Recent New Zealand deep-water benthic foraminifera: Taxonomy, ecologic distribution, biogeography, and use in paleoenvironmental assessment

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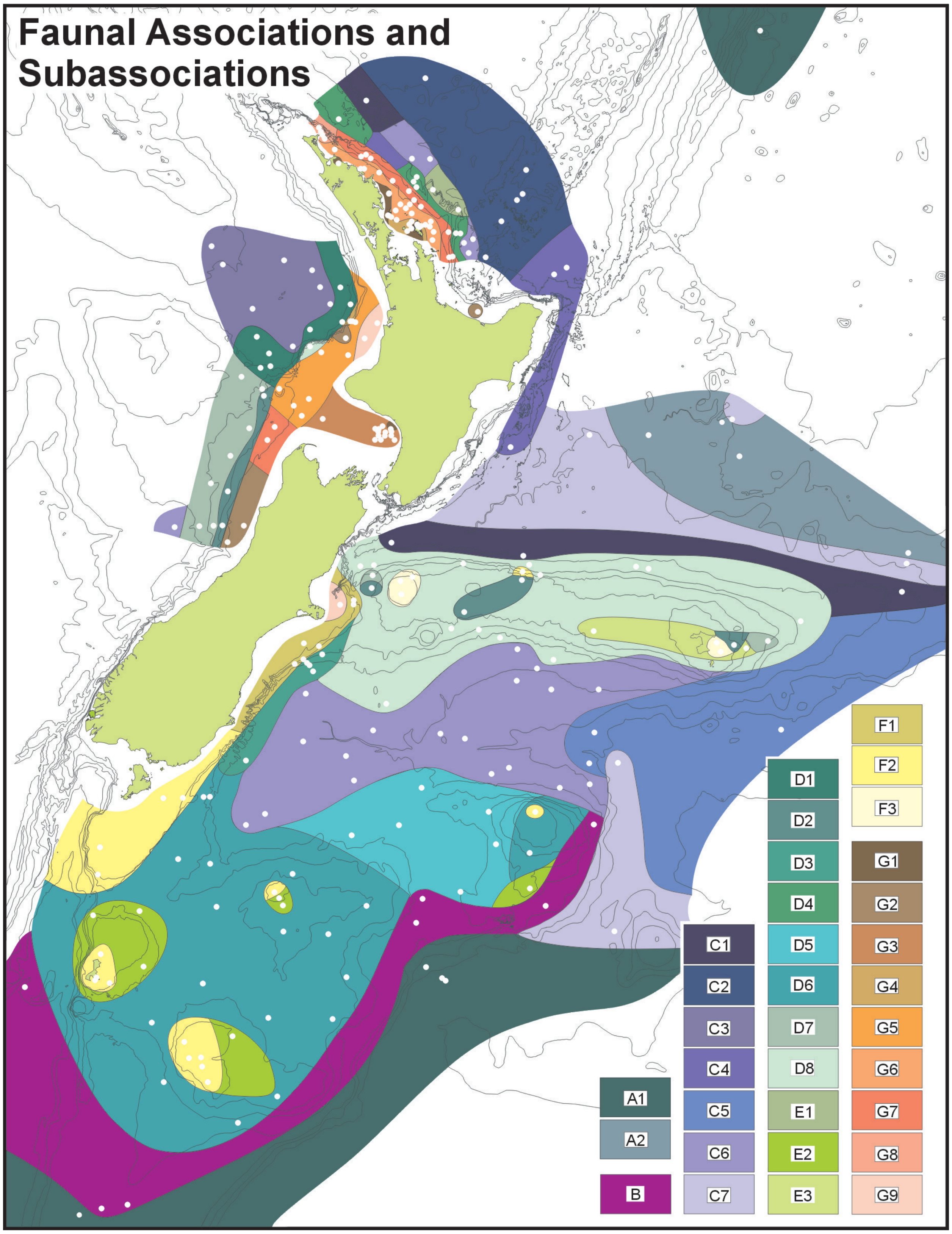
Front Cover: From the centre anti-clockwise: *Pyrgo serrata*, *Porogavelinella ujiiei*, *Favulina favosopunctata*, *Gavelinopsis praegeri*, *Sigmoidella elegantissima*, *Globocassidulina crassa*, *Fissurina laureata*, *Melonis affinis*, *Paratrochammina challengeri*, *Trifarina angulosa*, *Bulimina truncana*, *Cibicides subhaidingeri*, *Inaequalina disparilis*, *Notorotalia depressa*, *Pullenia salisburyi*, *Laticarinina pauperata*, *Buzasina galeata*, *Cyclammina trullissata*, *Cibicides pachyderma*, *Quinqueloculina seminula*, *Bolivina alata*, *Ehrenbergina hystrix*, *Pyrgo inornata*, *Planularia spinipes*, *Lagenosolenia falcata*, *Siphotextularia blacki*, *Lagena peculiariformis*, *Ammodiscus mestayeri*, *Lenticulina anaglypta.*



FRONTISPIECE

Figure 1. Distribution around New Zealand of the deep-water benthic foraminiferal sample subassociations identified from chord cluster analysis based on full census data.

CONTENTS

SUMMARY

Taxonomy

A total of 563 species is listed from deep water (>50 m) from the New Zealand Exclusive Economic Zone (EEZ). The 347 most common or distinctive species are fully illustrated and their diagnostic features outlined. Two new species are described: *Ammoscalaria georgescotti* n. sp. and *Spiroplectammina carteri* n. sp. When used in combination with our twin publication on New Zealand's shallow-water benthic foraminifera (Hayward *et al*. 1999), these two bulletins provide descriptive data and illustrations of the 504 most common and distinctive benthic foraminifera living in New Zealand marine and brackish environments.

Ecologic distribution of deep-water foraminifera

We use census counts (59,000 specimens) of 424 species in 264 samples to map the distribution of deep-sea (50-5000 m depth) benthic foraminifera around New Zealand. Using Q mode cluster analysis (chord similarity coefficient) of the full census data we identify 7 high-level ecologic associations (A-G), 6 of which can be further subdivided into 32 subassociations. The deepest association (A), dominated by *Nuttallides umbonifera* and *Globocassidulina subglobosa* occurs at mid-lower abyssal depths (>3500 m) east of New Zealand. The next deepest, C (*Epistominella exigua* - *Alabaminella weddellensis*), is widespread at lower bathyal – abyssal depths (>1200 m) off both sides of central and northern New Zealand, but does not extend into the subantarctic zone. Three bathyal associations are recognised, with D and E occurring right around New Zealand and B restricted to the subantarctic. Association D (*Cassidulina carinata* – *A. weddellensis*) is usually in deeper, less current-swept waters than E (*Globocassidulina canalisuturata* – *Bolivina robusta*). Association B (*Trifarina angulosa* – *Ehrenbergina glabra*) also occurs in deeper parts of the bathyal zone (900-2000 m) along the strong current-swept, south-eastern margin of the Campbell and Bounty Plateaux, beneath the Subantarctic Front. Associations F (*Cassidulina carinata* – *Trifarina angulosa*) and G (*Cassidulina carinata* – *Bulimina marginata* f. *marginata*) mostly occur at mid shelf-upper bathyal depths (50-600 m) around southern and northern New Zealand respectively, with the dividing line approximating the position of the Subtropical Front.

Q mode cluster analysis (Jaccard coefficient) of presence/absence data of the 424 species in the 264 samples allows the recognition of nine high-level associations (a-i), four of which are further subdivided into 13 subassociations. The distribution of these associations is similar, but not identical, to that based on the quantitative data, indicating that total species composition is just as important as the relative abundance of dominant species in defining these regions.

R-mode cluster analysis (Pearson product-moment correlation coefficient) of full census data for the 56 most common species allows the recognition of eight groups, whose distribution is most strongly linked to bathymetry and secondly to geography. Two abyssal-lower bathyal associations (dominated by *Globocassidulina subglobosa* and *Trifarina angulosa*) are most abundant off southern New Zealand; one from lower bathyal-abyssal depths (*Epistominella exigua*) occurs dominantly east of northern and central New Zealand; an outer shelf to mid bathyal association (*Cassidulina carinata*) is more common to the east and south than the west; and another from mid-lower bathyal depths (*Uvigerina peregrina*) dominantly occurs off the west coast of New Zealand. The remaining three are common all around New Zealand.

Canonical correspondence analysis was used to relate sample associations to a set of environmental "drivers" using the full census data. Bathyal and abyssal associations appear to be more strongly influenced by depth-related variables (e.g., bottom temperature, salinity, oxygen, carbon flux) and shallower associations by latitude-related differences in surface-water characteristics (e.g., temperature, surface phosphate, chlorophyll-a). Environmental variables that influence faunal patterns at abyssal and lower bathyal depths (Assocs. A-C) appear to be, in decreasing order: bottom current strength (mud percentage proxy), carbonate corrosiveness (fragmentation index and planktic % proxies), quality, quantity and seasonality of organic carbon flux to the sea floor (surface phosphate, sea surface temperature, spring and summer chlorophyll-a proxies), and possibly properties of bottom water masses (salinity proxy). Faunal patterns within bathyal associations (D, E) are most strongly influenced by organic carbon flux (surface phosphate proxy), bottom oxygen concentrations (bottom water measurements) and bottom current strength (mud percentage proxy). Latitude-related variables driving mid shelf-upper bathyal faunal patterns (Assocs. F, G) include water temperature and primary productivity in the overlying waters (chlorophyll-a and organic carbon flux proxies).

Species diversity

Based on calculations for individual samples, the species diversity (α, H) of New Zealand benthic foraminiferal faunas overall and at all depths down to mid abyssal (<3000 m) decreases from lower to higher latitudes. At lower abyssal depths (>3000 m) faunas from all regions have a similar range of species diversity. There are no consistent diversity or evenness trends related to depth. Faunal evenness (E) decreases from north to south around New Zealand with more dominance of opportunistic species in the south where nutrients and food supply are more seasonally pulsed.

Based on SHE analysis for biofacies identification (SHEBI), 16 communities were identified in the deep sea around New Zealand. The communities exhibit a north to south latitudinal trend with lnS, H and lnE decreasing to the south. In the north and in the south the communities show an increase in lnS and H with depth. There is no trend with depth in the east and west areas. The community structure in each community was compared using the log series as a null model. Each area exhibits a unique pattern of community structure. In the north-east, 4 communities are recognised and only one at mid-bathyal depths does not resemble a log series. In the west, 3 communities are identified and only the outer shelf does not resemble a log series. The east is very different, where 4 out of 5 communities do not resemble a log series with only the community at abyssal depths doing so. In the south, all 4 of the recognised communities resemble a log series. All abyssal communities resemble a log series and 5 of 6 communities deeper than 1300 m resemble a log series. The log series is characterised by a constant H and is interpreted as representing community stability.

Frequency of species occurrence

We found that the pattern of species occurrence in deep water and throughout New Zealand localities approximates a typical log series plot. As a consequence the vast majority of species occur rarely (37% of species occur in <2% of localities) and only a small number occur widely (4% occur in >50% of localities). Buliminid and rotaliid species and those that dominantly live in shallow water have the highest frequency of occurrence and carterinid, astrorhizid, lituolid, trochamminid and robertinid species the lowest occurrence frequency.

Species duration

We used the recorded regional stratigraphic ranges of 642 modern New Zealand species (both deep, shallow and brackish) to investigate species duration patterns. The percentage of extant species in each of the following orders having a New Zealand fossil record are: Carterinida 0%, Trochamminida 0%, Lituolida 5%, Astrorhizida 10%, Robertinida 20%, Spirillinida 22%, Textulariida 30%, Miliolida 36%, Lagenida 45%, Rotaliida 53%, and Buliminida 59%. Foraminifera that live dominantly in normal marine salinity, shallow (< 100 m) and deep (> 100 m) water have a similar proportion of species recorded fossil from New Zealand (38-42%), with a much lower proportion from brackish environments (11%), reflecting the poor fossil record from brackish settings.

Of the 249 extant species with recorded fossil ranges in New Zealand: 3% first appeared in the Cretaceous, 1% in Paleocene, 10% in Eocene, 16% in Oligocene, 47% in Miocene, 14% in Pliocene and 9% in Pleistocene. These species have a mean partial species duration of 20 million years, comparable with a mean of 21 myrs for benthic foraminifera from the Atlantic margin of north America. There is no major difference in the timings of first appearances nor mean partial species durations between deep- and shallow-water-dwelling species.

Eighty-one percent of commonly occurring species (in >25% of localities) have a fossil record (mean species duration 21 myrs) compared with 14% of rarely occurring species (mean species duration 24 myrs). Sixty percent of endemic species (mean species duration 13 myrs) have a New Zealand fossil record compared with 43% of cosmopolitan species (mean species duration in NZ of 24 myrs) – the reverse of North American Atlantic coast data. This indicates that endemic species have been more common in New Zealand waters than in the North Atlantic, possibly a reflection of New Zealand's isolation.

