The highest temperatures recorded at Auckland Is. and at Campbell I. are much the same, approximately 65°F., and are 12°F. higher than that at Macquarie I. (Table 12). The extreme minimum at Macquarie I. is 10°F. lower than that at Port Ross.

Sea temperatures at Campbell I. are about 3°F. warmer than the earth temperatures at 12 inches in mid winter and about 1½°F. colder in midsummer (Table 13).

TABLE 13. *Mean monthly earth and sea temperatures.*

	Earth temp. at 1 foot Campbell I.	Sea temp. Campbell I.	Sea temp. Auckland Is.
Jan.	51.0	49.5	50.8
Feb.	50.3	49.1	51.0
Mar.	48.5	48.5	50.5
Apr.	45.6	46.7	49.3
May	43.2	45.3	47.4
June	40.3	43.2	46.1
July	39.5	42.6	45.7
Aug.	40.0	42.9	45.1
Sept.	41.3	43.7	46.0
Oct.	43.4	44.6	46.8
Nov.	46.5	46.1	47.9
Dec.	49.6	48.5	49.2

NOTE. Sea temperatures for Campbell I. taken monthly in the enclosed waters of Tucker Cove, 1943-55, and for Auckland Is. at Port Ross, 1941-45.

REFERENCES

DE LISLE, J. F., 1964. Weather and climate of Campbell Island. *Pacific Ins. Monograph* 7: 34–44.

FABRICIUS, A. F., 1957. Climate of the Subantarctic Islands. In *Meteorology of the Antarctic*, ed. Van Rooy. Weather Bureau, South Africa.

FALLA, R. A., 1948. The outlying islands of New Zealand. *N.Z. Geographer* 4: 127–154.

HITCHINGS, M. G., 1949. Campbell Island. A subantarctic meteorological station. *Weather* 4: 389–92.

MARSHALL, O., 1909. The Meteorology of Campbell Island. In *The Subantarctic Islands of New Zealand*, ed. C. Chilton. Philosophical Institute of Canterbury. 2 vols.

MAWSON, D., 1915. *The home of the blizzard*. Heineman, London. 2 vols.

NEWMAN, W., 1929. Tabulated and reduced records of the Macquarie Island Station. In *Aust. Antarc. Exp.* 1911-14 *Sci. Rep.*, Ser.B., 3, Sydney.

N.Z. METEOROLOGICAL SERVICE, 1963. Summaries of radiosonde data 1956-61. *N.Z. Met. S. Misc. Pub.* 119.

ROBERTSON, N. G., 1964. The frequency of high intensity rainfalls in New Zealand. *N.Z. Met. S. Misc. Pub.* 118.

OCEANOGRAPHY AND MARINE ZOOLOGY OF THE NEW ZEALAND SUBANTARCTIC

ELLIOT W. DAWSON

*N.Z. Oceanographic Institute, D.S.I.R., Wellington.**

The Subantarctic Islands of New Zealand, comprising Bounty and Antipodes, Auckland and Campbell, Macquarie and the Snares, lie within the Subantarctic zone of surface waters, bounded on the north by the Subtropical Convergence Region and on the south by the Antarctic Convergence about the latitude of Macquarie I. (Fig. 1).

Whether the Chatham Is., the Snares, and even the southern New Zealand mainland should be considered 'subantarctic' may be resolved by defining as 'subantarctic' any regions washed by 'subantarctic water', in the hydrologist's use of the term. Undoubtedly these more northern regions show the effects of subantarctic waters and so should be discussed with the New Zealand Subantarctic. Similarly, Macquarie I., lying close to the Antarctic Convergence, should be included because it shows the mixed influence of Antarctic and Subantarctic waters.

* The Society is grateful to the N.Z. Oceanographic Institute for a contribution towards the cost of publishing this paper.—ED.

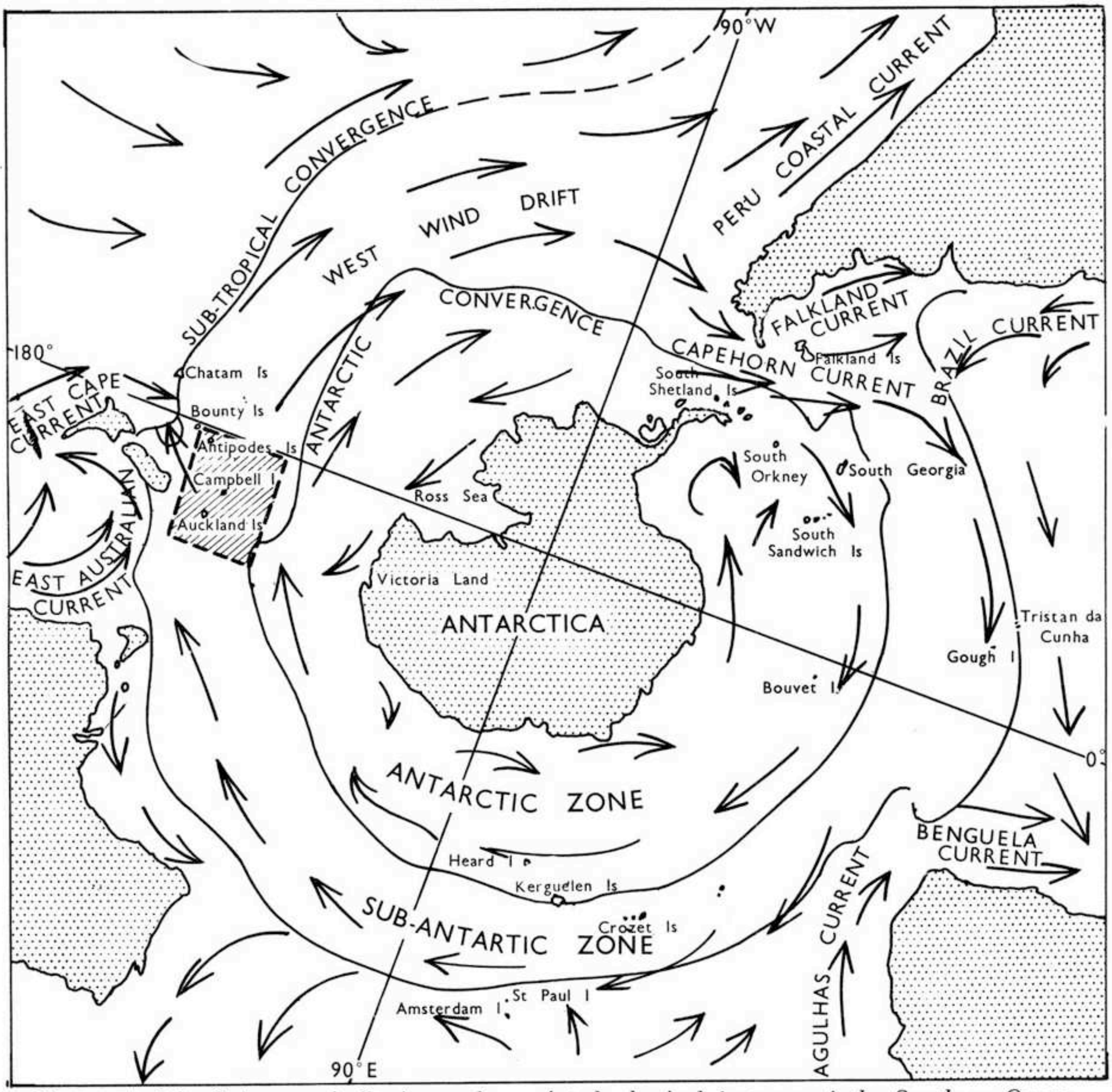

FIGURE 1. *The Subantarctic Region and associated physical features of the Southern Ocean.*

