boulenger, 1902

GEMPYLIDAE
Paradiplospinus gracilis (Brauer, 1906) *

Benthic and bentho-pelagic species

RAJIDAE
Bathyraja eatonii (Günther 1876)
B. maccaini Springer, 1971
Raja georgiana Norman 1938

BATHYLAGIDAE
Bathylagus antarcticus Günther, 1878

MURAENOLEPIDIDAE
Muraenolepis microps Lönnberg, 1905

MACROURIDAE
Coryphaenoides ferrieri (Regan, 1913)
Cynomacrurus piriei Dollo, 1909
C. lecointei (Dollo, 1900)
Macrourus whitsoni (Regan, 1913)

CETOMIMIDAE
Gyrinomimus grahami Richardson & Garrick, 1964

CYCLOPTERIDAE (LIPARIDAE)
Careproctus ampliceps Andriashev & Stein, 1998
C. catherinae Andriashev & Stein, 1998
C. inflexidens Andriashev & Stein, 1998
C. polarsterni Duhamel, 1992
C. pseudoprofundicola Andriashev & Stein, 1998
C. vladibeckeri Andriashev & Stein, 1998
Edentoliparis terraenovae (Regan, 1916)
Paraliparis andriashevi Stein & Tompkins, 1989
P. antarcticus Regan, 1914
P. devriesi Andriashev, 1980
P. fuscolingua Stein & Tompkins, 1989
P. macrocephalus Chernova & Eastman, 2001
P. rossi Chernova & Eastman, 2001

ZOARCIDAE
Dieidolycus leptodermatus Anderson, 1988
Lycodichthys dearborni (DeWitt, 1962)
Ophthalmolycus amberensis (Tomo, Marschoff & Torno, 1977)
O. bothriocephalus (Pappenheim, 1912)
Pachycara brachycephalum (Pappenheim, 1912)

NOTOTHENIIDAE
Dissostichus mawsoni Norman, 1937
Lepidonotothen larseni (Lönnberg, 1905)
L. squamifrons (Günther, 1880)
Notothenia coriiceps Richardson, 1844
Paranotothenia dewitti Balushkin, 1990
Trematomus bernacchii Boulenger, 1902
T. eulepidotus Regan, 1914
T. hansoni Boulenger, 1902
T. lepidorhinus (Pappenheim, 1911)
T. loennbergii Regan, 1913
T. newnesi Boulenger, 1902
T. nicolai (Boulenger, 1902)
T. pennellii Regan, 1914
T. scotti (Boulenger, 1907)
T. tokarevi Andriashev, 1978

ARTEDIDRACONIDAE
Artedidraco glareobarbatus Eastman & Eakin, 1999
A. loennbergi Roule, 1913
A. orianae Regan, 1914
A. shackletoni Waite, 1911
A. skottsbergi Lönnberg, 1905
Dolloidraco longedorsalis Roule, 1913
Histiodraco velifer (Regan, 1914)
Pogonophryne albipinna Eakin, 1981
P. barsukovi Andriashev, 1967
P. cerebropogon Eakin & Eastman, 1998
P. lanceobarbata Eakin, 1987
P. macropogon Eakin, 1981
P. marmorata Norman, 1938

P. mentella Andriashev, 1967
P. permitini Andriashev, 1967
P. scotti Regan, 1914

BATHYDRACONIDAE
Acanthodraco dewitti Skóra, 1995
Akarotaxis nudiceps (Waite, 1916)
Bathydraco macrolepis Boulenger, 1907
B. marri Norman, 1938
B. scotiae Dollo, 1906
Cygnodraco mawsoni Waite, 1916
Gerlachea australis Dollo, 1900
Gymnodraco acuticeps Boulenger, 1902
Prionodraco evansii Regan, 1914
Racovitzia glacialis Dollo, 1900
Vomeridens infuscipinnis (DeWitt, 1964)

CHANNICHTHYIDAE
Cryodraco antarcticus Dollo, 1900
C. hamatus (Lönnberg, 1905)
C. myersi (DeWitt & Tyler, 1960)
C. wilsoni (Regan, 1914)
Dacodraco hunteri Waite, 1916
Neopagetopsis ionah Nybelin, 1947
Pagetopsis macropterus (Boulenger, 1907)
P. maculatus Barsukov & Permitin, 1958

Table 7.1 List of species recorded form the Ross Sea and the Balleny Islands

Wandering albatross	*Diomedea exulans*
Black-browed albatross	*Thalassarche melanophrys*
Grey-headed albatross	*Thalassarche chrysostoma*
Light-mantled sooty albatross	*Phoebetria palpebrata*
Sooty shearwater	*Puffinus griseus*
Short-tailed shearwater	*Puffinus tenuirostris*
Grey petrel	*Procellaria cinerea*
White-chinned petrel	*Procellaria aequinoctialis*
Antarctic petrel	*Thalassoica antarctica*
Cape petrel	*Daption capense*
Snow petrel	*Pagodroma nivea*
Antarctic fulmar	*Fulmarus glacialoides*
Southern giant petrel	*Macronectes giganteus*
Thin-billed prion	*Pachyptila belcheri*
Antarctic prion	*Pachytila desolata*
Blue petrel	*Halobaena caerulea*
Mottled petrel	*Pterodroma inexpectata*
White-headed petrel	*Pterodroma lessonii*
Black-bellied storm petrel	*Fregatta tropica*
Wilson's storm petrel	*Oceanites oceanicus*
Diving petrel	*Pelecanoides* spp.
Emperor penguin	*Aptenodytes forsteri*
King penguin	*Aptenodytes patagonicus*
Chinstrap penguin	*Pygoscelis antarctica*
Adelie penguin	*Pygoscelis adeliae*
Macaroni penguin	*Eudyptes chrysolophus*
Southern skua	*Catharacta lonnbergi*
South polar skua	*Catharacta maccormicki*
Southern black-backed gull	*Larus dominicanus*
Arctic tern	*Sterna paradisaea*

Table 7.1.1 Seabird community composition in the Ross Sea region, after Ainley et al., 1984.

Seabird community	*Major species*	*Minor species*
High latitudes dominated by pack ice	Emperor penguin	Antarctic fulmar
	Adelie penguin	Southern giant petrel
	Antarctic petrel	Wilson's storm petrel
	Snow petrel	Southern black-backed gull
	South polar skua	Chinstrap penguin
Polar water north of pack ice, in ice berg zone	Antarctic fulmar	Light-mantled sooty albatross
	Wilson's storm petrel	Southern giant petrel
	Antarctic petrel	Cape petrel
	Mottled petrel	Snow petrel
		Antarctic prion
		Macaroni penguin
Polar front, essentially ice-free seas	Black-browed albatross	King penguin
	Light-mantled sooty albatross	Wandering albatross
	Southern giant petrel	Grey-headed albatross
	Cape petrel	White-chinned petrel
	Antarctic prion	Blue petrel
	Mottled petrel	White-headed petrel
	Sooty shearwater	Diving petrels
	Short-tailed shearwater	
	Black-bellied storm petrel	
	Southern skua	

Table 7.2.1 Breeding birds of the Ross Sea region, updated from Harper et al., 1984. *, Scott Island is a very small volcanic island subject to high seas and severe erosion; it is occupied opportunistically by these species (Harper et al., 1984); ?, breeding status unknown.