Biogeography

Sixty-four percent of the 642 extant New Zealand benthic foraminiferal species (both deep, shallow and brackish) have a cosmopolitan distribution, compared with 9% (52 spp) endemic to New Zealand and a further 8% to each of the South-west Pacific (including Australia), West Pacific and Pacific regions. A slightly greater proportion of deep-water (>100 m) species (69%) have a cosmopolitan distribution than do shallower-water (<100 m) species (55%), with brackish species (92%) having the highest proportion. Just 3% of deep-water species (*Sigmoilopsis finlayi*, *Siphonaperta crassa*, *Spiroloculina novozelandica*, *Ruakituria pseudorobusta*, *Jullienella zealandica*) are endemic to New Zealand, but 16% of shallow-water species are.

Our analyses of species presence/absence data suggest that the benthic foraminiferal biogeography around New Zealand differs at different depths and in different water masses. Five provinces can be recognised in our shallowest faunas (inner-mid shelf) and these correspond well with those identified from molluscs. At mid-outer shelf and upper bathyal depths, only 2 provinces can be identified. With increasing depth, greater subdivision is again possible, with 3 provinces recognisable at mid-lower bathyal depths and 4 at abyssal depths. Twenty-four percent (mostly common species) of all 424 species in our quantitative deep-water data set occur in all four regions - north, west, east and south of New Zealand - 17% are restricted to the north, 16% to the east, 8% to the south and just 4% to the west. The main faunal differences between regions are in the numerous rarely occurring species.

Paleoenvironmental assessment

There are many environmental drivers of the modern ecologic distribution of foraminifera and these vary from place to place. In this and previous shallow-water studies of modern foraminifera we have been able to correlate the strength of some of these environmental variables with the relative abundance of various taxa or associations. These correlations can be used to provide estimates of the paleoenvironments in which fossil foraminiferal faunas accumulated that are of value to geological, paleoclimatic and paleoceanographic studies. This uniformitarian approach is most applicable to Quaternary and Neogene faunas but far less reliable further back in time in the Paleogene and Cretaceous.

Planktic foraminiferal percentages and the relative abundance of different planktic species (census counts) can be used to estimate oceanicity, paleo-sea surface temperature and to give an indication of water depth. The composition of benthic foraminiferal faunas by order may provide a general indication of the past environment, but the relative abundance of benthic genera or species and the recognition of faunal associations allow more detailed environmental assessments. In the deep sea these are predominantly of water depth, seasonal or sustained carbon flux, strong bottom currents, bottom oxygen concentrations or exposure to carbonate corrosive bottom waters. In shallow or brackish environments these are predominantly water depth, tidal elevation, salinity, water temperature and exposure to water turbulence. Although depth is not a driver of foraminiferal distribution, a number of environmental variables show general trends with respect to depth, which allow depth estimates to be extracted from faunal composition data. Charts and tables summarising the depth distribution around New Zealand of a number of genera and species are provided to assist in paleodepth assessments. At bathyal depths we have identified c.60 benthic genera and species that appear to have distinct upper depth limits to their distribution and these provide an additional method to help refine paleodepth estimates of Neogene deep-sea faunas.

A method for rapid paleoenvironmental assessments of fossil New Zealand Neogene faunas is outlined, based on a quick estimate of planktic foraminiferal percentage, benthic foraminiferal composition and identification of dominant benthic taxa.

Keywords. Foraminifera; deep water; shelf environments; bathyal environments; abyssal environments; systematics; species frequency; species duration; biogeography; benthic foraminiferal associations; ecologic distribution; paleoenvironmental assessment; New Zealand; Subantarctic Islands; Bounty Plateau; Chatham Rise; Challenger Plateau

INTRODUCTION

RATIONALE

The shells of foraminifera (shelled marine protozoans) are abundant in seafloor sediments of the present day and the geologic past. Compared with many other microfossil groups (e.g., pollen, spores, diatoms, dinoflagellates), they are relatively easy to extract from the sediment for study. They are also easily recovered from small chips of rock brought to the surface by the circulating mud of drilling rigs exploring for hydrocarbons. All these factors have resulted in foraminifera being the most used fossil group for determining the age and depositional environments of New Zealand's marine Cenozoic sedimentary rocks (Hornibrook *et al.* 1989). Most research has focused on planktic foraminifera and their value in dating outer shelf and deeper water sedimentary rocks and correlating them with overseas' sequences (e.g., Jenkins 1971, Scott *et al.* 1990). Benthic foraminifera are used in a more limited fashion for dating shallow marine rocks within New Zealand, because their distribution is more strongly influenced by environmental variables and many have more local biogeographic distributions. On the other hand, benthic foraminifera are the most useful microfossil group used for determining past marine Cenozoic environments. In an earlier study (Hayward *et al.* 1999), we documented the ecologic and biogeographic distribution of shallow (<100 m depth), marine foraminifera around New Zealand, described and illustrated 233 of the more common and distinctive species and proposed methods for using them to infer past shallow-water environments. The goal of this present research was to produce a companion volume on the deep-water (>50 m depth) foraminifera of the New Zealand region, that improved the reliability and precision of benthic foraminiferal paleoenvironmental assessments in these deeper environments. This improved understanding is expected to also contribute to our dating capability in these environments.

Study of the taxonomy, ecologic distribution and biogeography of benthic foraminifera (Eukaryota, Protozoa) has application in both modern and fossil environmental studies. They provide the potential for a quick, cost effective method of assessing the impact on marine ecosystems, and subsequent recovery (e.g., Scott & Lipps 1995), of sewage and chemical pollution (e.g., Matthews *et al.* 2005), deforestation and urbanisation (e.g., Hayward *et al.* 2004a, 2006a), aquaculture (e.g., Grenfell *et al.* 2007) and other human-induced environmental changes (Hayward *et al.* in press).

Studies of sequences of deep-water fossil foraminiferal faunas have the ability to assess larger-scale paleoceanographic changes, such as upwelling and nutrient supply, phytoplankton productivity and seasonality and consequent food flux to the seafloor, climate-related movement of surface water masses and fronts, variations in bottom-water oxygen concentrations and carbonate corrosiveness as a result of deep water-mass changes (e.g., Hayward *et al.* 2004b, 2004c, 2005).

In shallower environments similar studies on young fossil foraminiferal sequences have the ability to document changes in paleosalinity, paleoenvironment, and paleo-sea level (e.g., Hayward *et al.* 2004d) with application in understanding Holocene coastal evolution (e.g., Goff *et al.* 2000; Cochran *et al.* 2005), quantifying paleoseismicity (e.g., Hayward *et al.* 2004e, 2006b, 2007a), and climate-warming-related sea-level rise (e.g., Gehrels *et al.* 2008).

Fossil benthic foraminiferal studies from both shallow- and deep-water, marine Neogene (last 25 million years) sediments are particularly useful in determining the paleoenvironment and water depth in which the sediments accumulated. Such assessments have application in reconstructing the evolving paleogeography of an area or region (e.g., Scott 1970; Hayward & Buzas 1979; Hayward & Brook 1994), in determining timings and amounts of tectonic uplift and subsidence (e.g., Hayward 1990a, 2004), and in the quantification of Cenozoic cyclothems, sequence stratigraphy and geohistory analysis (e.g., Hayward 1990a, Haywick & Henderson 1991; Abbott 1997; Naish & Kamp 1997). Better understanding of the environmental controls on benthic foraminifera in the deep sea is also valuable when trying to understand the causes of evolution and global mass extinctions (e.g., Kaiho *et al.* 1996; Hayward 2002).

SCOPE OF STUDY

This study focuses on the deep-water benthic foraminifera of mid shelf and greater depths (deeper than 50 m) of the New Zealand region (Fig. 2). It consists of four major sections:

1. Ecologic distribution

This section documents the ecologic distribution patterns of modern deep-water (mid-outer shelf, bathyal and abyssal) foraminifera around New Zealand and investigates which environmental variables are determining these patterns. It brings together the results of four, recently completed, quantitative studies - one in each of the north-east, west, east and south-east regions of New Zealand (Hayward *et al.* 2001, 2002, 2003, 2006c, 2007b). In each region, the depth range of studied sites was largely determined by the bathymetry, but also by the availability of samples in the store of the National Institute of Water and Atmosphere. The quantitative census counts from these four study regions have been combined and reanalysed together, along with additional samples from west of the South Island and east of central North Island.

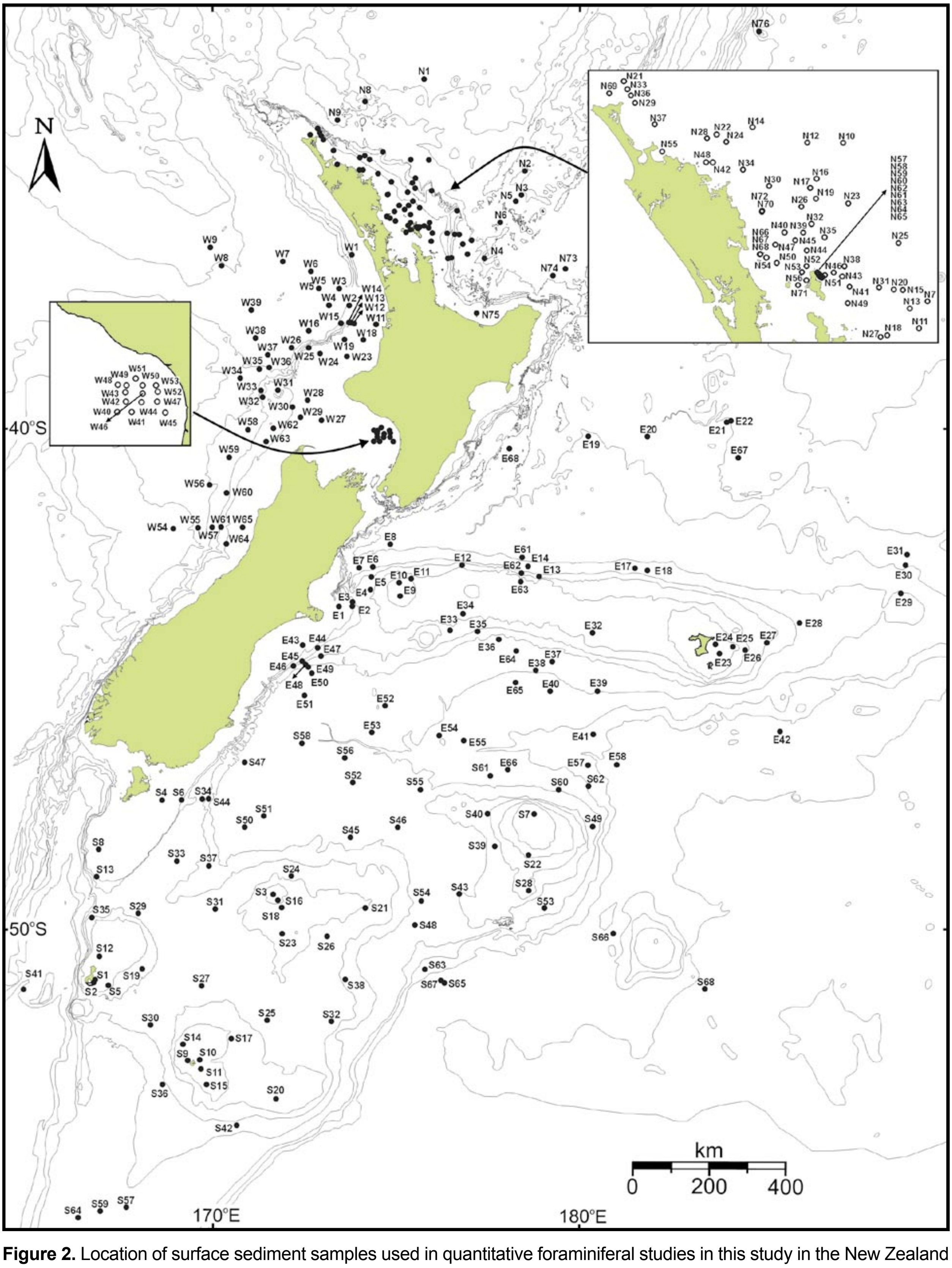


Figure 2. Location of surface sediment samples used in quantitative foraminiferal studies in this study in the New Zealand region.

2. Biogeography, frequency of occurrence and species duration

This section investigates the frequency of occurrence, species duration and biogeographic distribution of the deep-water foraminifera of the New Zealand region. The biogeographic distribution of deep-water species within the region is analysed using full species lists from 130 composite localities from all around New Zealand, largely comprising the species lists from the major quantitative ecologic studies in section 1. This data set is also combined with full species lists from an additional 32 composite shallow-water localities allowing analysis of the biogeographic distribution of all Recent foraminifera around New Zealand.

3. Use in paleoenvironmental assessment

This section enlarges on two earlier guides to paleoenvironmental assessment using New Zealand Cenozoic foraminifera (Hayward 1986a, Hayward *et al.* 1999) and brings it up to date, particularly with this recent work on deep sea benthic foraminifera. This section is not restricted to deep water nor benthic foraminifera, but includes planktics and shallow-water data (from Hayward *et al.* 1999) so that it can be used as a "one-stop-shop" for paleoenvironmental assessments of all New Zealand Neogene fossil foraminiferal faunas. The recommended methodology is based strongly on uniformitarian principles and has been considerably refined since 1986 by incorporating the environmental ranges of the modern New Zealand species and faunal associations.