HISTORY OF MARINE EXPLORATION

Oceanographic and marine biological exploration of the Subantarctic region began about 1840 with the great voyages of D'Urville, Ross and Wilkes and continued through the work of the French Transit-of-Venus Expedition to Campbell Island in 1874. As well as the famous 1907 Expedition of the Philosophical Institute of Canterbury, irregular visits were made by naturalists as passengers in the N.Z. Government vessels *Stella*, *Tutanekai* and *Hinemoa*, under Captains Fairchild and Bollons, both of whom were amateur naturalists of some experience. The real foundation of our knowledge of the marine fauna of the New Zealand Subantarctic was laid by the 1907 expedition and was later added to by the results of Dr. Th. Mortensen's cruise in the *Amokura* as part of his Pacific Expedition

(1914-1916), and by the war-time Cape Expedition, the results of which appear in the D.S.I.R. *Cape Expedition Bulletin* and latterly in the *Records of the Dominion Museum*. Dell (1952) and Knox (1960) have both discussed the zoogeographical affinites and relationships of the marine fauna of the New Zealand Subantarctic based on reports of these earlier expeditions which were, however, largely confined to the immediate surroundings of the islands. The nature of the fauna, sediments and bottom features of the ocean around and between these islands were until recently still unknown.

N.Z. OCEANOGRAPHIC INSTITUTE IN THE SUBANTARCTIC

The New Zealand Oceanographic Institute has in recent years extensively sampled and explored the sea floor surrounding the Subantarctic islands, across the Campbell Plateau, and along the Macquarie Ridge from the New Zealand Shelf to the Balleny Is. (Dawson 1963, 1964).

The first cruises were largely concerned with physical oceanography. Later cruises in H.M.N.Z.S. *Endeavour* (1959, 1963, 1964, 1965), H.M.N.Z.S. *Rotoiti* (1961, 1962) and m.v. *Taranui* (1962) have concentrated on benthic work. These stations, almost 300 in all, from deep water to intertidal shore collections, and a further 100 stations on the Chatham Rise and 400 on the New Zealand Shelf, provided a substantial basis on which to begin an ecological analysis of the marine benthic fauna of the New Zealand Region in general and of the Subantarctic in particular.

The sediments of the Subantarctic region are being analysed and, apart from dark volcanic sands and pebbles off Macquarie and Antipodes Is. and the rocky pebble-strewn high spots of the Macquarie Ridge, the general pattern is of a bryozoan shell sand, with areas of plain sands on the shelf of each island out to about 100 fathoms; this gives way to the east on the Campbell Plateau to a widespread mass of *Globigerina* ooze at an average depth of 300 fathoms. Both sediments support a rich animal life, the ooze being of particular interest because of its populations of archibenthal molluscs and echinoderms.

OCEANOGRAPHY

A 'convergence' may be defined as a point or line on the sea surface towards which surrounding surface water moves and at which it sinks. This movement is related to differences of temperature and salinity. North of the Antarctic Convergence, which lies between 52°S. and 62°S., the Subantarctic Region extends to meet the warmer Subtropical Water in the 'Subtropical Convergence Region' between 35°S. and 47°S., which extends further north in summer than in winter and varies from a broad zone near the west of New Zealand to a narrower and better defined zone to the east. There are two types of Subantarctic Water with differing salinity: Australasian Subantarctic Water mainly south of Australia and New Zealand, and Circumpolar Subantarctic Water further south.

An interesting feature of subantarctic hydrology is the intrusion from the Tasman Sea west of New Zealand of water warmer and more saline than the Subantarctic Water to the east and south. This intruding water is cut off from the Subtropical Water to the north by the upwelling of cold and weakly saline water off Otago. This, and the existence of the boundary between Circumpolar and Australasian Subantarctic Waters, with its associated front along the southern edge of the Campbell Plateau, are important in the marine ecology of the Subantarctic.

Garner (1959), Burling (1961) and Houtman (in press) have discussed the detailed physical oceanography but ecologists are concerned only with those factors influencing animal or plant life. There are still gaps in our knowledge of Subantarctic hydrology; for example, about bottom temperatures and the detailed effects of submarine topography on water movements. Since there are even more gaps in our knowledge of the life-history and behaviour of most marine animals, we may not yet know what questions to ask the physical oceanographer nor how he should frame his answers to help interpret ecological phenomena.

GEOGRAPHY AND GEOLOGY

Campbell I. and the Auckland Is., the shallow Pukaki Bank, and a recently recognised, unnamed submarine volcanic cone, are all high spots on an extensive submarine flat, the Campbell Plateau, with an average depth of about 300 fathoms (Fig. 2). The Bounty and Antipodes Is. to the east form a platform of their own separated from the Campbell Plateau by depths of about 700 fathoms