Species	**Scott Island**	**Balleny Islands**	**Victoria Land**	**Southern Islands**	**Marie Byrd Land**
Emperor penguin	-	-	+	+	?
Adelie penguin	-	+	+	+	+
Chinstrap penguin	-	+	-	-	-
Cape petrel	*	+	-	-	-
Antarctic fulmar	*?	?	?	?	?
Snow petrel	+	+	+	+	+
Antarctic petrel	*?	-	?	?	+
Antarctic prion	*	-	-	-	-
Wilson's storm petrel	+	?	+	-	?
Antarctic skua	-	+	+	+	+
South polar skua	-	?	-	-	-

Table 10.1.7.1 List of mammalian species found in the Ross Sea.

Seals
Weddell seal *Leptochynotes weddellii*
Crabeater seal *Lobodon carcinophagus*
Ross seal *Ommatophoca rossii*
Leopoard seal *Hydrurga leptonyx*
Southern elephant seal *Mirounga leonina*

Baleen whales
Blue whale *Balaenoptera musculus*
Fin whale *Balaenoptera physalus*
Sei whale *Balaenoptera borealis*
Minke whale *Balaenoptera acuturostrata*
Dwarf minke whale *Balaenoptera bonarensis*
Humpback whale *Megaptera novaeangliae*

Toothed whales
Sperm whale *Physeter macrocephalus*
Killer Whale *Orcinus orca*
Arnoux's beaked whale *Berardius arnuxii*
Southern bottlenose whale *Hyperoodon planifrons*
Long-finned pilot whale *Globicephala melas*
Hourglass dolphin *Lagenorhynchus cruciger*

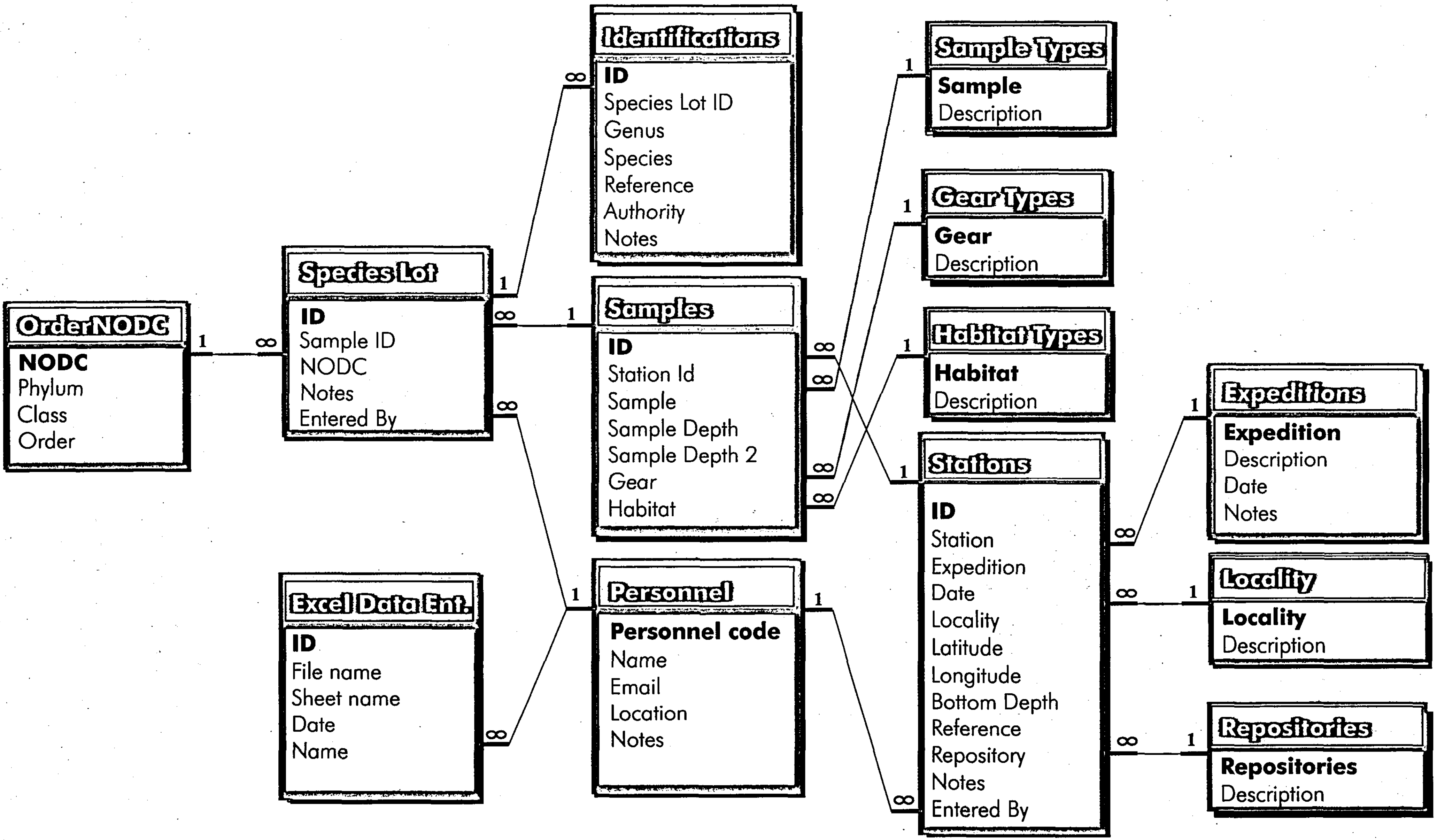


Fig. 1.1. Structure of the relational database for the Ross Sea (BIOROSS).