4. Taxonomy and atlas

The previous three sections all rely heavily on the accurate and consistent identification of the taxa. We have documented the distinctive features and fully illustrated all the common and more distinctive species encountered around New Zealand at depths greater than 50 m. Of the 233 species described and illustrated in our shallow-water monograph (Hayward *et al.* 1999), 76 of these that are also particularly common in deeper water are described and illustrated in this monograph. Other species that occur rarely in deep water around New Zealand are listed but not included in the taxonomy section. To improve the quality of our assessments of world biogeographic affinities of the species, we have where possible compared the New Zealand material with overseas taxa and where necessary have synonymised names. Graphs showing the abundance and latitudinal and bathymetric distribution around New Zealand of the 105 more common deep-water species have been produced using just our quantitative data set.

PREVIOUS WORK ON NEW ZEALAND RECENT DEEP-WATER FORAMINIFERA

The earliest report of Recent foraminifera from New Zealand waters was that of Brady (1884), contained in his huge monograph on foraminifera collected during the global scientific expedition by HMS *Challenger*. Many of his figured specimens were obtained from the four sediment samples collected from New Zealand waters - one from Wellington harbour (stn. 167A), two west of Cook Strait (stns. 166, 167, 550 m, 300 m), and one east of the North Island (stn. 168, 2200 m).

During the first twenty-two years of the 20th century five workers reported on Recent foraminifera from deeper water around New Zealand. Chapman (1906) described 103 species (one new) from 220 m of water off Great Barrier Island (36˚S). Chapman (1909) listed and described 160 benthic foraminifera (4 new) from five samples around New Zealand's Subantarctic Islands, which included samples from 100 m depth off Bounty Islands (48˚S), 120 m off the Snares (48˚S), and two samples from 170 m off the Auckland Islands (51˚S). Mestayer (1916) listed 144 species of foraminifera from 200 m water depth off the Three Kings Islands (34˚S), at the north end of New Zealand. Cushman (1919) joined the action with the description of a benthic foraminiferal fauna of 175 species (six new) from 120 m depth off the Poor Knights Islands (36˚S). Heron-Allen & Earland's (1922) treatise on the foraminifera collected by the British Antarctic Terra Nova cruise of 1910-1913, included 12 samples (11 deeper than 50 m) from northern New Zealand, East Cape and the subantarctic region, with 24 species described as new from the New Zealand samples.

Little was added to our knowledge of New Zealand's Recent foraminifera during the next thirty years, although this was the period when the knowledge and use of our fossil foraminifera suddenly bloomed with the work by Harold Finlay (Finlay 1939a-c, 1940, 1947). Finlay's successor at the New Zealand Geological Survey, Norcott Hornibrook also concentrated on fossil foraminifera, but also published a list of 20 benthic species collected from 160 m water depth off Banks Peninsula (44˚S; Hornibrook in Knox 1951).

In the 1950s, Paul Vella conducted the first detailed study of the ecologic distribution of Recent foraminifera in New Zealand by listing and describing the fauna from 61 dredge stations at 5-500 m depths from around Cook Strait (Vella 1957). The study area was an unfortunate choice because he was forced to conclude that strong bottom currents mixed the faunas from different biofacies together. In his monograph, Vella (1957) described 46 new species of benthic foraminifera, particularly belonging to the Order Miliolida.

In the 1960s, the New Zealand Oceanographic Institute briefly became the centre for research on New Zealand Recent foraminifera, as it was argued that "Foraminifera constitute the predominant part of the present-day sediments in a wide area around New Zealand" (Brodie in Eade 1967a). Following a year-long research visit to NZOI, Dr Hedley and colleagues from the British Museum, documented a fauna of 53 benthic species from 87 m depth off western Northland (Hedley *et al.* 1965). Meanwhile Kustanowich (1965) recorded the foraminiferal fauna in a seven sample transect along the length of Fiordland's Milford Sound (45˚S) at 120-300 m water depth. Later at NZOI, Jim Eade (1967a) compiled a checklist of all Recent foraminifera recorded from New Zealand and also revised the cassidulinid foraminifera from the region, including four new species (Eade 1967b). At the same research institution, Lewis & Jenkins (1969) investigated the geographic variation of populations of *Nonionellina flemingi* at inner and mid shelf depths around New Zealand and Lewis (1970) prepared a key and useful illustrated glossary to the genera of Recent foraminifera. As part of his PhD thesis at Victoria University, Keith Lewis (1971, 1979) undertook a study of the ecologic distribution of Recent foraminifera in shelf to upper abyssal depths (18-2500 m) off southern Hawkes Bay (40-41˚S). In a semi-quantitative study of foraminifera in different size fractions he recognised six depth-related biofacies

In another PhD study, this time at the University of Exeter, UK, Bob Hoskins (1978) documented the distribution of Recent foraminifera in a series of samples from inner shelf to abyssal off North Cape (33-34˚S). This was slightly north of Thompson's (1975) University of Auckland MSc study area in the outer Hauraki Gulf (36-37˚S), where he too documented the ecologic distribution of benthic foraminifera at inner shelf to upper bathyal depths. In a monumental taxonomic study of deep-water foraminifera of the Pacific Ocean, Saidova (1975) described and named 56 new species from the New Zealand region. More recently, Alexa Cameron (1995) based at Canterbury University, has recorded the distribution of 84 benthic foraminiferal species in a similar set of samples at shelf to bathyal depths (10-2000 m) off Kaikoura, northern South Island (42˚S).

Starting in the late 1970s, Bruce Hayward based at the New Zealand Geological Survey, later Auckland Museum, University of Auckland and Geomarine Research, began an increasingly intensive study of New Zealand's Recent benthic foraminifera. Early studies were mainly at inner shelf depths (see Hayward *et al.* 1999 for summary). Three of these studies included faunas dredged from mid shelf depths (50-100 m) off the Chicken Islands (36˚S; Hayward *et al.* 1984), north side of Great Barrier Island (36˚S; Hayward & Grenfell, 1994) and in Wanganui Bight (Hayward *et al.* 1997a). A later study of the benthic foraminifera of the Subantarctic Auckland Islands (51˚S) also included several samples from mid shelf depths (Hayward *et al.* 2007c).

In the early 21st century Hayward and his colleagues at Geomarine Research (Hugh Grenfell, Ashwaq Sabaa, Rowan Carter and assisted by NIWA's Helen Neil), have undertaken four regional studies of deep-water (>50 m) benthic foraminiferal distribution around New Zealand and attempted to determine the environmental variables responsible for the observed patterns. The first of these studies looked at faunas in 66 samples from 90-4700 m depth off the east coast of central New Zealand, between 40 and 47˚S (Hayward *et al.* 2001, 2002). The second study looked at 39 samples at 0-2150 m depth off the west coast of the North Island, between 36 and 40˚S (Hayward *et al.* 2003). Fifty-six samples at depths between 50 and 3800 m, were studied off the east coast of northern New Zealand, between 33 and 38˚S (Hayward *et al.* 2006c). In a final study, in the subantarctic zone off south-eastern New Zealand, 68 faunas at depths between 50 and 5000 m were documented between 46 and 55˚S (Hayward *et al.* 2007b).

TERMINOLOGY

The following terminology for bathymetry, and for various other general aspects of oceanic and seafloor environments, is used throughout this monograph (Table 1, Fig. 3).

Table 1. Terminology used throughout this study for bathymetry, oceanicity, bottom oxygen and trophic conditions.

BENTHIC DEPTH ZONES (Fig. 3)
littoral = intertidal
"shelf" = 0-200 m
inner = 0-50 m, middle = 50-100 m, outer = 100-200 m
bathyal = 200-2000 m
upper = 200-600 m, middle = 600-1000 m, lower = 1000-2000 m
abyssal = 2000-5000 m
upper = 2000-3000 m, middle = 3000-4000 m, lower = 4000-5000 m
hadal = >5000 m

OCEANICITY (refers to overlying water mass) (Fig. 3)
oceanic: indicative of open water conditions
marginal oceanic: on the edge of open waters
marginal neritic: on the edge of sheltered waters
neritic: indicative of enclosed or sheltered conditions, near land.

BOTTOM OXYGEN CONDITIONS (Kaiho 1994, 1999).
oxic: >1 ml/l O_2 - indicative of bottom water circulation
suboxic: 0.3-1 ml/l O_2
dysoxic: 0-0.3 ml/l O_2
anoxic: 0 ml/l O_2 - indicative of little or no bottom water circulation and maybe suggestive of an enclosed basin location

TROPHIC (FOOD SUPPLY) CONDITIONS
Eutrophic: high food supply - sea floor flux > 3 g labile C m^{-2} yr^{-1}
Mesotrophic: moderate food supply
Oligotrophic: low food supply

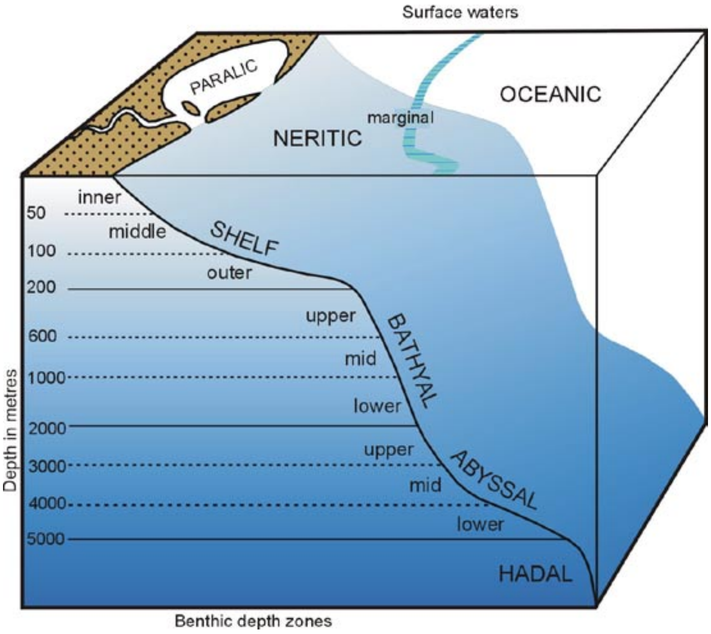


Figure 3. Terminology for benthic depth zones and surface water oceanicity (from Edwards 1979, Kennett 1982, van Morkhoven *et al.* 1986).

SOURCE OF SAMPLES

The seafloor sediment samples used in the quantitative study (Fig. 2, Appendix I) were mostly obtained from the archives held by the National Institute for Water and Atmospheric Research (NIWA, prefixed by A-Z) and the Geology Department, University of Auckland (prefixed by AU). This set of samples was supplemented by core top samples from eight Ocean Drilling Program (ODP) sites (prefix DSDP or ODP), two Roger Revelle piston cores (prefix RR) and three MV Marion Dufresne piston cores (prefix MD). A further 15 of the shallower samples from the Hauraki Gulf and around Great Barrier Island were taken by the authors using a hand-hauled bucket dredge. Additional qualitative samples used in parts of this study were mostly derived from the archival foraminiferal slide collection of GNS Science (prefix F20), supplemented by a few samples from the collections of Auckland Museum (prefix L) and the University of Auckland (prefix AU).

LODGEMENT OF COLLECTIONS

The specimens and faunas used in this study are lodged in the collections of:

a. the New Zealand national collection of foraminifera held by the Institute of Geological and Nuclear Sciences (GNS Science), Lower Hutt, New Zealand (formerly New Zealand Geological Survey and DSIR Geology and Geophysics). Sample catalogue numbers prefixed by F20; specimen catalogue numbers prefixed by TF (types), FP (figured and on slides) or BWHnnn/nn (figured and left on stubs).

b. the Geology Department, University of Auckland. Sample catalogue numbers prefixed by AU.

c. the Marine Department, Auckland War Memorial Museum. Sample catalogue numbers prefixed by L.

Catalogue numbers for the faunal samples used in this work are given in Appendices I and II.

Catalogue numbers and repositories for type specimens are given with the descriptions of new species.

Catalogue numbers for illustrated specimens are given in the plate captions.

ACKNOWLEDGMENTS

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We thank the Research Centre for Surface and Materials Science, University of Auckland for the use of their SEM for photomicrographs. Margaret Morley produced the beautiful drawings of the *Lenticulina* species (Pl.14). We thank Rowan Carter for his assistance with the study of the faunas from east of central New Zealand, and Catherine Reid for her assistance with the Wanganui Bight study. Mark Hadfield (NIWA) produced the surface chlorophyll maps. Rhiannon Daymond-King and Jennifer Jett drafted some of the figures. Jessica Hayward assisted with editorial work. Jon Kay did some of the plate preparation work.

We are especially grateful to our colleagues Marty Buzas, Giuseppe Cortese and Percy Strong for critically reading the manuscript and for suggesting improvements, and Jill Kenny for proof reading and page make-up.

NEW ZEALAND OCEANOGRAPHY

SUBMARINE PHYSIOGRAPHY

The New Zealand region straddles approximately 24° of latitude from the Kermadec Islands in the north to Campbell Island in the south (Fig. 4). Relative to it's land area New Zealand has a large continental shelf region and the New Zealand Plateau markedly interrupts the generally west to east flow of the two major surface water masses which surround it (Fig. 5), and by doing so, control biological production.