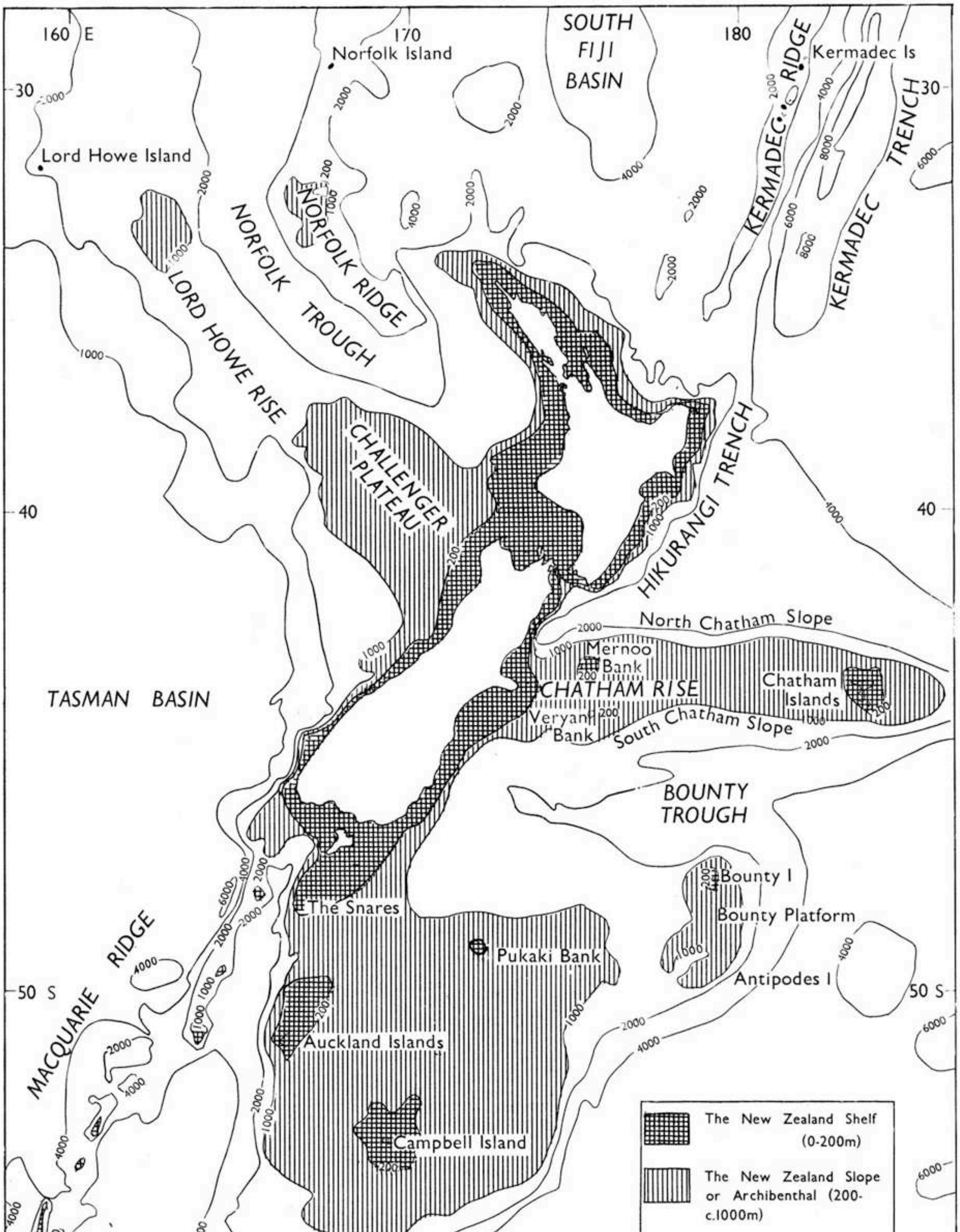

FIGURE 2. *The bathymetry of the New Zealand Region, including the New Zealand Subantarctic.*

and from each other by more than 500 fathoms. Macquarie I. is linked to the New Zealand land mass by a long intermittent submarine ridge (Brodie & Dawson, in press) which extends to the south towards the Balleny Is. on the fringe of the Antarctic Continent. Macquarie I. rises above the sea as an elongated part of this ridge.

The geological history of these islands is essentially a story of volcanism, erosion, glaciation, submergence and deposition. Geological accounts of Macquarie I., of Campbell I. and of the Snares are available by Mawson (1943), Oliver *et al.* (1950) and Fleming *et al.* (1953). The geology of the Auckland Is. has not yet been described in detail; but an account of the geology of the Bounty—Antipodes region is being prepared (D. J. Cullen, pers. comm.). The over-all geological history forms an interesting background to the formation of the sediments and submarine features on which marine benthic animals live.

BIOGEOGRAPHY

The New Zealand Subantarctic Region as a whole has been regarded as a separate marine faunal province (see Finlay 1925, elaborated by Powell 1951, 1961 and Dell 1962). This region, which excluded Macquarie I., was originally named the Rossian Province but later changed (Powell 1951) to Antipodean, preventing confusion with the Rossian subprovince of the Antarctic (cf. Knox 1960: 612).

Up to the present, the characteristics of the marine fauna of the Antipodean Province have been based on what is largely Cape Expedition material collected on the islands themselves, supplemented by the reports from the Mortensen Pacific Expedition. Cape Expedition reports include Fell (1953) on the Echinodermata, Powell (1955) on the Mollusca, and Parrott (1958) on fish. Mortensen's own reports on the Echinodermata (1921, 1925) are also important.

The biogeographical relationships of various species collected by these earlier expeditions have already been summarised by Dell (1952) and by Knox (1960, 1963) in reviews which illustrate the *status quo* of subantarctic biogeography until the recent work discussed here. Reports on the molluscs of the Snares (Dell 1963a) and on the benthic fauna of Foveaux Strait (Dawson, in press) help to define the Forsterian marine province which meets the Antipodean near Stewart I. Obviously such provinces cannot be delimited by arbitrary lines and, so long as they are believed to be correlated with hydrological zones, their boundaries must be thought of as zones themselves, varying with time.

There are problems at this stage of ecological analysis in identification of many of the important marine groups and there is little comparative material or information from critical areas in the non-New Zealand Subantarctic. Nevertheless, certain broad features of the marine zoology of the New Zealand Subantarctic have emerged and the following principal faunal elements can be recognised:

1. Widespread circum-Subantarctic genera.
2. New Zealand species, widespread around the mainland, ranging into the Subantarctic.
3. Endemic subantarctic species of New Zealand genera.
4. Local representatives (subspecies) of polytypic New Zealand genera, particularly amongst the Mollusca.

Animals within these categories have been specified by Dell (1952) and by Knox (1960, 1963), but a few other examples, from the Echinodermata, will be discussed later to illustrate particular points of interest in subantarctic ecology.

MACQUARIE ISLAND

Macquarie I. was separated from the Antipodean Province by Powell (1955, 1957), largely influenced by the molluscs of a single haul (Station 83) of the B.A.N.Z.A.R. Expedition in 38 fathoms off Lusitania Bay. He considered that Macquarie lay within the Kerguelenian Province which also included Kerguelen I., Marion, Prince Edward, and the Crozet Islands. The faunal affinities of the Kerguelenian Province are said to be with the Antarctic although there is a high endemic element.

Dell (1964) has recently shown that the 42 species of marine Mollusca so far recorded from Macquarie I. represent a faunal mixture derived from various sources, and he has suggested that Macquarie's inclusion within the Kerguelenian Province loses sight of the very distinctive character of the Macquarie fauna. Dell's analysis shows the following relationships: Kerguelenian, 12%; circum-Subantarctic, 12%; Heard Is., 5%; New Zealand, 5%; of no particular affinity, 2%. The recent collections of Echinodermata made by the N.Z. Oceanographic Institute off Macquarie show a much stronger link with New Zealand.

By contrast, in a report on the intertidal rocky shore fauna of Macquarie I., Kenny and Haysom (1962) conclude that Macquarie is biogeographically closer to the Antarctic Province than to the New Zealand Subantarctic region. Their analysis of 58 species is: 8 endemic, 14 New Zealand, 12 Kerguelen, 18 wide-ranging Subantarctic, and 6 Antarctic. This analysis warrants a little more caution than Kenny and Haysom's generalisation and may further support Dell's recognition of the distinctiveness of the Macquarie fauna.

A more detailed analysis of the marine fauna of Macquarie is difficult because the available collections have been taken from different localities or different environmental niches, so that few of the same species have been taken by successive collectors. This is especially so among the echinoderms, for example the species of the starfish genus *Henricia* (Fig. 5).

The conclusion, that Macquarie I. has a mixed fauna, is certainly what would be expected from its hydrological position and is supported by other evidence from the Echinodermata.

THE SNARES

The northern limit of the New Zealand Subantarctic (or Antipodean Province) lies, according to the hydrological definition of Subantarctic, in the region of the Snares Is. To exclude these islands from the Subantarctic is no more reasonable than to exclude Macquarie I. at the other extension of the New Zealand Subantarctic Region.

Subantarctic Water certainly influences the Snares Is. and their surrounding shelf. A subantarctic element is present in their fauna, which may be traced to a varying extent in Stewart I. and the southern New Zealand mainland.