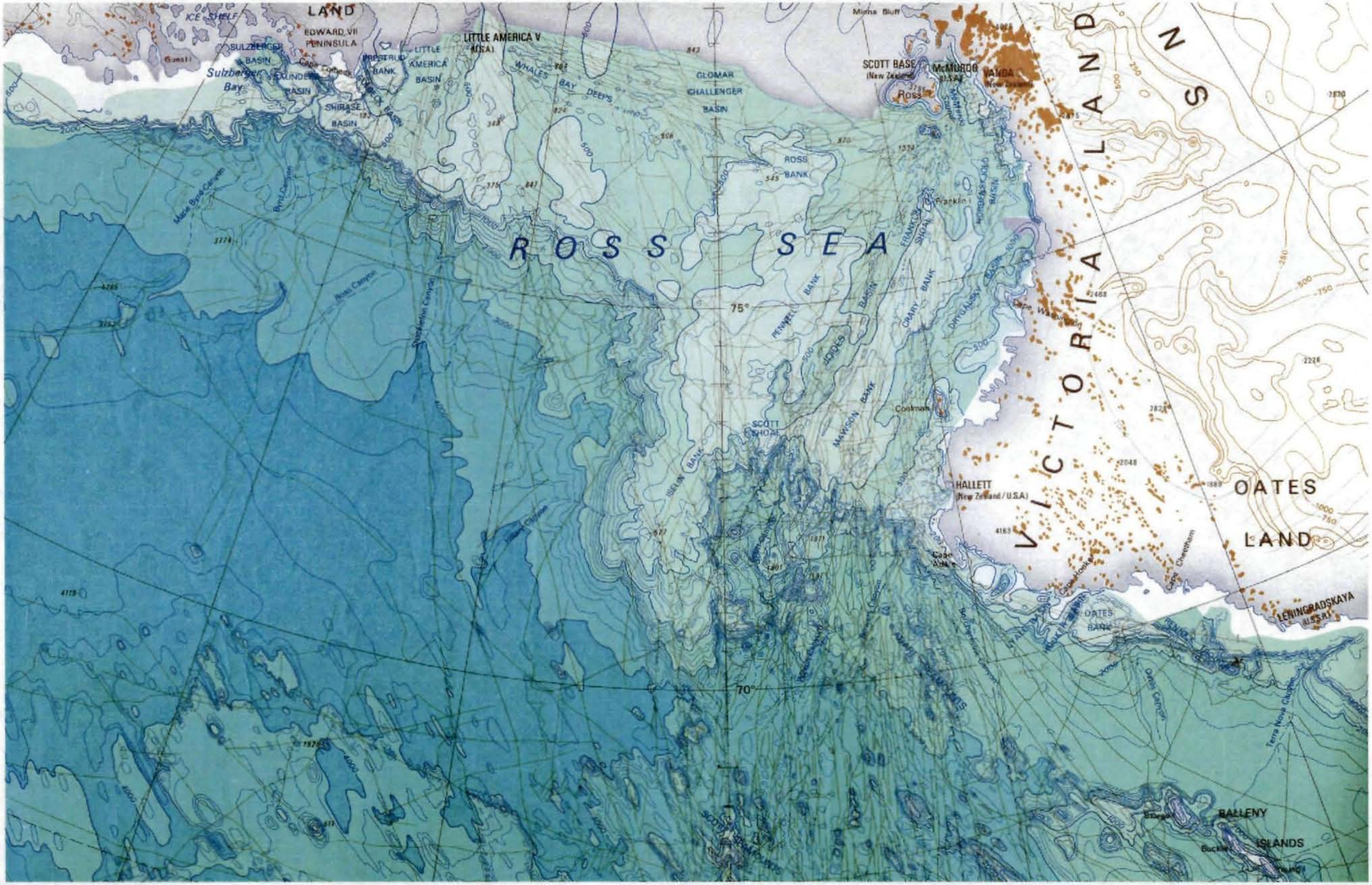


Fig. 1.2.1.1. Bathymetry of the Ross Sea (from GEBCO chart 5.18).

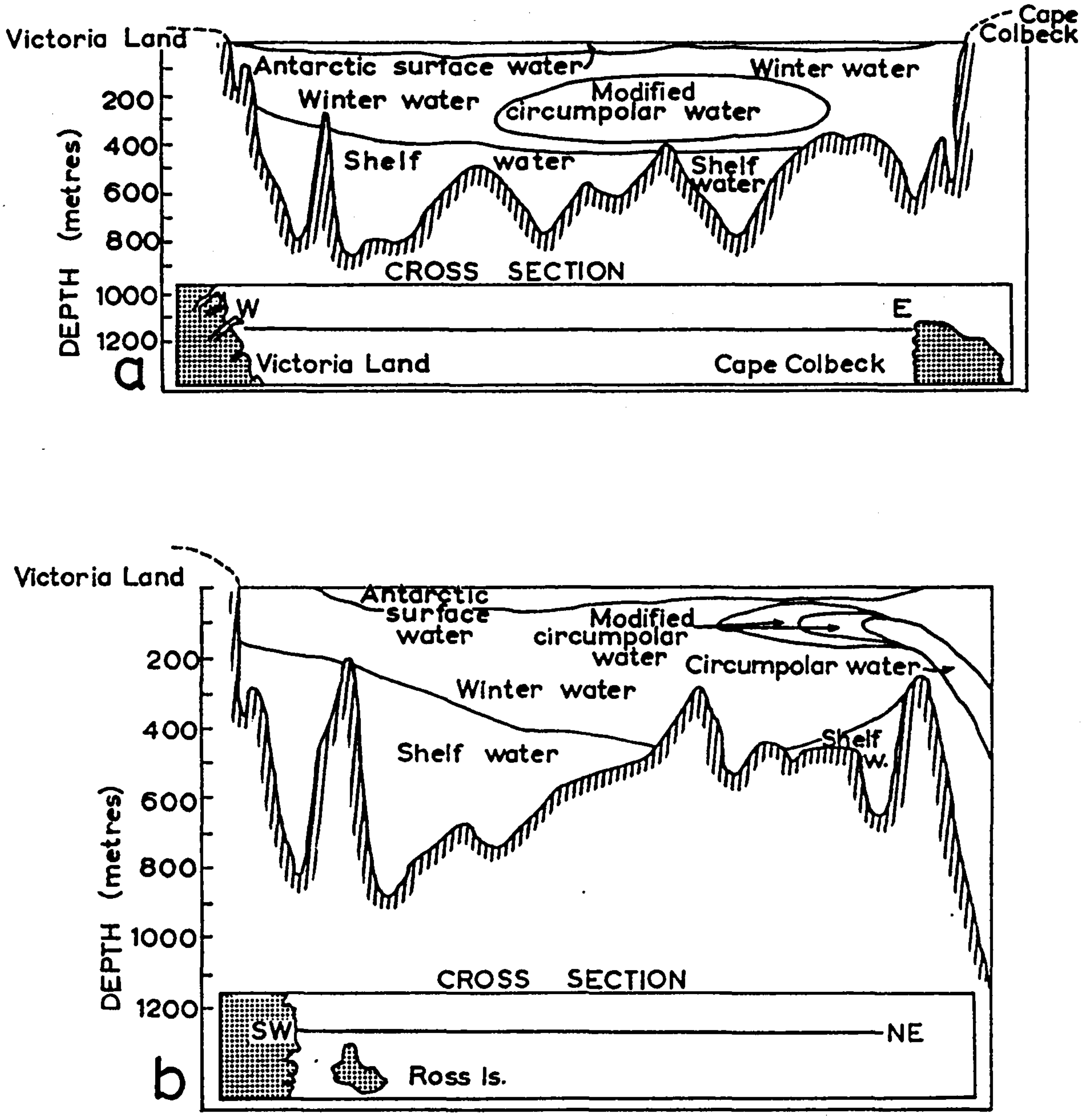


Fig. 1.2.2.1. Generalised relationships of water masses in the Ross Sea (from Countryman & Gsell, 1966): a, east-west section from Cape Colbeck to Victoria Land; b, north-east, south-west section from Ross Island.