The area studied surrounds all of New Zealand's main islands. West of New Zealand there is a wide West Taranaki continental shelf that narrows northwards along the coast of the Northland-Auckland Peninsula and narrows southwards down the West Coast of the South Island. This western continental shelf extends into Cook Strait between the North and South Islands and drops steeply down the continental slopes along its seaward Tasman Sea side. The large, ~1000 m-deep Challenger Plateau lies west of central New Zealand with the upper abyssal New Caledonia Basin to the north and the lower abyssal Tasman Basin to the south-west (Fig. 4).

North-east of New Zealand the study area includes the southern portions of the Three Kings Ridge, South Fiji Basin east to the Colville Ridge and Havre Trough, bounded by the hadal depth of the Kermadec Trench. (Fig. 4). Extending south down the east coast of the North Island the region crosses the extensive, abyssal Hikurangi Plateau. The main feature of the plateau is the Hikurangi Channel and its attendant levees that extend from near Kaikoura, 1400 km across the Plateau floor ending in an extensive fan (Lewis 1994). To the south the plateau rises up along the northern flank of the Chatham Rise. The Chatham Rise extends eastwards from the coast of the South Island, and shoals to average depths of ~300 m. Mernoo Saddle separates the Rise from the continental shelf of emergent New Zealand.

Continuing south the study region crosses the Bounty Trough which extends ~1000 km east of the continental margin of the South Island. The trough is bounded to the north and south by the submerged continental masses of the Chatham Rise and Campbell Plateau. The Bounty Trough contains two fan systems, the Otago Fan Complex at its head and the Bounty Fan at its base, which merges with the 4500 m deep abyssal plain of the South-west Pacific (Fig. 4). These two fan systems are linked by the Bounty Channel and levee system – a conduit for feeding sediment eroded off the South Island down to the abyssal Bounty Fan (Fig. 4).

To the south the plateaux bordering the Bounty Trough comprise the south-eastern extent of the area studied and include all of the Campbell and Bounty Plateaux and extend down to lower abyssal depths (~5000 m) in the south (Fig. 4). Both plateaux are submerged continental platforms. Campbell Plateau is mostly at depths of 600-1000 m but shoals up to shallower than 250 m in three places – Pukaki Rise and the volcanic Auckland and Campbell Islands. Bounty Plateau ranges from 200-1000 m with two small island groups – Bounty and Antipodes Islands. The two plateaux are separated by the ~1400 m-deep Pukaki Saddle. The eastern margins of the plateaux are precipitous, plunging from 1000 to >4000 m, often at gradients of 1:4. Also included in the study is an area of continental shelf extending south-east from Stewart Island. The continental slope around the margin of this shelf is also precipitously steep dropping from 200 m to 700-1200 m before leveling out (Fig. 4).

The region therefore includes: broad continental shelves (the West Taranaki Shelf which widens to the south, Three Kings Shelf and an area extending south-east from Stewart Island); narrow, and often precipitously steep, continental slopes; a shallow continental rise (upper bathyal Chatham Rise); the gentle slopes of Challenger Plateau (mid-lower bathyal), Northland Plateau (mid-bathyal), Campbell and Bounty Plateau (upper-mid bathyal); and the flat floors of the New Caledonia Basin (lower bathyal-upper abyssal), Bounty Trough (bathyal-abyssal), Hikurangi Plateau and South Fiji Basin (abyssal) and lower abyssal depths (~5000 m) in the south.

SEAFLOOR SEDIMENT

The majority of the region surrounding New Zealand is mantled by a drape of terrigenous mud and sand or biogenic gravel, sand and ooze (Fig. 6). Primary sources of terrigenous material are the background supply of sediment from active erosion of uplifting mountain chains and volcanoclastic contributions from intermittent large eruptions. This material is transferred to the deep sea via seafloor failure, fall of volcanic ash, and dispersion via submarine channels. Biogenic sources are dominated by calcareous nannoplankton and foraminifera, with minor siliceous components. Broad regional differences in biogenic supply are a result of both differing production and dilution by terrigenous sediment.

The crest of the Chatham Rise is predominately composed of Paleogene and Miocene chalk deposits (Wood *et al.* 1989), exposed in places due to episodic current winnowing, and draped by thin, impersistent deposits of authigenic and biogenic silty sand, localised accumulations of phosphorite nodules (Cullen 1987, McDougall 1982) and localised biogenic gravel and sand deposits with some terrigenous cobbles and pebbles (McDougall 1982). Pelagic carbonate and hemipelagic sediment mantles both the northern and southern flanks of the Chatham Rise, while the top and flanks of the gently sloping Plateau (Challenger, Campbell and Bounty) are mantled by pelagic carbonate sediment (Fig. 6). This is fine-grained, white and homogeneous, consisting mainly

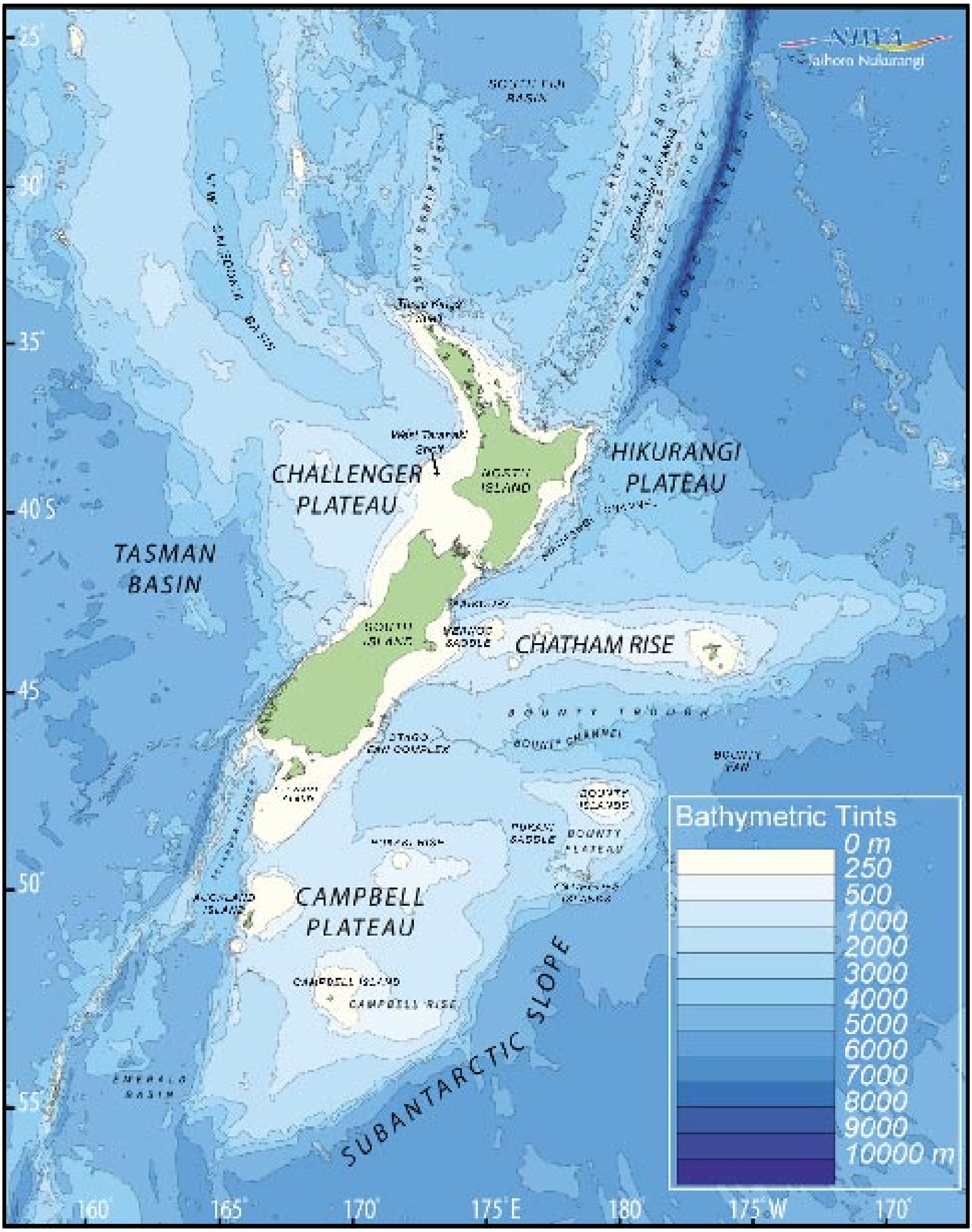


Figure 4. Bathymetry of the New Zealand region, with names of prominent physiographic features and islands (after CANZ 2008).

of foraminifera, coccolith plates, and ~10-20% non-carbonate material. Sediment cover on the associated steep flanks is patchy and coarse due to erosion and winnowing by associated deep currents, with mass failure also playing a role. Localised accumulations of manganese nodules also occur at the base of these steep slopes (e.g., Glasby 1976, Carter 1989).

In contrast regions crossed by submarine canyons, fans and channels (Hikurangi, Bounty, West Coast, New Caledonia Basin) are dominated by hemipelagic and terrigenous sedimentation (Fig. 6). The head of these

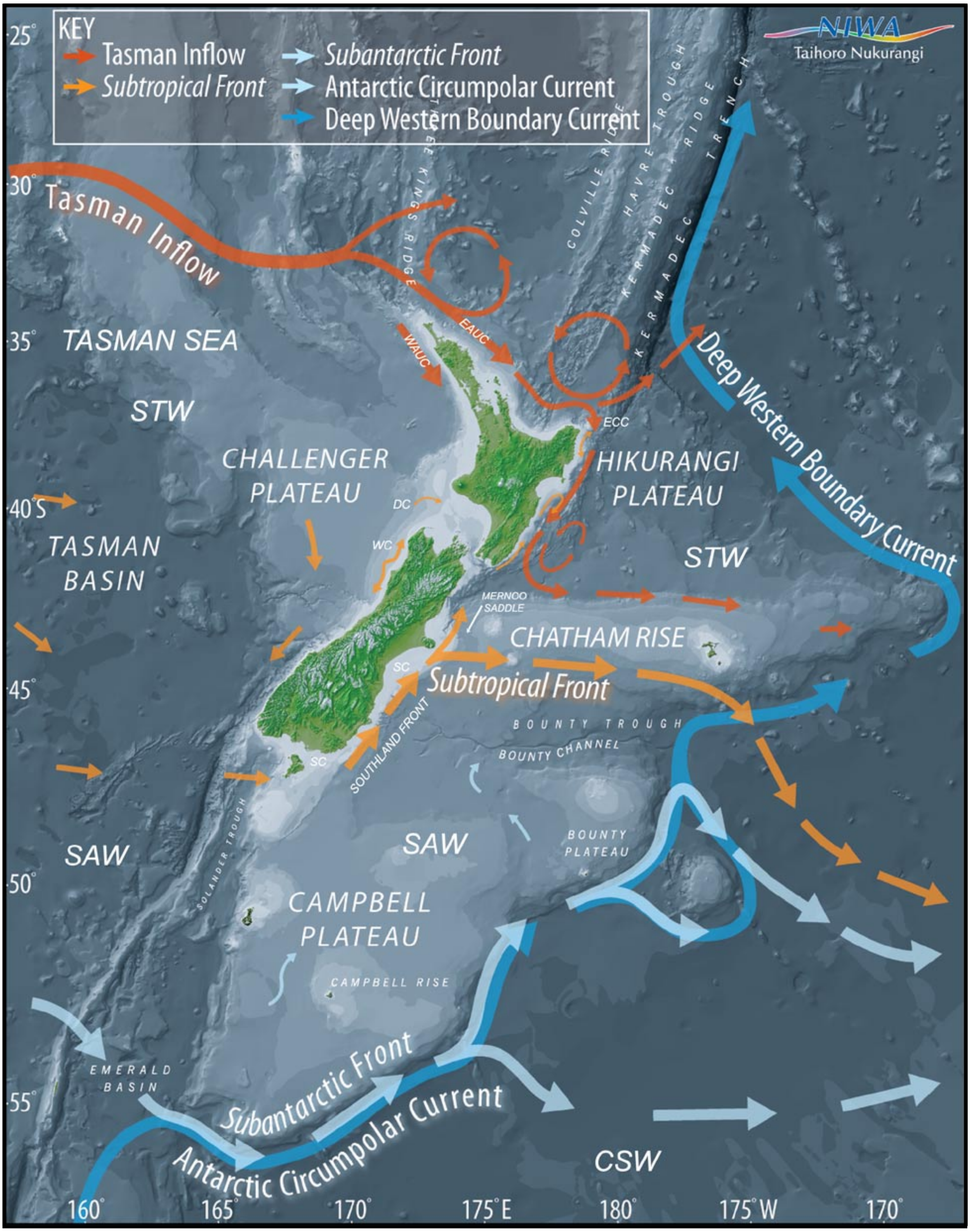


Figure 5. Representation of the surface currents and fronts and deep currents around New Zealand (modified after Carter *et al*. 1998, Neil *et al*. 2004).

systems generally consist of muddy sand with associated calcareous and terrigenous gravel and gravelly sand (e.g., McDougall 1982, Herzer 1981). Modern turbidity current activity is absent in the bathyal to abyssal reaches of the Bounty Channel and Trough (Carter & Carter 1993), and the channels west of New Zealand, resulting in overlying pelagic and hemipelagic ooze. In contrast, the Hikurangi Channel-Fan complex that dissects the Hikurangi Plateau has been active during recent times. This has resulted in the deposition of sandy terrigenous-bearing turbidity currents across an extensive levee-plain, mantled by pelagic and hemipelagic sediment, about the Hikurangi Channel (Lewis 1994).