Four species of echinoderms taken on the shores of the Snares led Fell (1953: 108) to conclude:

> ". . . the Snares seem to be related more closely to the New Zealand mainland than to the other subantarctic islands; for, of the four genera known to have species there . . . two are represented on the New Zealand mainland by identical species, and two others occur in the subantarctic islands as well as the New Zealand mainland, identical species being involved in each case. There are no Snares echinoderms which are shared with the other subantarctic islands and not also shared with the New Zealand mainland. Hence . . . the northern boundary of the Rossian marine province would fall south of the Snares; the latter would form part of the Forsterian, with south Otago and Stewart Island."

Since 1953, a further six species of asteroids, four of ophiuroids, nine of echinoids, and two of holothurians have been taken by the N.Z. Oceanographic Institute from the Snares, and from shore collections.

With the exception of the holothurian *Stereoderma leoninoides,* all are shared with the New Zealand mainland as well as with the subantarctic islands. The close resemblance between the intertidal molluscs of the Snares and those of Stewart I. is further evidence of the link between the two faunas (Dell 1963a). The Snares undoubtedly lie in an interesting marginal region.

> "There seems little doubt that there is a well defined faunal break between the southern islands of New Zealand (Campbell, the Aucklands, Bounties and Antipodes) and the New Zealand mainland including the Snares. At the same time many of the really characteristic Antipodean genera and species cross this faunal break and extend to a varying degree to the north" (Dell 1962: 50).

MARINE FAUNA

So far, the systematics of only a few groups of marine bottom-living animals of the New Zealand Subantarctic are sufficiently well known to make possible the compilation of faunal lists and the plotting of species distributions. Two such groups are the Mollusca and the Echinodermata.

MOLLUSCA

The Mollusca of the shallower parts of the New Zealand Subantarctic, in particular of the shelf around each group of islands, are currently being examined and some additional information to that given by Powell (1955) is already available. For instance, the gastropod *Cymatona kampyla* (Watson 1885), originally described from "Challenger" station 164B off the New South Wales coast and since recorded by Dell (1956) from the Chatham Rise, off the east Otago coast, and in 200-300 fathoms in Palliser Bay, is now known to be common throughout the New Zealand Subantarctic particularly in shallower depths off the Bounty and Antipodes Is. A very closely allied species, *Cymatona tomlini* Powell, 1955, occurs off Macquarie I. The echinoderms and molluscs of the *Globigerina* ooze of the Campbell Plateau vividly demonstrate the uniformity and extensive range of the archibenthal fauna of the New Zealand slopes.

Archibenthal molluscs so far identified from the Campbell Plateau include *Penion benthicola* Dell, 1956; *Ellicea recens* Dell, 1951; *Galeodea triganceae* Dell, 1953; *Cymatona kampyla* Watson, 1885; *Coluzea mariae* Powell, 1952; *Coluzea altocanalis* Dell, 1956; *Otukaia blacki* Dell, 1956 (formerly *Alertalex*); *Baryspira bathami* Dell, 1956; *Pachymelon (Palomelon) smithi* Powell, 1950; *Teremelon knoxi* Dell, 1956; and *Iredalina mirabilis* Finlay, 1926; all these are members of the deepwater molluscan fauna recognised by Dell (1956) from the Chatham Rise and the New Zealand slopes. These discoveries extend to 52°S., the southernmost limits of this widespread archibenthal fauna which is also becoming known progressively further north, as far as the Bay of Plenty at 35°S. (Dell 1963b).

One of the biggest question marks lies over the Bounty Trough, the East Otago Slope, and the South Chatham Slope which separate the Campbell Plateau from the Chatham Rise. The nature of the bottom animals and sediments of these three areas and their possible relationship to those of the Campbell Plateau and Chatham Rise are unknown.

ECHINODERMS

Echinoderms are especially suitable for ecological and biogeographical studies. They are relatively sedentary and usually have a limited bathymetrical range, often showing definite sediment preferences and correlations with salinity and temperature. The shortness or absence of a pelagic larval stage is also important in the distribution of certain species.

The northern limit of the New Zealand Subantarctic is here taken at the latitude of the Snares Islands, 48°S., and the southern limit at 58°S., the furthest south from which samples are at present available.

TABLE 1. *Number of species and biogeographic distribution of major groups of echinoderms (excluding Ophiuroids and Crinoids) from New Zealand subantarctic islands (shelf and shore) and the Campbell Plateau (archibenthal).*

	No. of species	Common with N.Z. shelf and/or slope	Endemic to Subantarctic	Extra limital distribution
AUCKLAND IS.				
Asteroids	11	7	2	2
Echinoids	4	4	–	–
Holothurians	8	6	2	–
CAMPBELL I.				
Asteroids	5	4	1	–
Echinoids	2	1	1	–
Holothurians	4	3	1	–
ANTIPODES IS.				
Asteroids	2	2	–	–
Echinoids	4	3	1	–
Holothurians	2	2	–	–
BOUNTY IS.				
Asteroids	1	1	–	–
Echinoids	5	4	1	–
Holothurians	2	1	1	–
SNARES IS.				
Asteroids	10	10	–	–
Echinoids	9	9	–	–
Holothurians	2	1	1	–
MACQUARIE I.				
Asteroids	14	6	6	2
Echinoids	1	1	–	–
Holothurians	6	4	1	1
CAMPBELL PLAT. (Archibenthal)				
Asteroids	17	13	? 4	?
Echinoids	5	5	–	–
Holothurians	Not yet identified		–	–
TOTAL SPECIES	70	48	19	5

NOTE. Asteroids at Macquarie I. include all identifications of *Henricia* spp.

Longitudinal boundaries are placed at 158° and 180°E. The distribution of the echinoderms (excluding Crinoidea) so far identified from this arbitrarily defined area is summarised in Table 1.

Several new records have been added to the known species from the Auckland Is. The occurrence of the echinoid *Apatopygus recens* has been confirmed. There also occur on the edge of the shelf large numbers of *Araeosoma thetidis*. This species, previously considered subtropical, is called by Fell (1962a: 84) a "dangerous sea urchin" and has been known to cause painful wounds in Australia and New Caledonia. *Henricia ralphae* and a new species of holothurian of the genus *Stolus* (cf. Pawson in press) are now recorded. Campbell I. has about half the number of species known from the Aucklands and all are shared with these islands. The holothurian *Trochodota dunedinensis* is a new record for Campbell I.

Eight species of echinoderms are now known from the Bounty Is. and all except *Pseudechinus novaezealandiae* are new records; they include the same new species of *Stolus* and new species of the echinoid *Brisaster* (cf. Pawson in press).

Of nine species from the Antipodes Is. eight are new records. Only three species have been found at both Antipodes and Bounty Is.: *Apatopygus recens*, *Pseudechinus novaezealandiae* and *Spatangus thor* previously known only from Foveaux Strait. Of particular interest is a species of *Austrocidaris*, a genus previously only known from two species in the Magellanic-Falklands region.

Macquarie I. has a rich starfish fauna (Clark 1962). Knowledge of the holothurian fauna of Macquarie has been substantially increased (Pawson in press), and there are two new records and three occurrences of species also known from New Zealand.