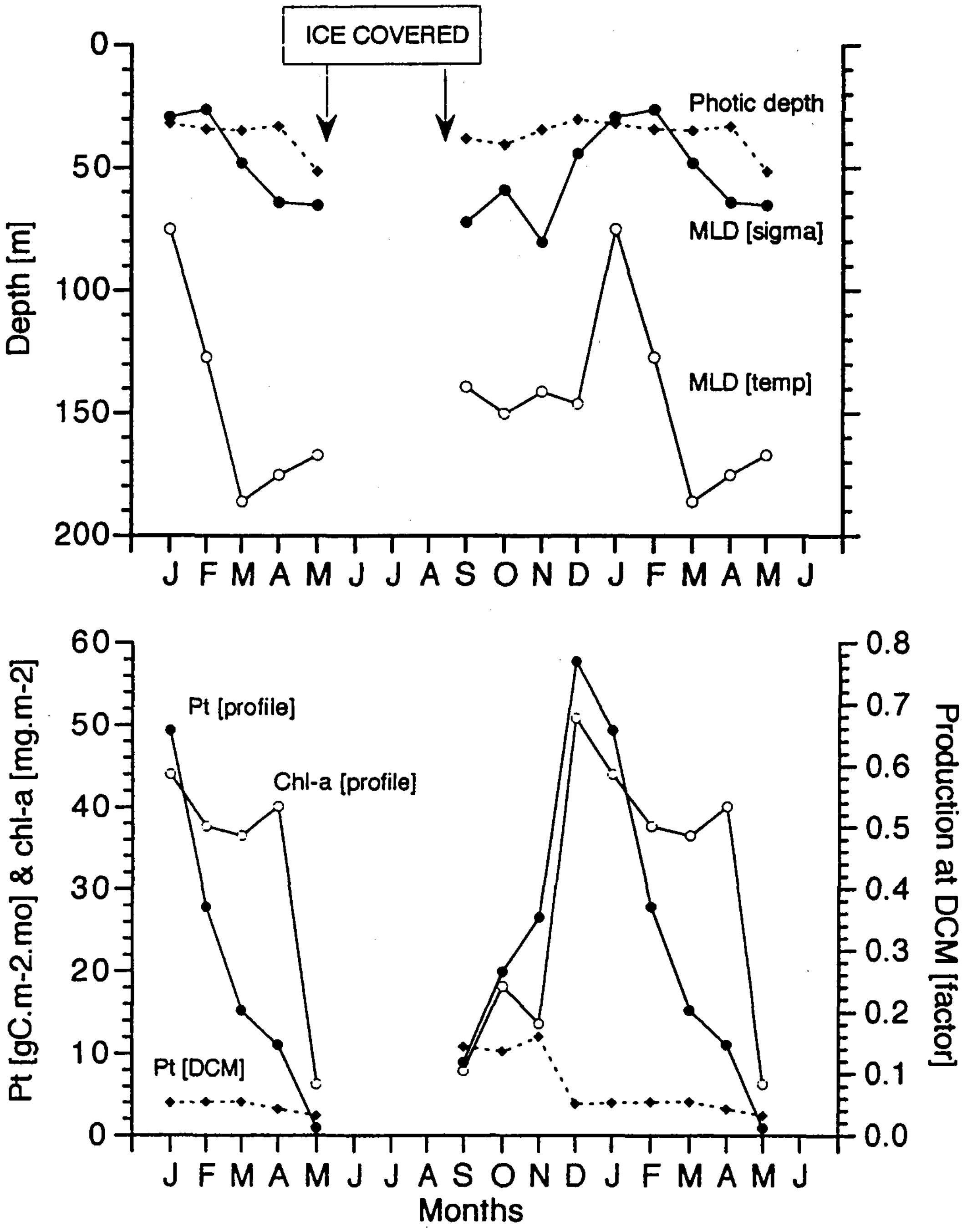


Fig. 2.2.1. Austral Polar Province characteristic seasonal cycles of monthly averaged mixed layer and photic depths, chlorophyll and rate of primary production, both depth integrated, and at the deep chlorophyll maximum (from Longhurst, 1998).

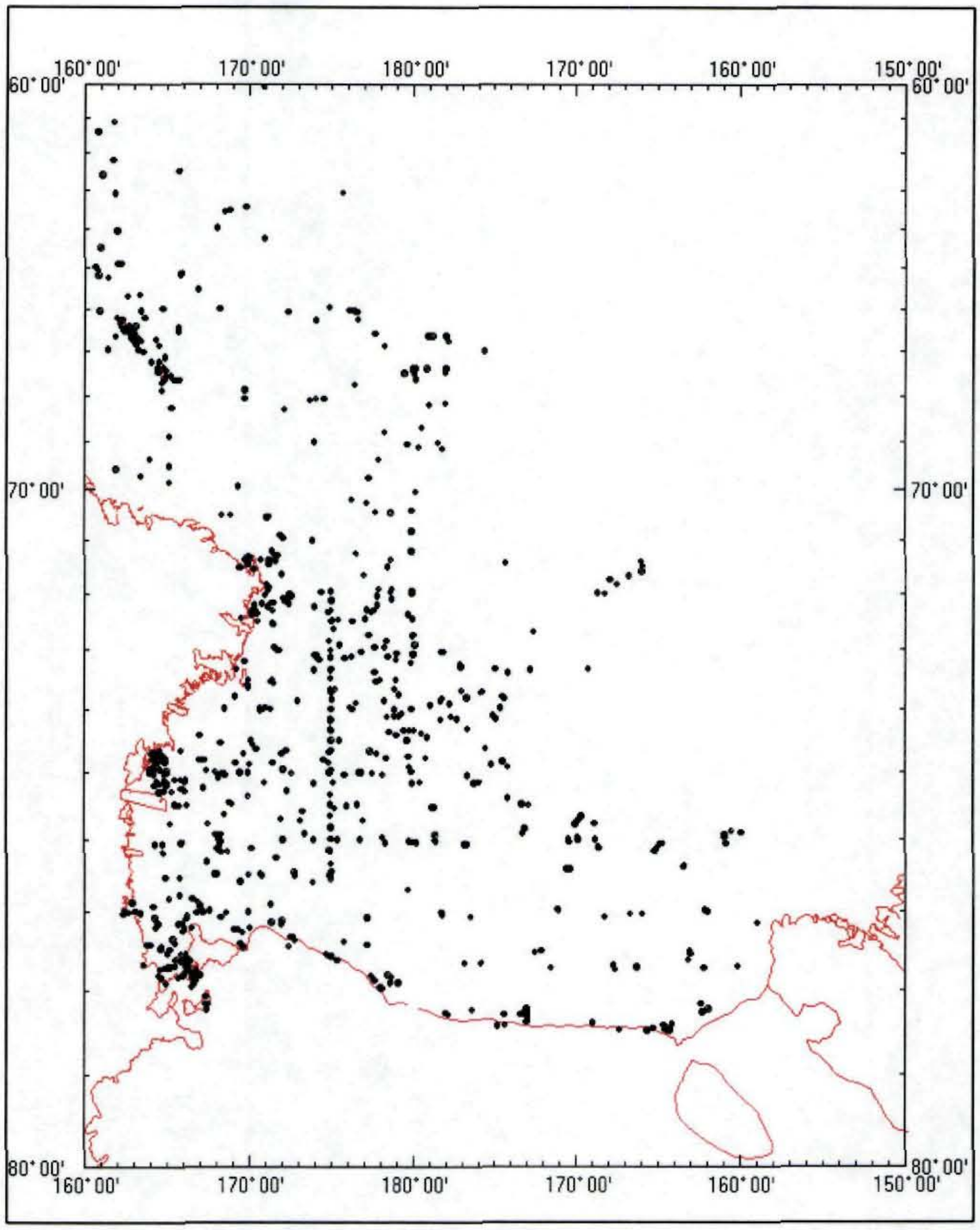


Fig. 3.1. Chart locating the historical sampling stations, including water column and benthic habitats, in the BioRoss relational database and listed in Table 3.1.