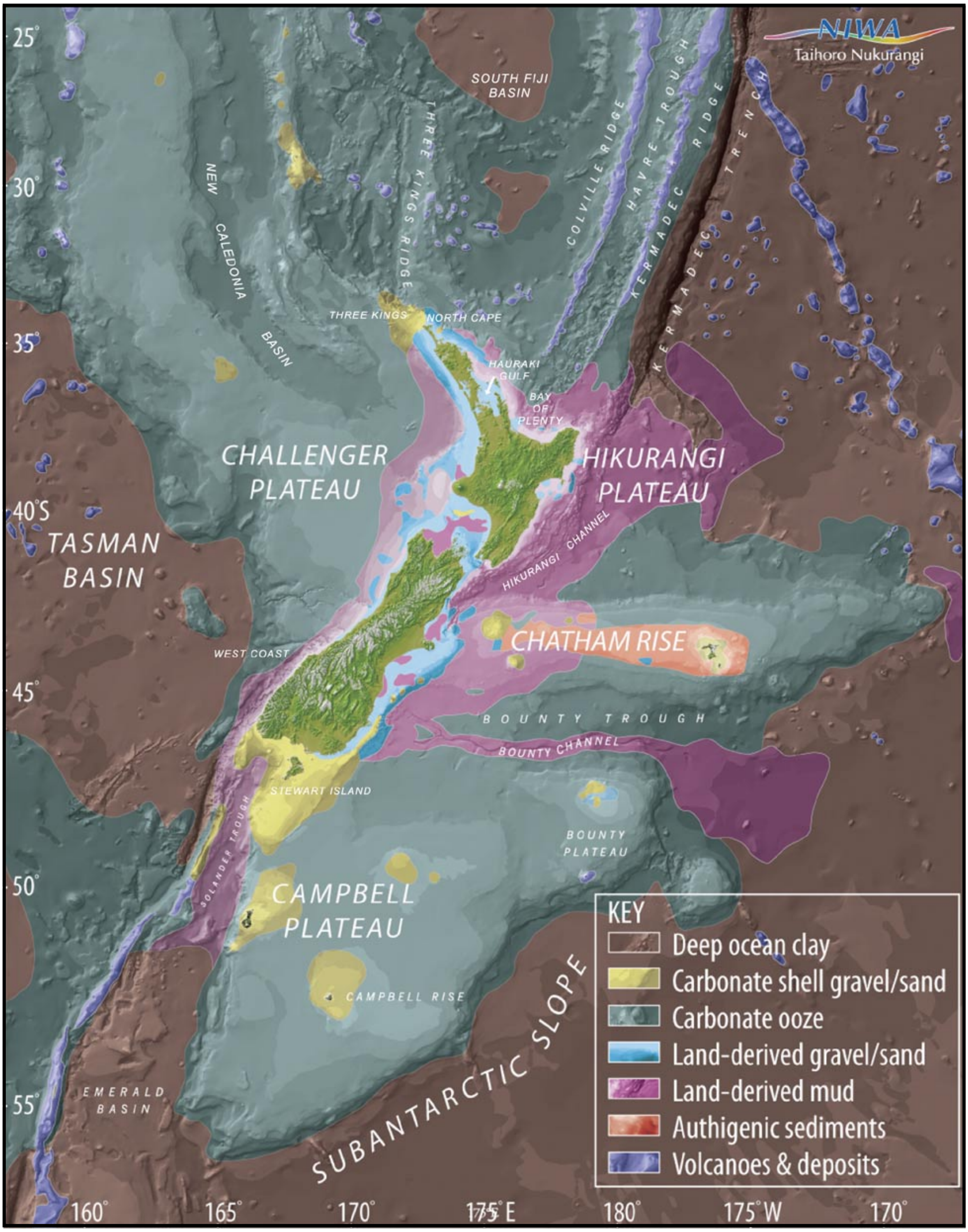


Figure 6. Map showing the distribution of seafloor sediment in the New Zealand region (after Orpin, *et al.* 2008).

The continental shelves are dominated by mud or sandy mud with the broad West Taranaki continental shelf also comprising significant bodies of fine to medium sand, coarse sand and shell gravel (probably relict), with cobble and boulder beds also present. The broad continental shelves of Three Kings and Stewart Island are dominated by biogenic sands as well as coarse sand and shell gravel with some cobble and boulder beds (Fig. 6).

In the north-east of the region, the distribution of seafloor sediment reflects the interactions between an oceanic rain of pelagic carbonate sandy mud, carbonate-producing shelf biotas (North Cape and central Hauraki Gulf), and southern-sourced terrigenous mud and sand (from the

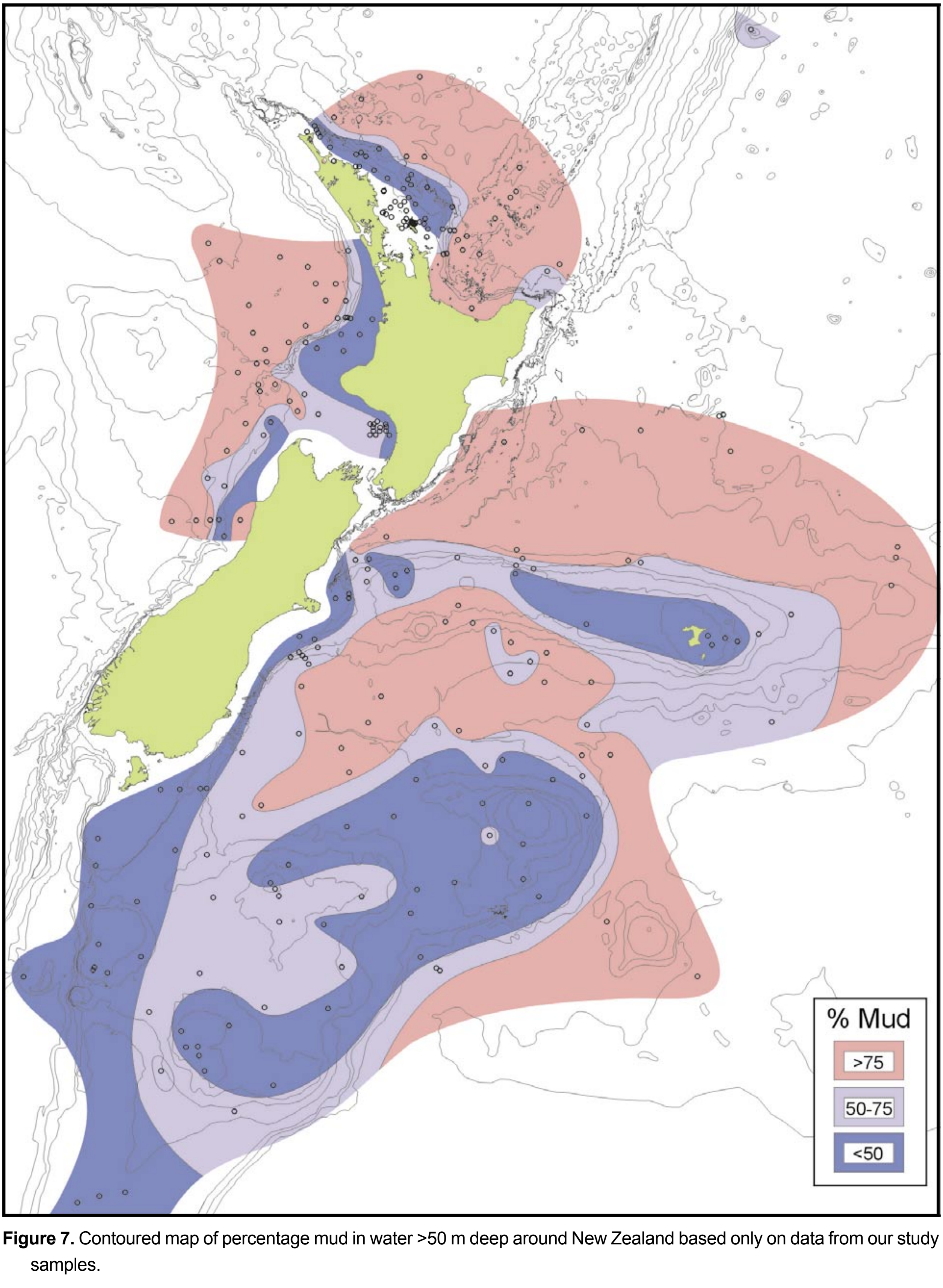


Figure 7. Contoured map of percentage mud in water >50 m deep around New Zealand based only on data from our study samples.

Bay of Plenty and Hauraki Gulf), swept in the north and along the slope edge by strong bottom currents. At lower bathyal-upper abyssal depths in the South Fiji and New Caledonia Basins the sediment is pelagic carbonate mud or sandy mud (Fig. 6).

Martinez (1994) estimated the modern lysocline to be at ~3100 m in a south-west to north-east transect through the New Caledonia Basin (east Tasman Sea). Thus, the area studied west of New Zealand presently lies well above the calcium carbonate compensation depth (CCD). East of New Zealand the CCD is estimated to be 4750 m depth (Carter & McCave 1997) and the foraminiferal lysocline, where foraminiferal shells start dissolving, at ~3500 m (Weaver *et al.* 1997). Deeper samples in the east are approaching the CCD and a region of lower abyssal-hadal deep ocean clay.

Mapping of the percent mud from samples in this study (Fig. 7) shows the usual trend of fining sediment with increasing water depth, with only the deepest samples at lower abyssal depths having >80% mud. At bathyal and abyssal depths much of the sand fraction is planktic foraminifera, but dissolution starts removing these at >4000 m depth. The continental shelf and summits of submarine plateaux and rises (<300 m) have sandy sediment cover with <25% mud. Contrary to the depth-related fining trend, there is often a belt of cleaner sand (<20% mud) running along the upper slopes of plateau escarpments, beneath the route of the strong frontal-related currents which often extend down to the seafloor. Less muddy sediment also occurs below the route of strong bottom currents (Fig. 7).

WATER MASSES AND FRONTS

Within the New Zealand region, there are two surface and three subsurface water masses (Figs 5, 8). The surface water masses are separated from each other by oceanic fronts which are characterised by rapid spatial changes in water properties (Heath 1985, Bradford-Grieve *et al.* 1991, Carter *et al.* 1998).

North of the Subtropical Front (STF), surface waters are highly saline, nutrient-depleted, warm (Fig. 9) Subtropical Water (STW) sourced from the north, whereas south of the STF surface waters have lower salinity, and comprise nutrient-rich, cool (Fig. 9) Subantarctic Surface Water (SAW) derived from south of New Zealand. These surface water masses meet across the STF. The STF in the New Zealand region crosses the Tasman Sea at ~43°S, is continuous around southern New Zealand, along the continental margin off the south-eastern South Island, turning east along Chatham Rise at ~43°S, following approximately the 15°C isotherm in summer. Along the south-east coast of the South Island, the STF is referred to as the Southland Front (Fig. 5). The STF is a complex and irregular frontal zone comprising large meanders and eddies. In the Tasman Sea it is free to meander while east of New Zealand it is constrained by easterly flows along the flanks of Chatham Rise (Chiswell, 1994). South of New Zealand, constrained by the Campbell Plateau (Fig. 5), the Subantarctic Front (SAF) separates SAW from Circumpolar Surface Waters (CSW).

Antarctic Intermediate Water (AAIW), a major northward-spreading water mass, occurs immediately below surface water masses at depths of ~600–1450 m (Fig. 8). AAIW, is characterised by salinities of 34.3–34.5‰ and temperatures of 3–7°C. AAIW in this location is strongly influenced by bathymetry, with those waters bathing the southern sector of the New Zealand region being sourced from the south and taking the shortest route from the Antarctic Convergence. However, AAIW in the north enters the region from the western South Pacific Ocean via the Coral and Tasman Seas, before extending around the northern tip of New Zealand (Tomczak and Godfrey, 1994). This northern-sourced AAIW is distinguished on the basis of a slightly higher salinity minimum (Stanton 2002). Subantarctic mode water often considered a component of AAIW, lies north of the Subantarctic Front at depths of ~300–700 m as an isothermal subsurface layer (Fig. 8).