The only echinoid so far recorded from Macquarie, *Pseudechinus novaezealandiae*, has a pelagic larval stage and occurs at all islands in the New Zealand Subantarctic (Fig. 3). Hydrological circumstances do not favour the transport of larvae to Macquarie I. by southwards surface water movements. The influence of the West Wind Drift, which crosses the southern part of the New Zealand Region in a west to east direction, would tend to carry pelagic larvae well away to the east of New Zealand. Variations in the East Australian Current which impinges on the West Wind Drift would probably affect such larval drifting in the same way. Whereas previously it has been necessary to postulate a drift mechanism for dispersal to the Macquarie region, a possible shallow middle depth migration route has now been shown to exist.

With its known bathymetric range of at least 10 to 150 fathoms, *Pseudechinus novaezealandiae* is much more likely to have reached Macquarie I. from New Zealand along the submarine ridges and sea mounts of the Macquarie Ridge. *Trochodota dunedinensis*, a viviparous holothurian which ranges from intertidal depths to about 100 fathoms, could presumably only have come to Macquarie in such a way. Transport on floating algae has been proposed to account for such distributions (Mortensen 1925); but the problem of moving against the prevailing water movement is still real and various species which might have made use of pelagic drifting of their larvae or of algal transport are absent from similar situations in subantarctic South America and from other Southern Ocean islands. Other bottom-living holothurians, such as *Psolus antarcticus*, found in Magellanic and Antarctic South America and Macquarie I., have presumably spread along the deep ocean floor or along deeper ridges.

The echinoids and holothurians of Macquarie I. are very distinctly related to the fauna of New Zealand and the rest of the New Zealand Subantarctic, rather than having marked Kerguelenian or Antarctic affinities. The asteroids are more varied in their relationships if the presence of a number of species of *Henricia* is real and if the occurrence of what seems to be a species of *Pseudarchaster* from the New Zealand shelf can be confirmed. The circum-Subantarctic genera *Anasterias*, *Hymenaster*, *Smilasterias* and *Cycethra*, and the Antarctic *Porania antarctica* give a more southerly flavour to the Macquarie fauna, as might be expected from the situation of Macquarie on a southwards-extending submarine ridge which straddles the Antarctic Convergence and is exposed to surface drift from the Kerguelenian Province.

In summary, 68% of the known echinoderms from the New Zealand Subantarctic are shared with the New Zealand Shelf or Slope. Endemic species are 27%, and 7% of the subantarctic species are also known from the Magellanic or other extra-limital area.

Despite Fell's (1962b) otherwise convincing hypothesis of echinoderm dispersal through the Southern Ocean by epiplanktonic drift, the wind-driven surface layers of the Southern Ocean appear to have contributed no species of echinoderms to the New Zealand Subantarctic. However, the seaweed-inhabiting holothurians of the genera *Trachythyone*, *Stereoderma* and *Ocnus* may have been distributed by this West Wind Drift.

The widespread Australian, Indo-West Pacific and cosmopolitan genera *Trochodota*, *Chiridota*, *Spatangus*, *Paramaretia*, *Brisaster*

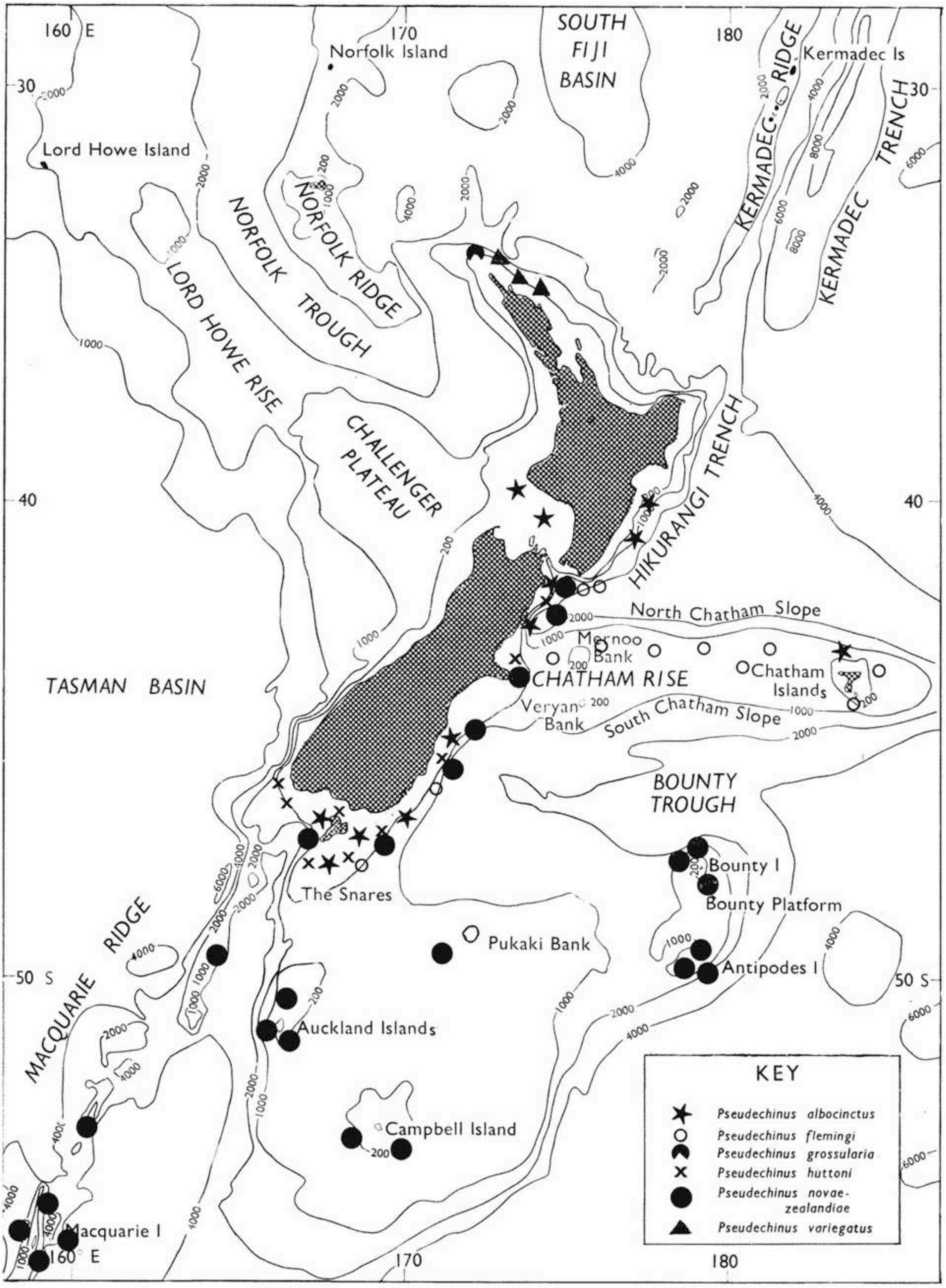

FIGURE 3. *The distribution of the echinoid genus* Pseudechinus *within the New Zealand Region.*

and *Psolus* contribute at least eight species to the fauna; the bathymetrical tolerances of these species have probably allowed them to migrate along submarine ridges and other bottom features without it being necessary to invoke pelagic drift of larvae or epiplanktonic adults as a mechanism.