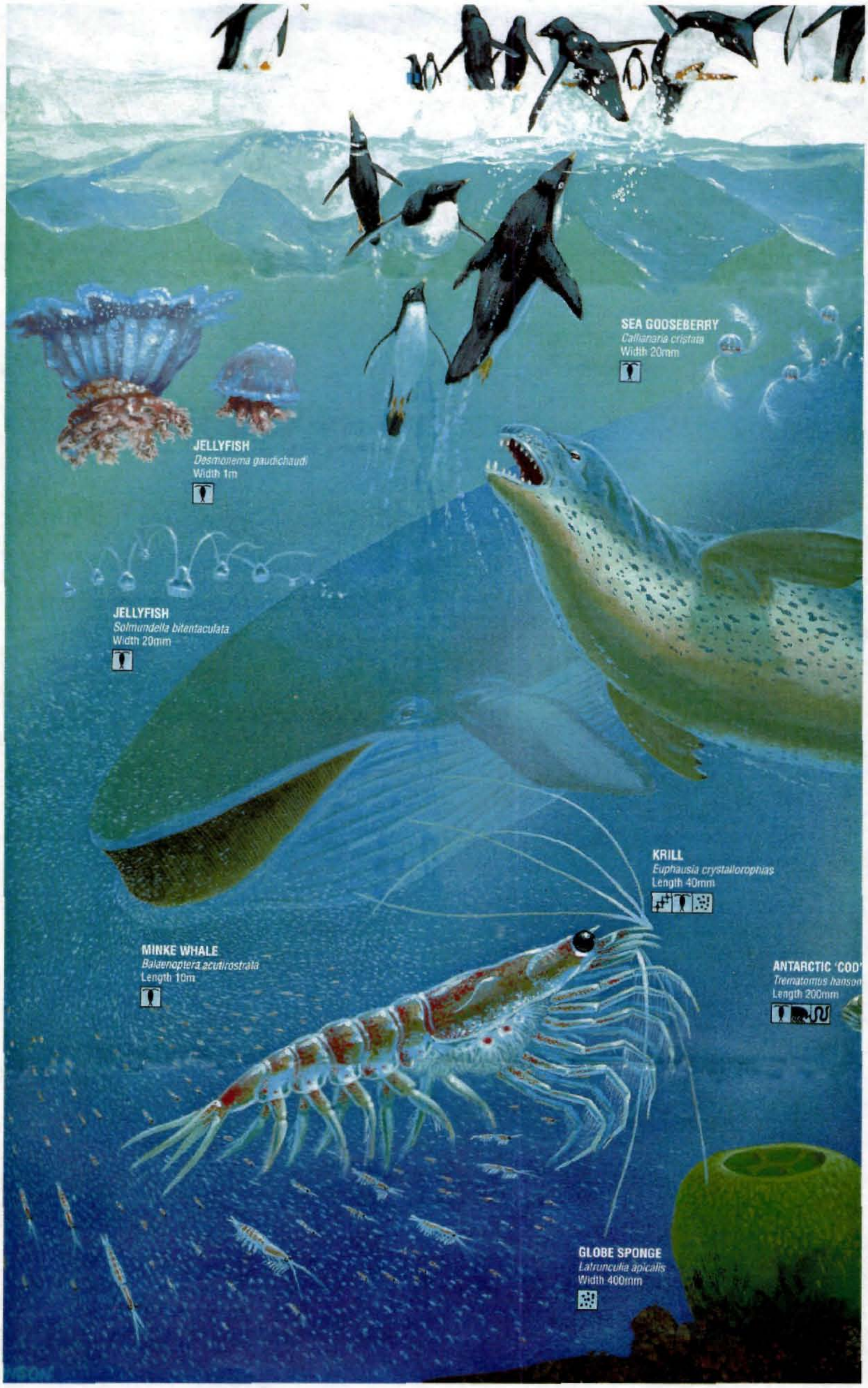


Fig. 4.1. Diagram of part of the food web of McMurdo Sound, Antarctica (from Gunson, 1991). Note the large predators that feed both near the beginning of the food web on krill (baleen whale), and at the top of the food web (leopard seal), and the Adélie penguin that feeds somewhere in between.