Circumpolar Deep Water (CPDW), underlying AAIW down to the seafloor in this region, comprises two layers (Fig. 8). Water from 1450-2500 m in the south (Carter and McCave, 1997), deepening to 2900 m (McCave & Carter 1997), is considered to be upper CPDW (uCPDW). It has temperatures of 1.8–3.0°C, salinities of 34.5–34.7‰ and includes an oxygen minimum of 3.03–3.45 mol kg^{-1}. A variable mixing history for uCPDW includes input from North Atlantic Deep Water (NADW), Antarctic Bottom Water, and AAIW, as well as Subtropical Indian and Pacific Deep Water (Oppo *et al.* 1990). Lower CPDW (lCPDW) underlies uCPDW and occurs as a propagating tongue of highly saline (>34.7‰) water. It is the primary deep water mass west of New Zealand and of the Deep Western Boundary Current (DWBC) east of New Zealand and comprises two distinct zones (Carter & McCave 1994). Water that contains a distinct salinity maximum, deepening northwards and includes a significant component of NADW extends from ~2500–2900 m to 3800 m. Below 3800 m is colder, lower-salinity water mixed from NADW and Antarctic deep waters from the Weddell and Ross Seas. These deep waters are present east of New Zealand but do not flow directly into the east Tasman Sea (Martinez 1994).

CURRENTS

Major surface currents off New Zealand (Fig. 5) originate from two arms of the east-flowing Tasman Inflow. This inflow is sourced from the South Pacific western boundary current, which flows down the coast of Australia, before separating from the Australian landmass at c. 31-32°S (Ridgway & Dunn 2003). The bulk of the flow crosses the Tasman Sea as the Tasman Inflow (Stanton 1981, Ridgway & Dunn 2003), before bifurcating around New Zealand as the West Auckland (WAUC) and East Auckland (EAUC) currents (Fig. 5). These bring in STW with the former flowing down the west side of northern New Zealand and the latter down the east. The warm EAUC flows south-east around East Cape (Heath 1985), where it is called the East Cape Current (ECC), then south down to Cook Strait (Fig. 5) where it is deflected eastwards along the STF. Associated with this current system is the semi-permanent Wairarapa Eddy.

The water south of the Tasman Inflow, east of the influence of the East Australian Current and north of the Subtropical Front is thought to be relatively quiescent.

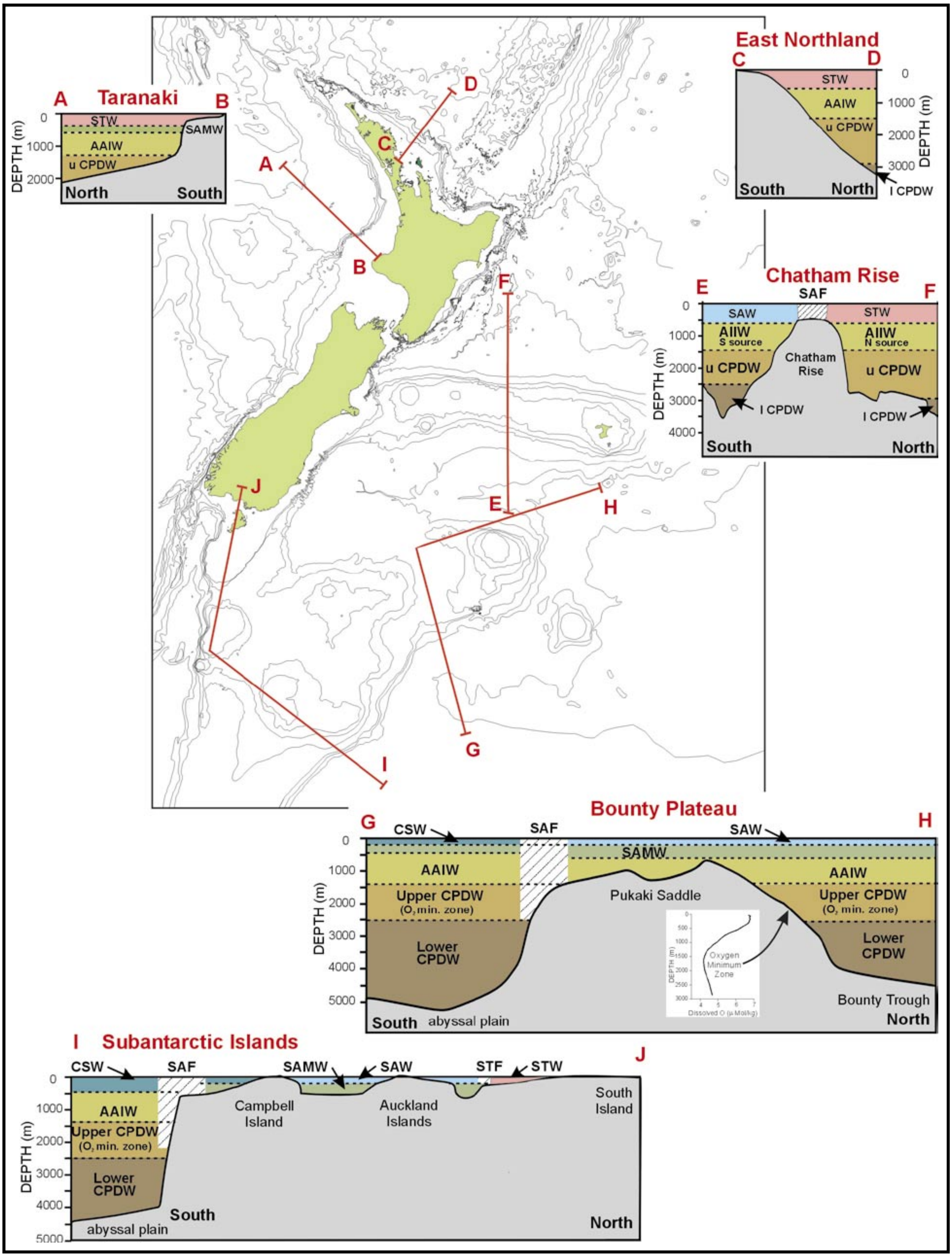


Figure 8. Cross-sections of the ocean around New Zealand showing the distribution of water masses and the surface fronts. AAIW – Antarctic Intermediate Water, CSW = Circumpolar Surface Water, CPDW = Circumpolar Deep Water, SAF = Subantarctic Front, SAMW = Subantarctic Mode Water, SAW = Subantarctic Surface Water, STF = Subtropical Front, STW = Subtropical Surface Water.

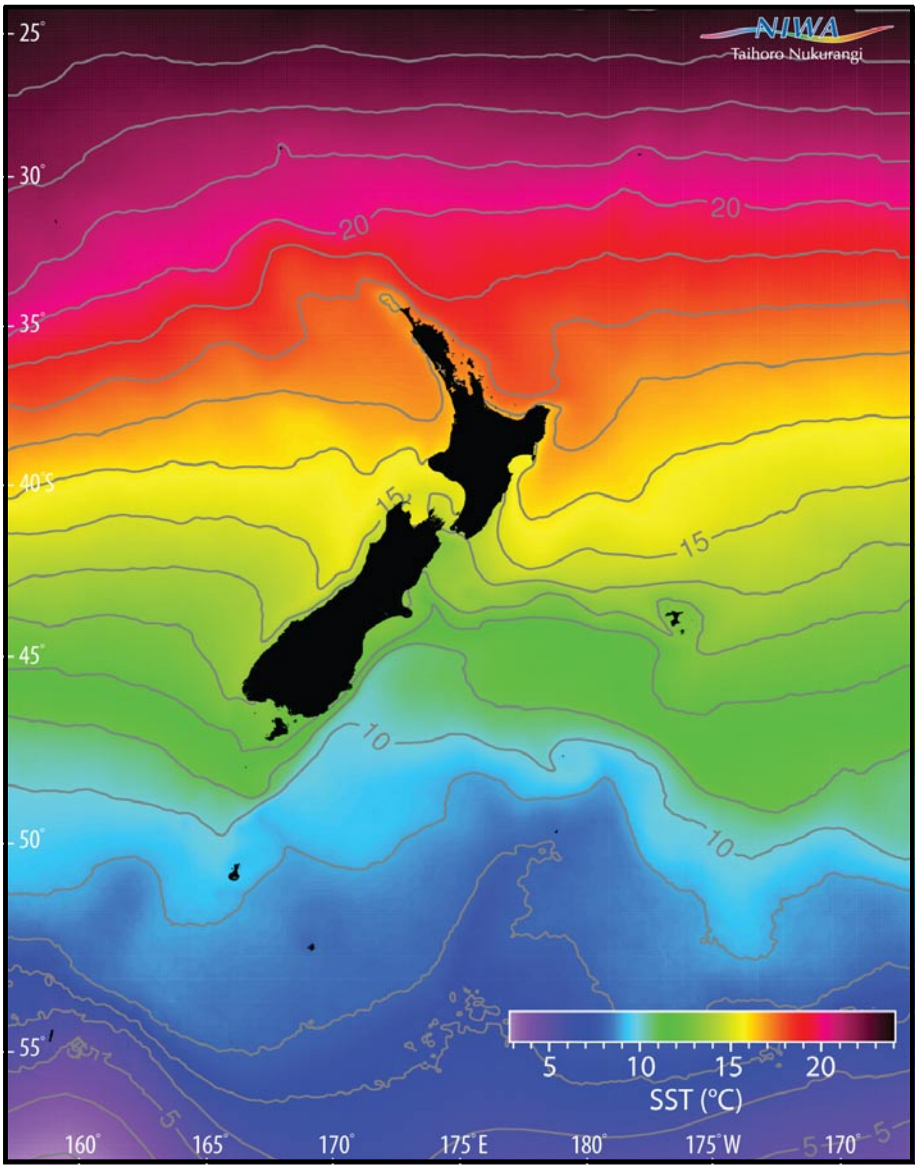


Figure 9. Contoured map of mean annual sea-surface temperature around New Zealand (from NIWA). Annual mean SST was estimated from an harmonic analysis of monthly composite data from the NIWA SST Archive (Uddstrom & Oien 1999). The analysis results in a high-resolution (9 km) data set showing a coherent relationship between the SST patterns and underlying oceanographic features (Hadfield et al. 2007,Uddstrom & Oien 1999). For the present work the analysis period covered the years 1993–2002. Because the NIWA climatology does not cover the entire analysis area, a similar climatology was also calculated from the CMB global 1° × 1° SST dataset (Reynolds et al. 2002), also for the years 1993–2002. The two climatologies were interpolated onto a common 4 km grid and then blended using a function that introduced CMB data south of 55° S. (Prepared with the help of Mark Hadfield, NIWA).

Warm saline STW flows north along the western margin of South Island as the West Coast Current (WC) meeting D'Urville Current (DC) in the western reaches of Cook Strait (Fig. 5). Warm STW also flows south along the west coast of the southern South Island becoming the Southland Current that flows around southern New Zealand, and then swings northwards along the east coast of the South Island (Fig. 5) mixing with cooler Subantarctic water across the Southland Front (Heath, 1972). Part of the Southland Current (SC) crosses Chatham Rise over the Mernoo Saddle, while a second component turns east along the southern flank of Chatham Rise and STF, resulting in cool SAW veering east as it meets Chatham Rise.

All indications are that the eastern Tasman region overlying Challenger Plateau is not very energetic (Sutton *et al.* 2005). Hence, the main inflow of deep water into the Pacific Ocean is via the DWBC that extends around the eastern plateau–rise complex of New Zealand. The path of this deep flow, with a volume of $\sim 16 \pm 12 \times 10^6$ m^3 s^1 and velocities of ~9 cm s^1 (Whitworth *et al.* 1999), is constrained by bathymetry. Hence, the current path passes along the eastern margin of Campbell and Bounty Plateaux to enter the Bounty Trough and pass over the Bounty Fan. The current then passes around the eastern end of Chatham Rise and along the edge of the Hikurangi Plateau before extending into the Kermadec Trench.

FOOD SUPPLY/PRODUCTIVITY AND ORGANIC MATTER FLUXES

Ocean surface productivity and the resultant particulate export from surface waters is the major source of food for the benthic community. Nutrient-, temperature- and light-induced changes in the planktic community structure mediate the rate, mode and quality of organic material exported and hence the benthic response to variations in food supply and quality (e.g, Karl *et al.* 1996, Nees & Struck 1999). Heightened particulate export from surface waters to the benthic community is often associated with oceanic fronts (Yoder *et al.* 1994), such as the STF that bisects this study region. Chlorophyll in the oceans about New Zealand is generally highest in the Subtropical Frontal region where subtropical and subantarctic waters mix (Figs 5, 10). The hydrographic zonality of the STF influences biological processes in the vicinity of Chatham Rise with the position of the STF influencing the distribution and abundance of many floral and faunal groups (e.g., macrobenthic organisms, Probert & McKnight 1993).

The STF is characterised by higher levels of primary production relative to its attendant water masses (Bradford-Grieve *et al.* 1997). Marked seasonality is exhibited in the Chatham Rise region with long-term sediment trap deployments reporting episodic export of particulate material (Nodder and Northcote, 2001). Annual particulate organic carbon fluxes at 1000 m water depth of 7.5 g m^{-2} yr^{1} on north Chatham Rise, as opposed to 1.8 g m^{-2} yr^{1} on the southern flank (Nodder & Northcote 2001), suggest there is pronounced spatial difference in particulate flux across this region. These flux rates are considered moderately low in comparison to global rates. The export of particulate material to the north of Chatham Rise occurs as a solitary spring sedimentation event, with persistent spring export over 3 months taking place in the south (Nodder & Northcote 2001). Hence, high benthic biomass south of Chatham Rise reflect high energy, labile food sources in sinking particulate matter which are able to support a larger and more diverse community compared to the northern flank of Chatham Rise (Probert & McKnight 1993).