PSEUDECHINUS

The echinoid genus *Pseudechinus*, exemplified by the widespread species *P. novaezealandiae*, is worth close ecological examination; its distribution and sediment preferences on the New Zealand Shelf have been studied (McKnight, in press). Six species occur in the New Zealand Region, although only *P. novaezealandiae* is known from the New Zealand Subantarctic. The geographic and bathymetric ranges of all the species are shown in Fig. 3.

Pseudechinus novaezealandiae (Mortensen 1921) ranges widely in coarse and fine sands from the southern Cook Strait shelf on the east coast and from off Fiordland on the west through the Subantarctic to Macquarie I., but has a limited depth range of 0–168 fathoms and is found mainly between 12 and 85 fathoms.

Fell (1962b) presents the hypothesis that echinoderms are dispersed through the southern circumpolar seas by epiplanktonic drift. He says of *Pseudechinus:* ". . . one suspects that the genus set out from New Zealand long ago, circumnavigated the globe and, like Magellan's sailors, arrived back whence it started, but from the other direction."

Of the four other species of *Pseudechinus* known to me, two occur in Australia, one off Marion, Gough, Crozet and Prince Edward Is. and one in southern South America, Falklands, Tristan da Cunha and New Amsterdam. It may be, however, that *Pseudechinus novaezealandiae* has not colonized New Zealand from the southwest as Fell suggests, but is spreading through the southwest from New Zealand to Macquarie along shallow submarine ridge tops.

GONIOCIDARIS

The cidarid *Goniocidaris* is represented by three species in New Zealand (Fig. 4). The new species *Goniocidaris magi* Pawson 1964, is known from gravelly sand in 30–50 fathoms off the Three Kings and may be common in the northern archibenthal.

Goniocidaris umbraculum (Hutton 1872) mainly occurs between 50–200 fathoms in sand and gravelly sand throughout the eastern and southern shelf from Cook Strait to south of Stewart I., although known from 300 fathoms in Cook Strait. Recent work on the Chatham Rise has, however, yielded *G. umbraculum* from five stations from 240–610 fathoms. These apparently anomalous records will be discussed elsewhere (Dawson, in progress). *G. umbraculum* has now been found on the Macquarie Ridge and on the Auckland Is. Shelf (Fig. 4). It is a brood-protecting species (Mortensen 1926) and its distribution along the Macquarie Ridge is comparable with that of *Pseudechinus novaezealandiae*, which has pelagic larvae.

Goniocidaris parasol Fell 1958, described from 130 fathoms east of the Chatham Is., replaces *G. umbraculum* in the southern archibenthal of the Campbell Plateau and extensively (Fig. 4) on the Chatham Rise.

ASTEROIDS

The starfish of the New Zealand Subantarctic have not been fully analysed but an analysis of distribution patterns and sediment correlations of archibenthal species over the Chatham Rise is being prepared (Dawson, in progress) and a similar study of the New Zealand Shelf species has been made (D. G. McKnight, in progress).

A surprising feature of the southern distributions is the presence of deep-living warm water species, such as *Benthopecten pentacanthus* Fell 1958 and *Zoroaster spinulosus* Fisher 1906, known from the Bay of Plenty and the Indo-Pacific, and of deep-water starfish of the Chatham Rise, *Plutonaster knoxi* Fell 1958, *Hippasteria trojana* Fell 1958 and *Crossaster japonicus* (Fisher 1911). A species of *Pseudarchaster* from 200 fathoms off Macquarie I. is hardly distinguishable from *P. abernethyi* Fell 1958, a Cook Strait Shelf species.

Two unexpected new generic records of starfish from the Campbell Plateau of considerable biogeographical interest are *Lithosoma* and *Ceramaster*, genera previously unknown from Australasia. The *Lithosoma* species is probably new, but related to *L. penichra* Fisher.

Lithosoma comprises five known species, all Indo-West Pacific. This is the first record south of the Tropics and is of particular interest since

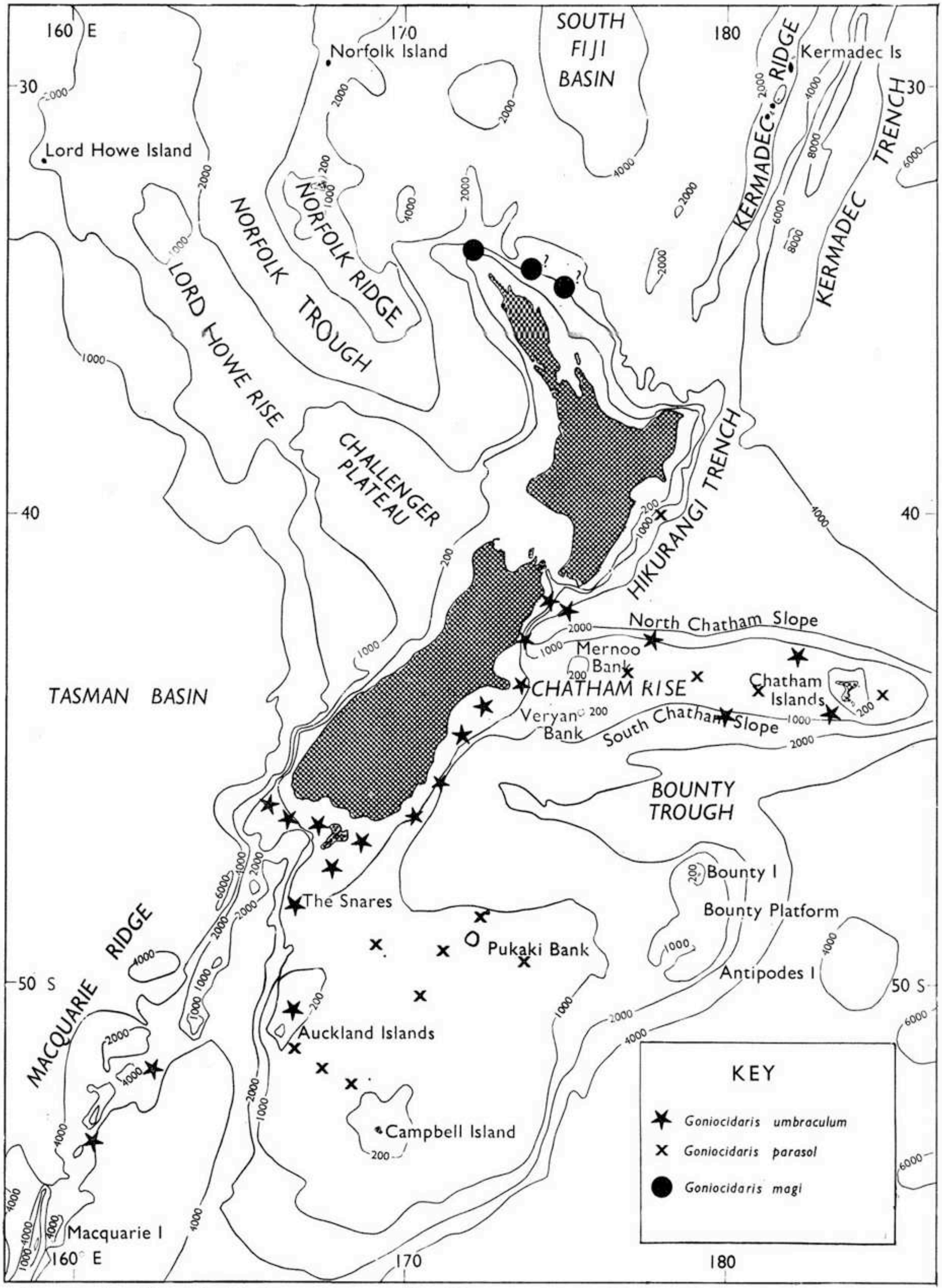

FIGURE 4. *The distribution of the echinoid genus* Goniocidaris *within the New Zealand Region.*

fragments of a fossil *Lithosoma* have been found in the New Zealand Tertiary.