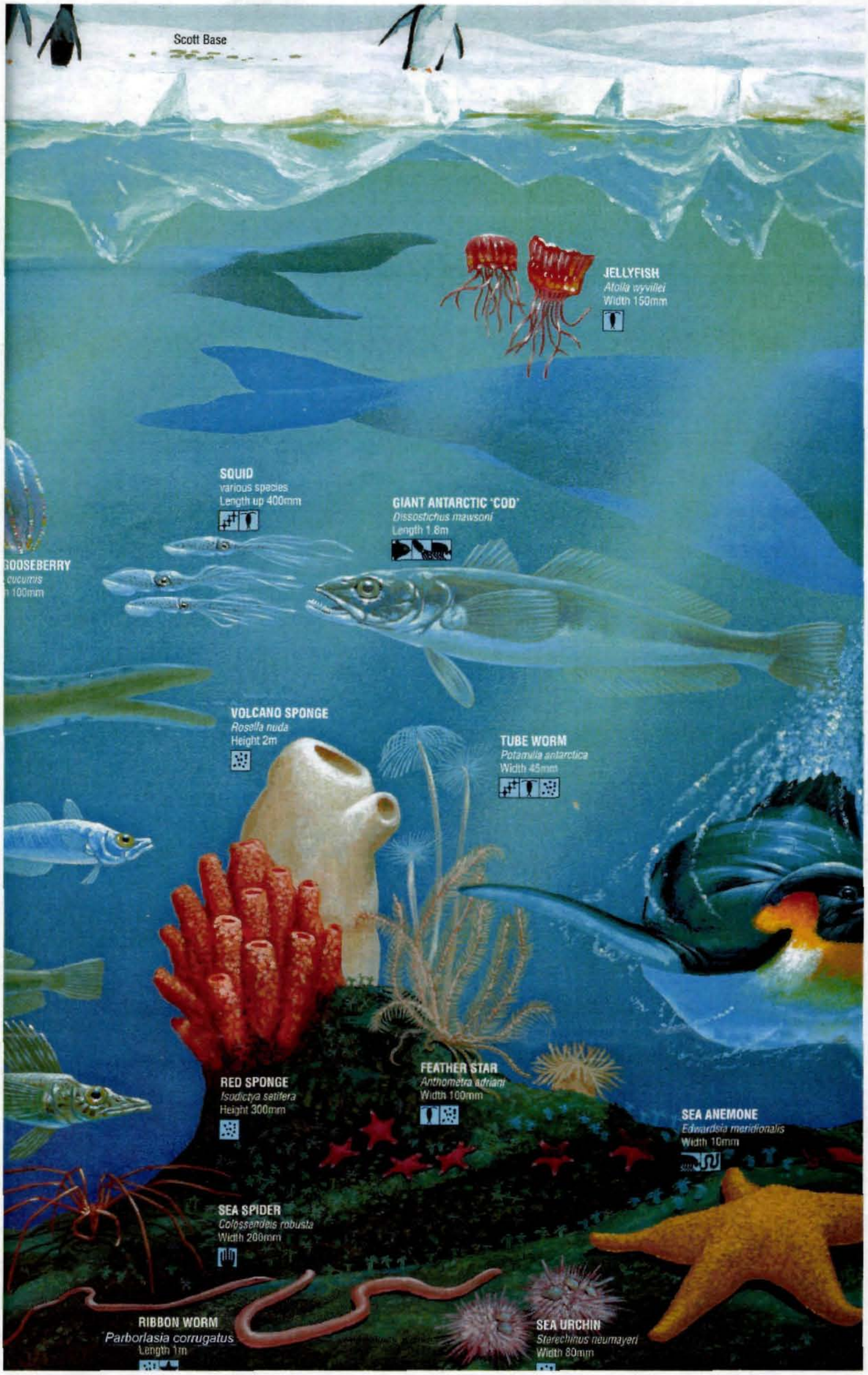


Fig. 4.2. Diagram of part of the food web of McMurdo Sound, Antarctica (from Gunson, 1991). Note the fine-particle-feeding sponges that are a dominant part of some benthic communities, and the largest nemertean worm in the world; also note squids and the animals that feed upon them (emperor penguin and giant Antarctic cod).

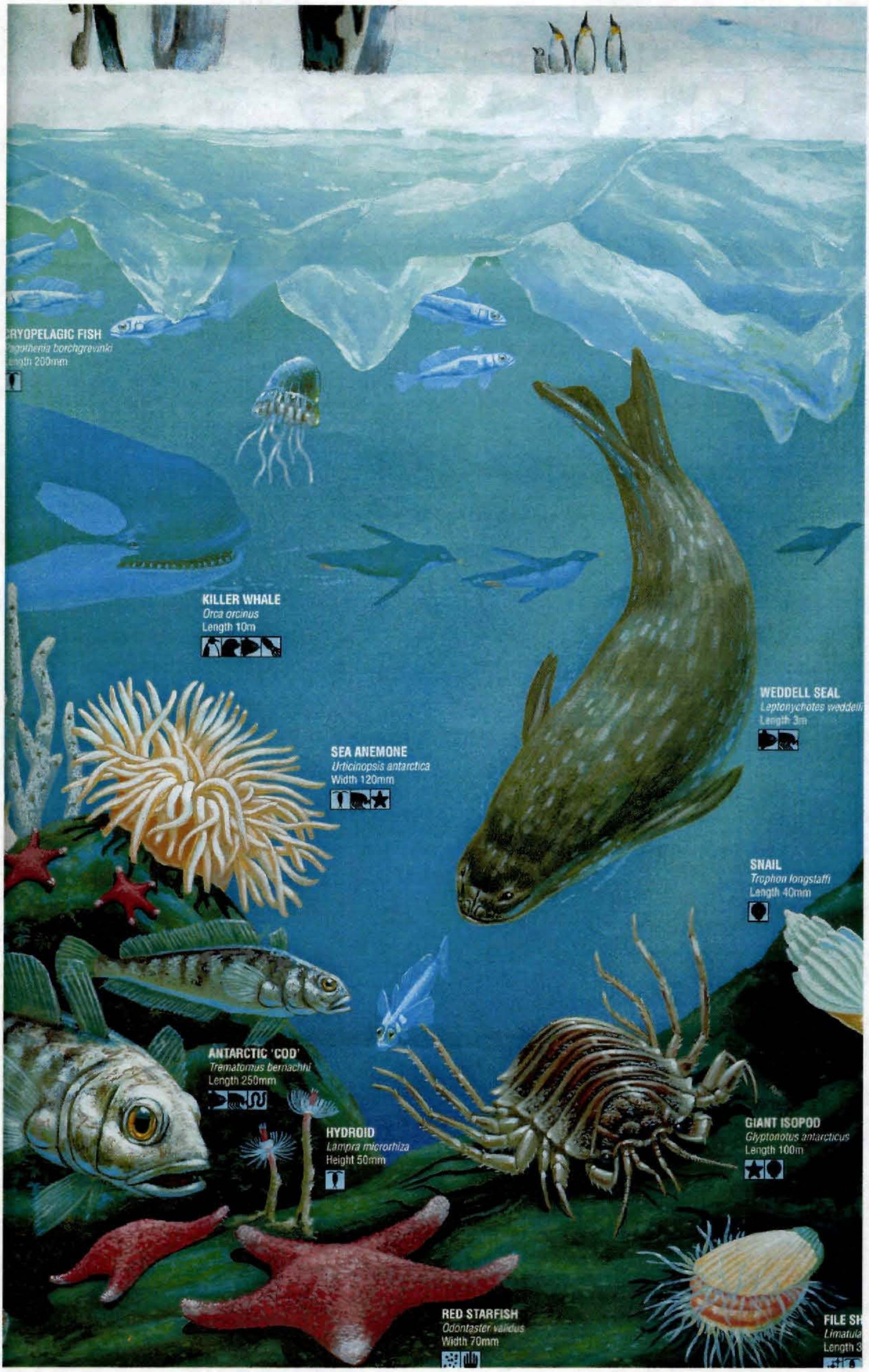
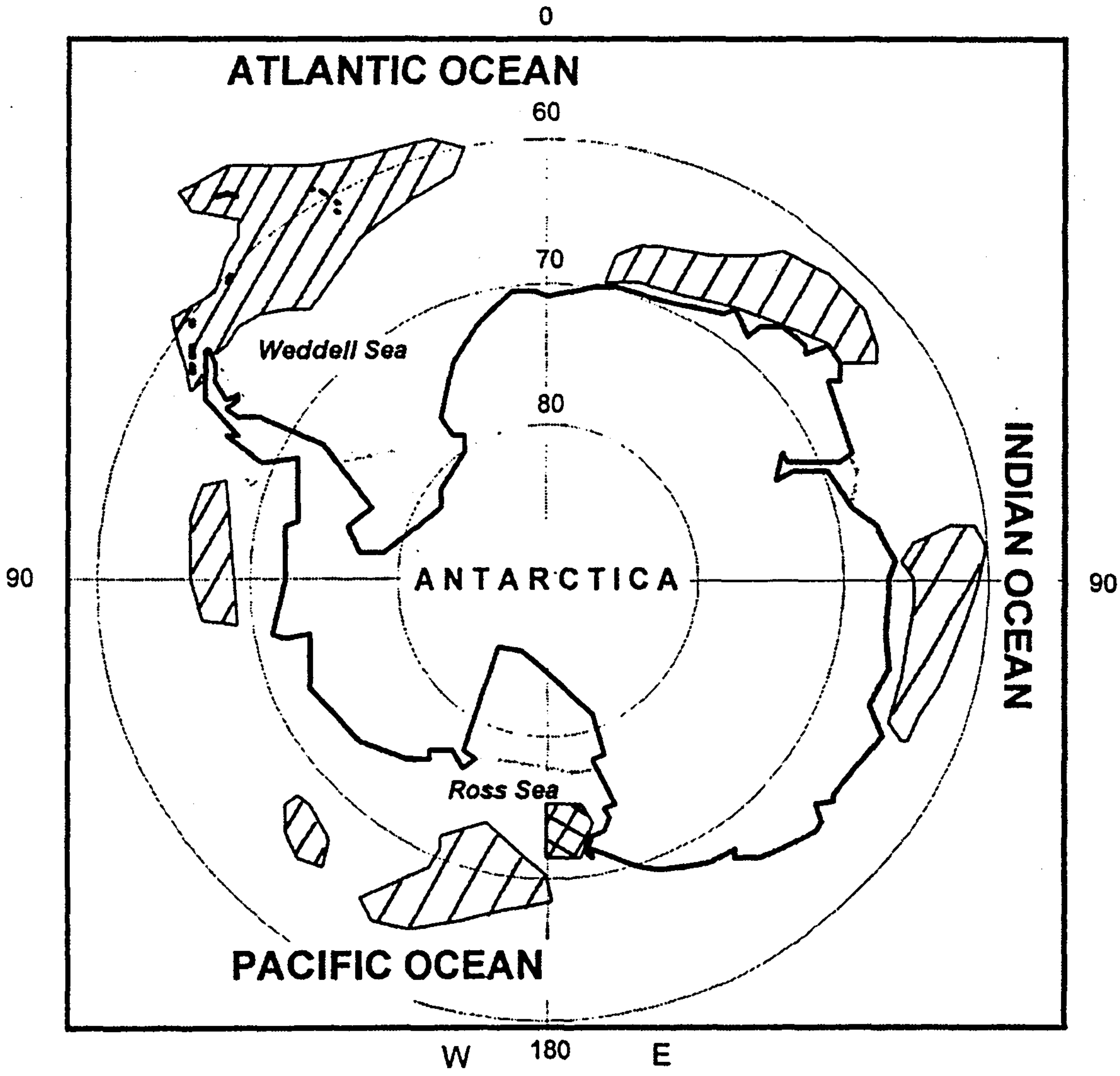