Production within the oligotrophic northern Subtropical and Tasman Sea waters (STW) is generally co-limited by nitrate and light, with cycles of spring blooms. Over and south-west of the Challenger Plateau, although based on scant data, surface chlorophyll-a, primary productivity, and integrated primary productivity concentrations appear to be low. The analysis of satellite chlorophyll data by Behrenfeld & Falkowski (1997) and Murphy *et al.* (2001) suggest this area of the Tasman Sea has only a low annual and a moderate seasonal phytoplankton primary production rate. Off the north-east coast of New Zealand the EAUC and ECC have nutrient and biological

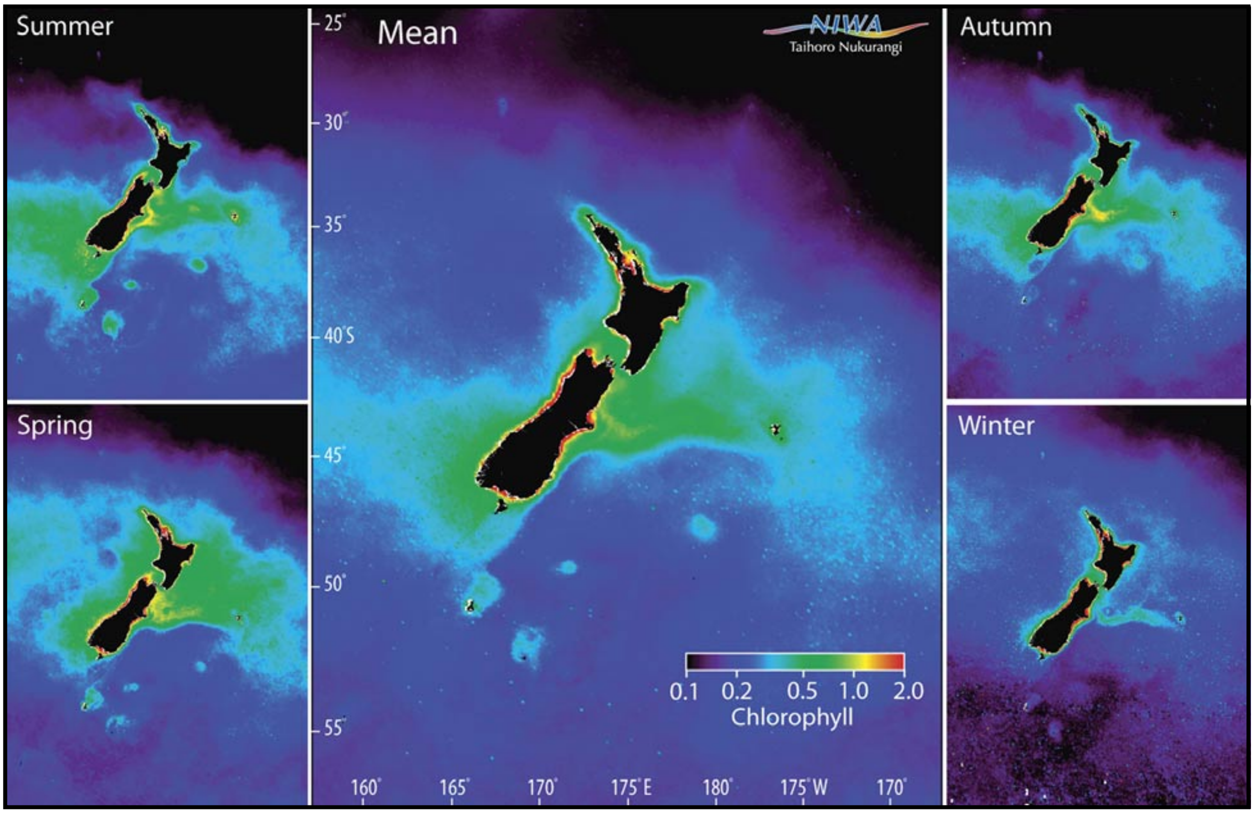


Figure 10. Contoured map of mean annual and seasonal surface water chlorophyll-a values (μ mol/l) around New Zealand. These are the mean values for each reading over a year or a 3 monthly season and not the mean total values for one year or one season. Surface chlorophyll concentration was taken from the SeaWiFS, Level 3, mapped monthly climatology (Thomas & Franz 2005), plotted on its original 9 km grid. The results shown here are based on data from September 1997 to December 2007. (Prepared by Mark Hadfield, NIWA).

importance. A series of persistent eddies along this coast are frequently regions of low chlorophyll concentration often associated with lower biomass. Slightly elevated biomass occurs at the edge of eddies, the boundaries of which are also often marked by a region of enhanced chlorophyll accumulation or production (Bradford 1980, Murphy *et al.* 2001). In addition the current shoals near the coast and this, combined with the prevailing winds which favor upwelling, can result in high, near-surface nutrient levels at the shelf edge (Sutton & Roemmich 2001).

Subantarctic waters (SAW) have low chlorophyll abundance and a low annual cycle of chlorophyll often displaying a patchy nature for chlorophyll distribution in surface waters (Murphy *et al.* 2001) (Fig. 10). Therefore, primary production is relatively low, due to a co-limitation of light and iron during winter and early spring, and a co-limitation of iron and silicate during late spring and summer (e.g., Boyd *et al.* 1999). Marked seasonality is therefore exhibited, with total planktic community biomass (as carbon) being twice as great in spring than early winter in SAW (Bradford-Grieve *et al.* 1999), with persistent spring export occurring over 3 months in the Bounty Trough area (Nodder & Northcote 2001). Total mean annual chlorophyll-a in surface waters (Fig. 10) shows a peak in the STW over the Stewart Island shelf, south of New Zealand, and in the vicinity of the STF which flows around the edge of the continental shelf of Stewart Island. Over the entire subantarctic area there is a progressive decrease in concentrations from north-west to south-east with higher surface productivity indicated over the Bounty Trough and northern parts of the Campbell and Bounty plateaux and lowest associated with, and south-east of, the SAF.

In this study we use chlorophyll-a concentrations taken from satellite images (Fig. 10) as a proxy for primary productivity and phosphate concentrations (Fig. 11) as a proxy for nutrients.

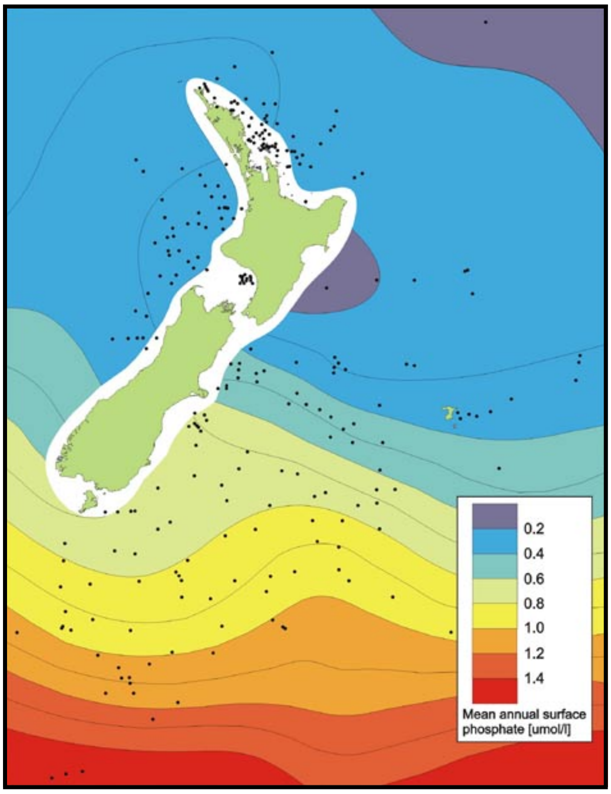


Figure 11. Contoured map of surface phosphate concentration, P, around New Zealand (from Garcia *et al.* 2006).

ECOLOGIC DISTRIBUTION

METHODS

Field and laboratory

The hand-hauled bucket dredge used by the authors to take the 15 samples from the Hauraki Gulf and around Great Barrier Island usually penetrates 7-10 cm into the seafloor sediment. The NIWA-sourced samples were taken from the top few centimetres of gravity and piston cores or from surficial grab or dredge samples. Consequently these samples generally come from the upper 10 cm of bioturbated, often oxidised top layer of sediment, where the composition of the benthic foraminiferal fauna was still being modified by variations in the production and taphonomic loss of different infaunal species (e.g., Denne & Sen Gupta 1989), over time scales of decades to centuries, depending on sedimentation rates. There was no opportunity to distinguish living from dead shells. Thus these assemblages of dominantly dead foraminiferal tests cannot be directly compared with assemblages identified elsewhere using only live specimens obtained from box core samples. Following their death, deep-sea foraminiferal tests may be dissolved away by preferential carbonate dissolution of smaller or thinner-walled specimens and the tests of some agglutinated taxa disaggregate and disappear (Schmiedl *et al.* 1997, Hayward *et al.* 2002), thereby potentially changing the live assemblage composition considerably. Additionally, the composition of a live fauna reflects environmental and seasonal conditions at the time of collection, whereas our dead samples from the upper 10 cm of seafloor sediment are time-averaged over a period of tens to hundreds of years.

Sediment samples were dried and weighed, then washed gently over a 63 µm sieve to remove the mud. The sand residue was dried and weighed. In samples with abundant terrigenous sand, foraminiferal tests (dead plus live) were concentrated from the dried sand fraction (<2 mm to >0.063 mm) by flotation with a sodium polytungstate solution with a specific gravity of 1.59. The float or terrigenous-poor sand samples were each microsplit down to an amount containing approximately 200 benthic specimens. All benthic foraminifera were picked from the microsplit, mounted on faunal slides, identified and counted (Appendix III). All taxa were identified to species level, except unilocular forms which were identified to generic level. Specimens of planktic foraminifera were also counted during picking to estimate planktic percentage of the foraminifera. Absolute abundance of benthic foraminifera was determined by calculating the number of specimens per g of dry bulk sediment. Our studies clearly show that 200 specimens provide a sufficiently accurate assessment of faunal composition for use in identifying and mapping associations as the computer programmes employed are primarily influenced by the numerically dominant taxa in each fauna.

A complete qualitative pick was made of selected samples representative of different depths and regions. These were identified for inclusion in the biogeographic analyses but were not used in the quantitative ecologic studies.

Samples included in quantitative analyses

For the quantitative analyses of the New Zealand's deep-sea benthic foraminifera and their ecologic distribution, we used all the foraminiferal faunas (>63um) from water depths deeper than 50m, that the authors had quantitatively picked and identified consistently and counted ourselves (Table 2, Appendix I). These comprised all the samples from previously published regional studies from east of central New Zealand (Hayward *et al.* 2001, 2002), west of central New Zealand (Hayward *et al.* 2003), north-east of the North Island (Hayward *et al.* 2006c) and south-east of the South and Stewart Islands (Hayward *et al.* 2007b). These were supplemented by samples from deeper than 50 m in previous studies from the Wanganui Bight (Hayward *et al.* 1997a), around Great Barrier Island (Hayward & Grenfell 1994) and the Chickens Islands (Hayward *et al.*

Table 2. Source of quantitative foraminiferal samples used in the quantitative analysis of deep-sea benthic foraminifera around New Zealand.

Region	No of samples	Stn Nos	GNS & AK Cat. Nos	Source of samples	Published results
North-east NZ	56	N1-N56	F202454-509	NIWA, AU	Hayward *et al*., 2006
West central NZ	34	W1-W39	F202415-53	NIWA	Hayward *et al*., 2003
East central NZ	61	E1-E66	F202351-410	NIWA, ODP	Hayward *et al*., 2001, 2002
Southern NZ	68	S1-S68	F202510-77	NIWA	Hayward *et al*., 2007
Wanganui Bight	13	W40-W53	L13014-30	NIWA	Hayward *et al*., 1997
Great Barrier	9	N57-N65	F201857-2061	GNS, AKMus	Hayward & Grenfell, 1994
Chickens Is	3	N66-N68	F201921-3	GNS	Hayward *et al*., 1984
Hauraki Gulf	5	N69-N72,N76	F202632, AU	NIWA,AU	unpublished
West South I.	12	W54-W65	F202620-31	NIWA	unpublished
East North I.	2	E67-68	F202615-6	Roger Revelle cruise	unpublished
East North I.	3	N73-N75	F202617-9	Marion Dufresne cruise	unpublished
Total	264				

1984); plus additional samples from the marine sediment stores of NIWA (numerous alphabetic prefixes), the Geology Dept of the University of Auckland (AU), and the Marine Dept of Auckland War Memorial Museum (L); and several samples from a 2005 research cruise of the Roger Revelle (RR) and a 2006 research cruise of the MV Marion Dufresne (MD). Most picked faunas are housed in the national fossil collections of GNS Science, Lower Hutt (prefix F200…).

Statistical analyses

A combination of cluster analysis and detrended correspondence analysis (DECORANA) was used in each of the four regional study areas to group the samples into faunal associations and examine their interrelationships, and similar techniques were used on the total data set.