Ceramaster, on the other hand, is a large genus represented in all oceans. The Campbell Plateau species, taken in considerable quantity, has not yet been finally identified but is not closely related to the only other known southern species, *C. patagonicus*. More specimens of *Ceramaster* have recently been trawled off Macquarie I., providing another biogeographic link.

These records are further evidence suggesting that Australian Indo-Pacific and cosmopolitan elements contribute to the fauna of the New Zealand Subantarctic, and that Kerguelenian circum-Subantarctic and Antarctic elements are rare.

HENRICIA

Henricia is a notoriously difficult genus systematically. Despite this, the local representatives of this small starfish from the New Zealand and Subantarctic areas can now be seen to fall into three species with another doubtful species, *Henricia compacta* (Sladen 1889), described from a unique juvenile specimen taken at "Challenger" station 166 in 275 fathoms north-west of Cape Farewell. The distribution of *Henricia* within the New Zealand Region is shown in Fig. 5.

Henricia lukinsi (Farquhar 1898) occurs at the Auckland Is., Campbell I., Chatham Is. in shallow water, and on the New Zealand Shelf, and the Veryan and Pukaki Banks. Although recorded as deep as 300 fathoms, it seems essentially a shallower water species. It has now been discovered off Macquarie I.

Henricia aucklandica Mortensen, 1925 occurs on the Chatham Is. shore and is said by Fell (1962c: 38) to "range from Cook Strait southward" although substantiated records are not available for the New Zealand Shelf. It is now known from the Campbell Plateau and the Antipodes Is., Auckland Is., and Campbell I., to depths of over 300 fathoms and appears to be a deeper water species. It has also been taken off Macquarie I.

Henricia ralphae Fell 1952, is known from depths to 50 fathoms off South Canterbury and East Otago and is now known to be common on the shelf near the Snares. There is a single record from the Auckland Is. Shelf, and it has also turned up off Macquarie I.

The only published identification of *Henricia* from Marquarie is of specimens collected in Lusitania Bay in 38 fathoms (B.A.N.Z.A.R.E. Sta. 83). These have been identified as *Henricia obesa* (Sladen 1889). This is the first record of this species outside the Magellanic-Falklands area (Clark 1962: 48). Other *Henricia* spp. occur at Kerguelen and Marion Is. in the Kerguelenian Province.

Specimens of *Henricia* collected from high spots along the Macquarie Ridge await identification.

CONCLUSION

Since identification and interpretation of the recent collections of bottom-living animals of the New Zealand Region is not yet complete it is premature to generalise about ecological and biogeographical relationships within the New Zealand Subantarctic, or between this sector of the circum-Subantarctic region and the Kerguelenian and Magellanic Provinces. The faunal links between the interesting Macquarie I. material and New Zealand appear much stronger than previously supposed. Reports on the Pycnogonida, the nemertean worms, the patellid limpets, the brachiopods and the scleractinian and stylasterine corals are now being prepared. The over-all picture will be considerably clearer with the analysis of these and other important groups and there will probably be as many surprises in their distributions and biogeographical relationships as have been found amongst the Echinodermata.

ACKNOWLEDGEMENTS

I am grateful to Professor H. Barraclough Fell, Dr. D. L. Pawson, Miss Helen Shearburn-Clark and Mr. D. G. McKnight for identifying the echinoderms referred to in this paper; and to the New Zealand Naval Board for their continued co-operation in making H.M.N.Z.S. *Rotoiti* and H.M.N.Z.S. *Endeavour* available.

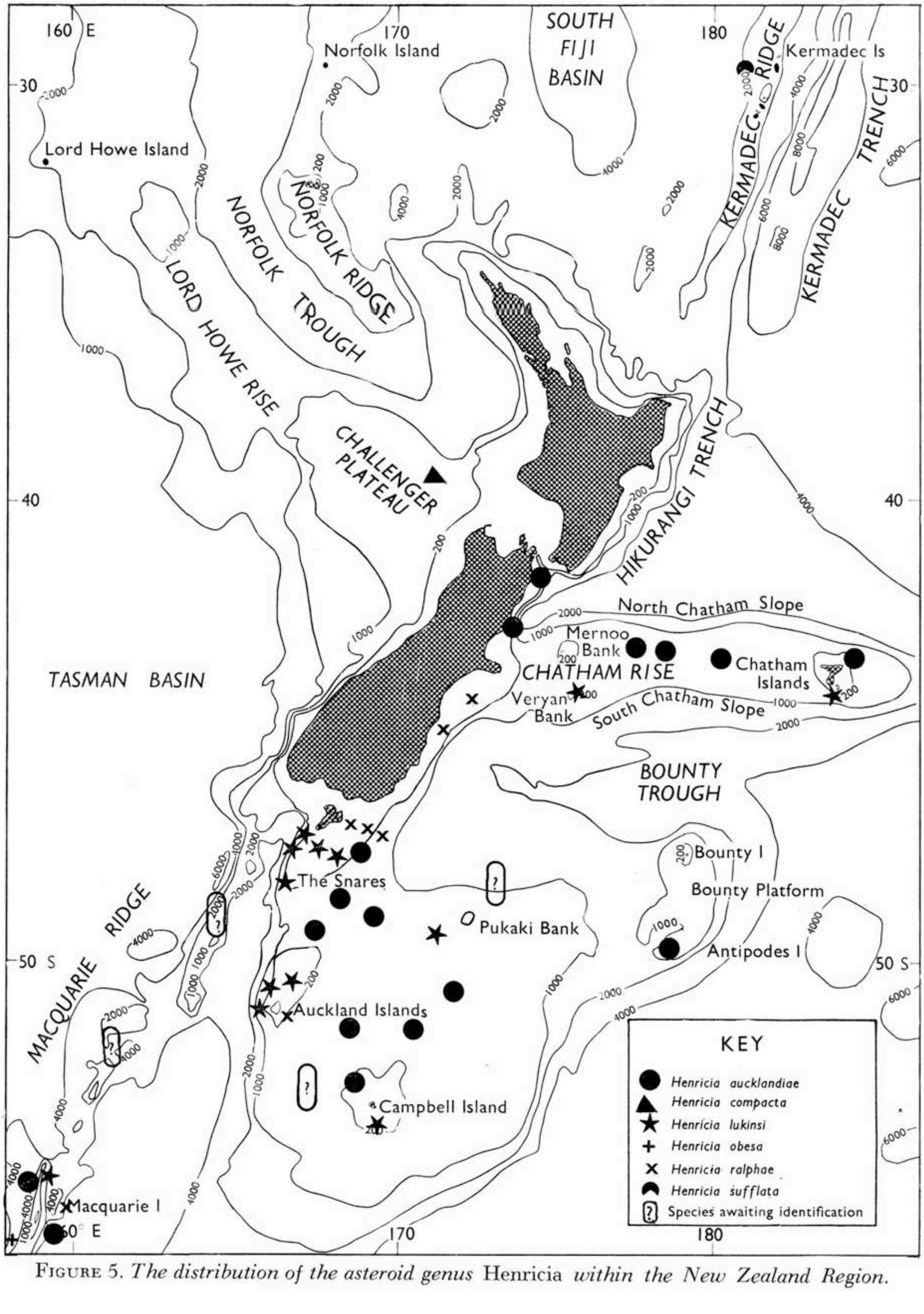

FIGURE 5. *The distribution of the asteroid genus* Henricia *within the New Zealand Region.*

REFERENCES

BRODIE, J. W., and DAWSON, E. W. (in press). Morphology of North Macquarie Ridge. *Nature*.