Fig. 4.3. Diagram of part of the food web of McMurdo Sound, Antarctica (from Gunson, 1991). Note the sponges, anemones, and starfish that are conspicuous components of the benthos in the Ross Sea, and the giant isopod; also note the predators (penguins, weddell seals, and killer whale) that feed at different levels in the food web.



▨ Large-scale concentration of krill around Antarctica, according to Mackintosh (1973).

▩ Distribution of krill concentrations in the Ross Sea, according to Azzali and Kalinowski (2000).

Fig. 4.4.1.1.1. Large scale concentrations of krill in the Antarctic region (from Azzali & Kalinowski, 2000).

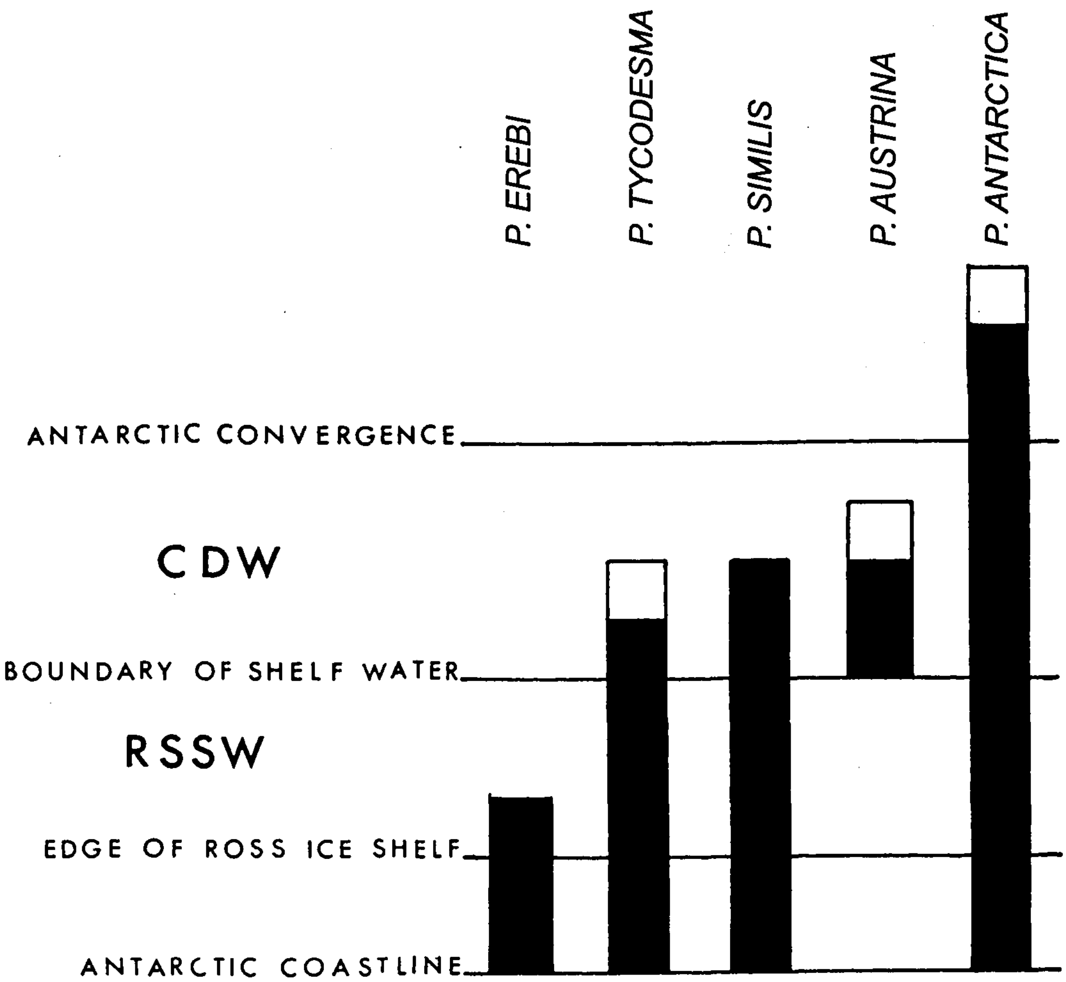


Fig. 4.4.3.1. Diagramatic representation of the northward distribution of species of the *Pareuchaeta antarctic* group in relation to the boundaries of water types. Bars with white tips indicate species whose ranges extend north of that recorded here (from Fontaine, 1988).