BURLING, R. W., 1961. Hydrology of circumpolar waters south of New Zealand. *N.Z. D.S.I.R. Bull.* 143: 1–66 (*N.Z. Oceanogr. Inst. Mem.* 10).

CLARK, A. M., 1962. Asteroidea. *B.A.N.Z.A.R. Exped. Rep.* (B) 9: 1–104.

DAWSON, E. W., 1963. Oceanography in the Subantarctic. *Antarctic* 3: 312–314.

DAWSON, E. W., 1964. Antarctic oceanography. *Antarctic* 3:430–432.

DAWSON, E. W. (in press). The marine benthic fauna of Foveaux Strait, Southern New Zealand. *N.Z. Oceanogr. Inst. Mem.* 34.

DELL, R. K., 1952. Marine biology. In *The Antarctic Today*, ed. Simpson, pp. 129–150. Reed, Wellington.

DELL, R. K., 1956. The archibenthal mollusca of New Zealand. *Bull. Dom. Mus.* 18: 1–235.

DELL, R. K., 1962. New Zealand marine provinces—do they exist? *Tuatara* 10: 43–52.

DELL, R. K., 1963a. The littoral marine mollusca of the Snares Islands. *Rec. Dom. Mus.* 4: 221–229.

DELL, R. K., 1963b. Archibenthal mollusca from northern New Zealand. *Trans. Roy. Soc. N.Z. Zool.* 3: 205–216.

DELL, R. K., 1964. Marine mollusca from Macquarie and Heard Islands. *Rec. Dom. Mus.* 4: 267–301.

FELL, H. B., 1953. Echinoderms from the Subantarctic islands of New Zealand: Asteroidea, Ophiuroidea and Echinoidea. *Rec. Dom. Mus.* 2: 73–111.

FELL, H. B., 1962a. A dangerous sea-urchin. *Tuatara* 9: 84.

FELL, H. B., 1962b. West-wind drift dispersal of echinoderms in the Southern Hemisphere. *Nature* 193: 759–761.

FELL, H. B., 1962c. *Native Sea Stars*. Reed, Wellington.

FINLAY, H. J., 1925. Some modern concepts applied to the study of Cainozoic Mollusca from New Zealand. *Verbeek Mem. Birthday Vol.*: 161–172.

FLEMING, C. A., REED, J. J., and HARRIS, W. F., 1953. The geology of the Snares Islands. *N.Z. D.S.I.R. Cape Exped. Ser. Bull.* 13:1–42.

GARNER, D. M., 1959. The sub-tropical convergence in New Zealand surface waters. *N.Z.J. Geol. Geophys.* 2: 315–337.

HOUTMAN, TH. J. (in press). Water masses and fronts in the Southern Ocean, south of New Zealand. *N.Z. Oceanogr. Inst. Mem.* 36.

KENNY, R., and HAYMAN, N., 1962. Ecology of rocky shore organisms at Macquarie Island. *Pacif. Sci.* 16: 245–263.

KNOX, G. A., 1960. Littoral ecology and biogeography of the southern oceans. *Proc. Roy. Soc. Lond.* B, 152: 577–624.

KNOX, G. A., 1963. The biogeography and intertidal ecology of the Australasian coasts. *Oceanogr. Mar. Biol. Ann. Rev.* 1: 341–404.

MCKNIGHT, D. G. (in press). An outline distribution of the New Zealand Shelf fauna; the Echinoidea. *N.Z. Oceanogr. Inst. Mem.* 37.

MCKNIGHT, D. G. (in prep.). An outline distribution of the New Zealand Shelf fauna: the Asteroidea. *N.Z. Oceanogr. Inst. Mem.* 44.

MAWSON, D., 1943. Macquarie Island. Its geography and geology. *Austral. Antarct. Exped.* 1911–14. *Sci. Rep.* (A) 5: 1–194.

MORTENSEN, TH., 1921. Echinoderms of New Zealand and the Auckland and Campbell Islands. Part I. Echinoidea. *Vidensk. Medd. dansk. naturh. Foren.* 73: 139–198.

MORTENSEN, TH., 1925. Echinoderms of New Zealand and the Auckland and Campbell Islands. Parts III—V. Asteroidea, Holothuroidea and Crinoidea. *Vidensk. Medd. dansk. naturh. Foren.* 79: 261–420.

MORTENSEN, TH., 1926. *Goniocidaris umbraculum*, a brood-protecting species. *N.Z.J. Sci. Tech.* 8: 192.

OLIVER, R. L., FINLAY, H. J., and FLEMING, C. A., 1950. The geology of Campbell Island. *N.Z. D.S.I.R. Cape Exped. Ser. Bull.* 3: 1–62.

PARROTT, A. W., 1958. Fishes from the Auckland and Campbell Islands. *Rec. Dom. Mus.* 3: 109–119.

PAWSON, D. L., 1964. A new Cidaroid from New Zealand waters. *Trans. Roy. Soc. N.Z. Zool.* 5: 67–70.

PAWSON, D. L. (in press). Echinozoa from the New Zealand Subantartic, Macquarie Island, and the Chatham Rise. *N.Z. Oceanogr. Inst. Mem.* 41.

POWELL, A. W. B., 1951. Antarctic and Subantarctic Mollusca. "*Discovery*" *Rep.* 15: 151–222.

POWELL, A. W. B., 1955. Mollusca of the Southern Islands of New Zealand. *N.Z. D.S.I.R. Cape Exped. Ser. Bull.* 15: 1–152.

POWELL, A. W. B., 1957. Mollusca of Kerguelen and Macquarie Islands. *B.A.N.Z.A.R. Exped. Rep.* (B) 6: 107–150.

POWELL, A. W. B., 1961. New Zealand biotic provinces. *Tuatara* 9: 1–8.

NOTES ON THE VEGETATION OF THE AUCKLAND ISLANDS

E. J. GODLEY

Botany Division, D.S.I.R., Christchurch

The following observations on the vegetation of the Auckland Islands, made between 26 December 1962 and 20 January 1963, are additional to or amplify those of Hooker (1847), Cockayne (1904, 1909) and Moar (1958a, b).

ALTITUDINAL DISTRIBUTION

Hooker (1847: 2) made the following important note on the vegetation in the north of Auckland I. "It is especially towards the summits of these hills that the most striking plants