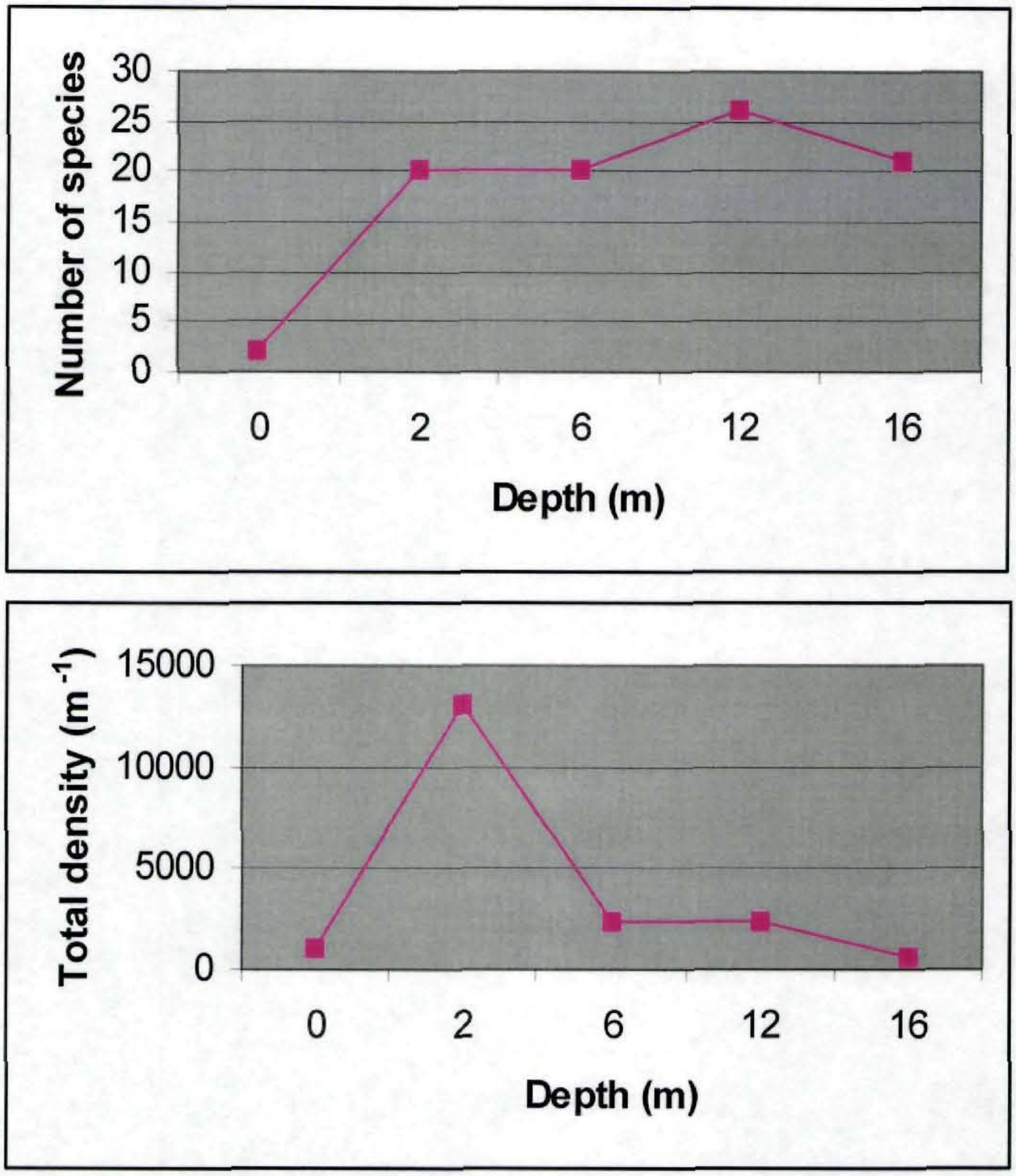


Fig. 5.1.3.2.1. Diversity (top) and abundance (bottom) of fauna associated with subtidal algae on rocky shores in Terra Nova Bay (from Gambi & Mazzella, 1991).

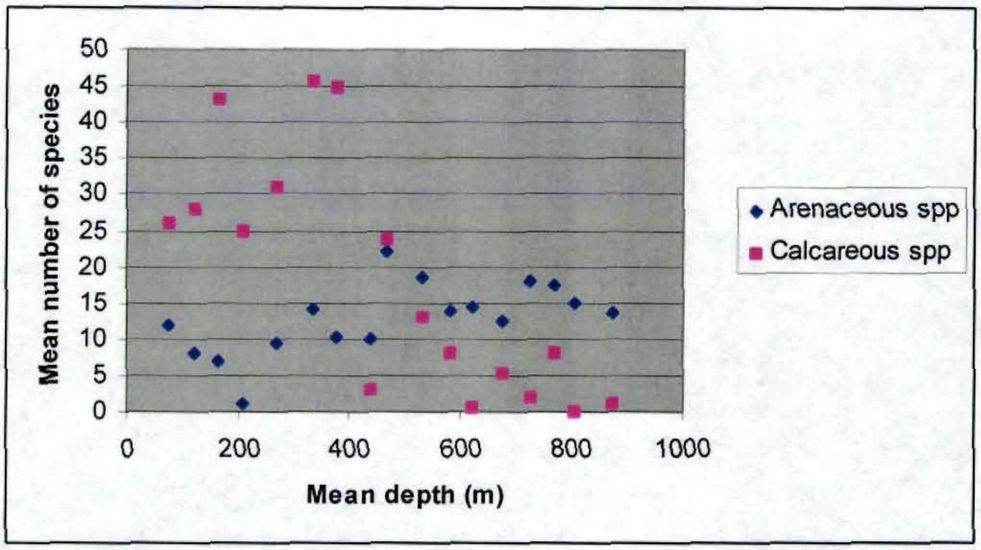


Fig. 5.2.2.1. Diversities of Foraminifera at different depths in the Ross Sea and McMurdo Sound. Data from Kennett (1968) are means for species numbers and depths in 50 m depth intervals.

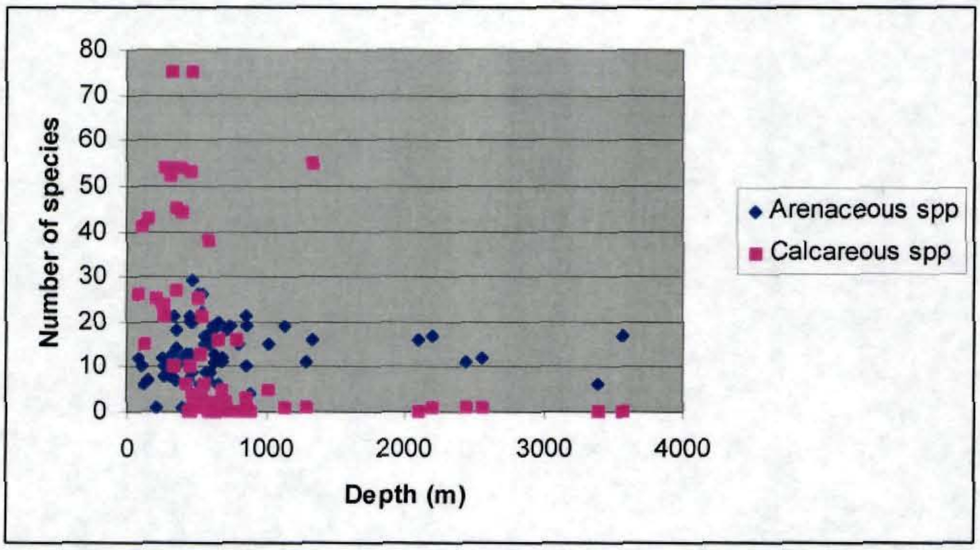


Fig. 5.2.2.2. Changes in numbers of species of benthic Foraminifera in samples at different depths in McMurdo Sound and the Ross Sea (data are counts from Kennett, 1968).