CLUSTER ANALYSIS: The faunal data set consists of census counts of 424 foraminiferal species in a set of 264 samples. This data matrix was standardised by converting counts to proportions of sample totals (= relative abundances). Unweighted pair group Q-mode cluster analysis using arithmetic averages of a Chord distance matrix was used to produce dendrogram classifications from which sample associations were selected based on whether their geographic distribution was mappable and useful. Similar R-mode cluster analysis of a distance matrix produced using Pearson's similarity coefficient was used to produce a dendrogram classifications of the abundant species from which species associations were selected. We also generated a dendrogram classification of faunal samples using unweighted pair group Q-mode cluster analysis of a Jaccard similarity coefficient matrix which just uses presence/absence information on species occurrence. Mathematical definitions of the Chord, Jaccard and Pearson coefficients are given in Sneath & Sokal (1973) and Rohlf (1989). The Pearson index downweights the more abundant species and produces a more realistic clustering of species that commonly occur together. Cluster analyses were computed using the "MVSP" statistical package (Kovach 1993).

CANONICAL CORRESPONDENCE ANALYSIS (DCCA): The technique of detrended correspondence analysis (DECORANA), using the program CANOCO (Ter Braak 1985), was used to summarise the total faunal data and relate it to a set of measured environmental variables (Table 3). A representation of the samples and abundant species in 4-dimensional space was produced. The coordinates of a sample in each of the 4 dimensions are weighted averages of all the species proportions and similarly the coordinates of a species in each dimension are weighted averages of all the sample proportions. These representations are plotted on the first two Decorana axes, on which we then overlayed the sample associations produced by cluster analysis.

DCCA produces vectors which show the axis and direction of increasing values of each environmental factor. The length of each vector arrow is a measure of the correlation between that factor and the faunal pattern - the longer the arrow, the stronger the correlation. Ranking of species or samples with respect to each environmental variable may be determined by projecting its plotted position perpendicularly onto the appropriate environmental arrow. The location of the cluster of arrows on any diagram does not matter since the arrows are effectively endless.

CORRELATION COEFFICIENTS: Correlation co-efficients were calculated using the software programme PAST (Hammer *et al.* 2008). Pearson's r values range from -1 to 1. Values approaching -1 indicate a strong negative correlation, while values approaching +1 indicate a strong positive correlation. No correlation is indicated by a value of 0. The significance of the correlations was assessed by using Moore and McCabe's (1993) P test. The lower the P value, the higher the likelihood that a significant or reliable relationship exists between the two variables. A P value of <0.05 equates to a 95% probability that the two values are correlated and this is the usual cut-off point for acceptable data.

Calculating species diversity

Three measures of species diversity have been calculated for individual samples using the PAST statistical package (Hammer *et al.* 2008) for each foraminiferal fauna (Appendix 1). The mean values of each species diversity measure were also calculated for each sample association. The three measures are:

1. FISHER ALPHA INDEX: $S = \alpha \ln(1 + N/\alpha)$ where N is the number of individuals in the sample and S is the number of species. This is an iterative equation and cannot be solved directly for α. An extensive table of values (Appendix IV) is given by Hayek & Buzas (1997), see also Williams (1964, fig. 125). Fisher's α is the parameter of a log series distribution and is when species proportions are distributed as a log series independent of N whereas S is dependent on N. Fisher's α is often used as a measure of diversity even when the species abundance distribution is not a log series (see, Hayek & Buzas 1997, for a discussion).

2. SHANNON INFORMATION FUNCTION: $H = -\sum p_i \ln p_i$ where p_i is the proportion of the ith species (Shannon 1948, Hayek & Buzas 1997). Unlike α, H is a distribution-free measure that gives little weight to very abundant or very rare species. When species proportions are distributed as a log series, however, it is directly proportional to α through the equation $H_{\text{log series}} = \ln\alpha + 0.577$ where 0.577 is Euler's constant.

3. EVENNESS: $E = e^H/S$ where e is the base of the natural logarithms (Buzas & Gibson 1969). This is solely a measure of species evenness irrespective of the number of species present within a fauna at a fixed N. For most species abundance distributions E like S is a function of N so care must be exercised when comparing between faunas.

SHE ANALYSIS: She analysis was calculated using excel. SHE analysis is an information-theoretic approach

Table 3. Environmental "variables" and species diversity indices that were scored for each station (Appendix I) and used in the quantitative analysis of the relationship between deep-sea benthic foraminiferal faunal patterns and environmental drivers.

1. **Latitude** (LAT) – degrees south of the equator; possible proxy for latitudinal differences in productivity;
2. **Longitude** (LONG) – degrees east of Grenwich; possible proxy for latitudinal differences in productivity;
3. **Water depth** (DEPTH) - water depth below mean sea level (in metres); proxy for numerous depth-related factors;
4. **Mud** - percentage of sediment composed of mud fraction (<63 μm); proxy for bottom current strength, distance from terrigenous sediment sources;
5. **Benthic foraminiferal absolute abundance** (ngsed) – number of benthic foraminiferal tests (>63 μm) per gram of bulk dry sediment; proxy for seafloor productivity;
6. **Planktic foraminiferal percentage** (plank) – percentage of the >63 μm foraminiferal fauna composed of planktic tests; proxy for oceanicity, surface water productivity, and carbonate dissolution at abyssal depths
7. **Fragmentation Index** (FI) - planktic foraminiferal fragmentation index (>63 μm) after Le and Shackleton (1992); proxy for carbonate dissolution at abyssal depths and high energy bottom waters at shelf or bathyal depths;
8. **Annual Chlorophyll-a** (Chl-ann) - mean annual surface chlorophyll a values (μmole/l) for 1994-2001 derived from NOAA, NODC World Ocean Atlas 2001 (NODC 2001);
9. **Spring Chlorophyll-a** (Chl-spr) - mean spring surface chlorophyll a values (μmole/l) for 1994-2001 derived from NOAA, NODC World Ocean Atlas 2001 (NODC 2001);
10. **Summer Chlorophyll-a** (Chl-sum) - mean summer surface chlorophyll a values (μmole/l) for 1994-2001 derived from NOAA, NODC World Ocean Atlas 2001 (NODC 2001);
11. **Seasonality Index** (Seas) – minimum number of months required for production of 50% of total annual chlorophyll-a at each site, derived from SeaWiFS data from Sept 1997 to Sept 2009.
12. **Organic carbon flux** (Jz**)** - proxy for organic carbon flux to the seafloor, a function of primary productivity and water depth, using the empirical relationship of Berger and Wefer (1990) and surface chlorophyll-a values (NODC 1998);
13. **Sea surface temperature** (SST) – proxy for temperature (^{o}C) -related differences in the phytoplankton and zooplankton components of the food flux to the benthic foraminifera;
14. **Bottom water temperature** (BTEMP) - bottom water temperature (^{o}C) estimated from nearby CTD profiles; possible proxy for water mass;
15. **Bottom salinity** (SAL) – bottom water salinity estimated from nearby CTD profiles; proxy for water mass;
16. **Bottom water dissolved oxygen** (O_2) – bottom water oxygen concentration estimated from nearby CTD profiles; proxy for water mass;
17. **Surface phosphate** (P) – annual phosphate concentration (μmole/l) in surface waters (from World Ocean Atlas, 2005); proxy for phytoplankton productivity;

Factors 4-7 were not measured for a few stations.

for comprehensive diversity evaluation of a community (Buzas & Hayek 1996, 2005). The methodology depends upon the decomposition equation H = lnS + lnE where H and E are defined above. Because lnS is known to be a function of lnN, so are H and lnE. The method depends on the accumulation of samples. From the species proportions in the first sample lnS, H and lnE are obtained and then the individuals of each species from the next sample are added to the first and species proportions are recalculated to again estimate lnS. H and lnE. This procedure is repeated until all samples are accumulated. For all commonly used statistical distributions a plot of lnE versus lnN is a straight line. SHE analysis when performed for biofacies or community identification (SHEBI) uses this linear relationship for the identification of biofacies. Departure from linearity indicates a new community or biofacies. Within each linear accumulation the samples are considered replicates from a single community. The canonical ensemble of values for lnN, lnS, H and lnE are displayed on a single graph called a biodiversitygram or BDG (Hayek & Buzas 2006). Because the expected value of H is known for various distributions and lnN and lnS are observed with the value of lnE fixed by the decomposition equation, SHE analysis for community structure identification (SHECSI) can determine the underlying distribution. The log series distribution is used as a null model (Buzas & Hayek 2005). For the log series the expected value of H = lnα – 0.577 where α is the parameter of the log series and 0.577 Euler's constant. Because α is a constant so is H and the accumulation of H with an increase in N plots as a straight line. Therefore, in the regression equations $\ln S = \beta_0 + \beta_1 \ln N$ and $\ln E = \beta_0 + \beta_1 \ln N$, the regression coefficient β_1 must have the same value but with opposite sign. This being so the regression equation $\ln S = \beta_0 + \beta_1 \ln E$ must have $\beta_1 = -1.00$. In this is the situation, the regression $\ln S = \beta_0 + \beta_1 \ln E$ is equivalent to the decomposition equation where $\beta_0 = H$ and $\beta_1 = -1$. In addition to a visual interpretation of the BDG, the subtraction of the β's from a log series and the observed values gives a quantitative evaluation of how close the observations are to a log series.

Calculating fragmentation Index

To determine the planktic foraminiferal fragmentation index (FI), a microsplit of the sand residue (>63 µm) in each sample was examined and the numbers of whole (4 or more chambers together) and fragmented planktic foraminiferal tests were counted. FI was calculated using the formula of Le and Shackleton (1992), where each planktic foraminiferal test is assumed to fragment into eight pieces during dissolution.

Calculating organic carbon flux (Jz)

For our environmental analyses we calculated Jz, a proxy for organic carbon flux to the seafloor, a function of primary productivity and water depth, using the empirical relationship of Berger & Wefer (1990) modified from Suess (1980), and surface chlorophyll-a values (NODC 1998). This is only useful at depths >100 m.

Calculating seasonality of organic carbon flux (Seas)

For our environmental analyses we calculated a proxy for how seasonal or sustained is the primary production above our sites. Our seasonality index (Seas) is a simplified modification of that proposed by Berger & Wefer (1990) and used by Corliss *et al.* (2009). This index is not derived from differences or variation in the magnitude of production, as used by Lutz e*t al.* (2007), but on the time course of production. Our seasonality index attempts to quantify the intermittency at which primary production was generated over the course of a year above each site, where:

Seas = 1 - (minimum number of months required to produce half the annual chlorophyll concentrations/6).

Values range between 0 and 1, with a high degree of seasonality having a higher value than a low degree of seasonality. Our calculations are based on monthly means of SeaWiFS-derived chlorophyll concentrations for the period Sept 1997-Sept 2009 using 0.5 degree resolution.

RELATIVE ABUNDANCE OF PLANKTIC FORAMINIFERA

The percentage relative abundance of planktic forms in the seafloor foraminiferal faunas off New Zealand (Figs 12-13) displays the usual pattern of increase with increasing depth (e.g., Gibson 1989, Hayward *et al.* 1999, van der Zwaan *et al.* 1999). In our data, planktic % and depth have a relatively strong positive correlation (r = 0.57, Table 4). This pattern is usually explained as being related to increasing oceanicity of the surface waters moving away from the neritic influences of major landmasses (e.g., Bé 1977, Hayward *et al.* 1999), as most planktic foraminifera live in the upper 600 m of clear oceanic water and do not thrive in turbid, nearshore, neritic water (Bé 1977). Thus there is usually a general trend of increasing relative abundance of planktic foraminifera moving away from land, and this usually corresponds with increasing water depth (Gibson 1989).

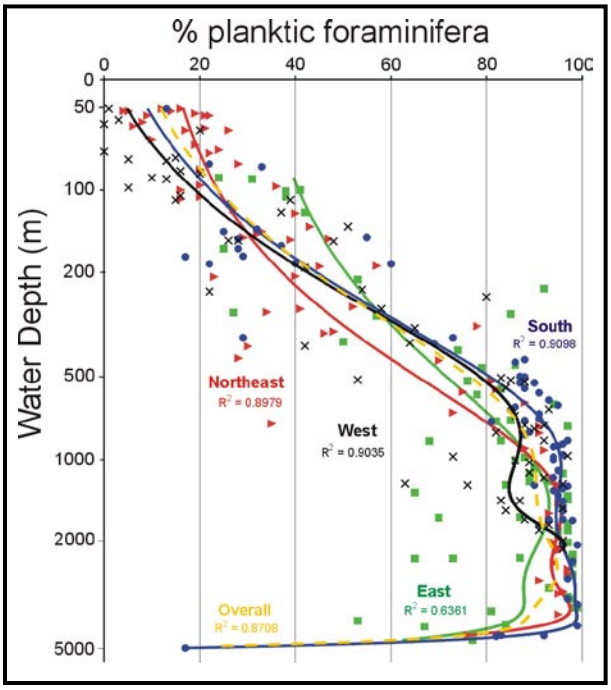


Figure 12. The relative abundance of planktic foraminifera (>63 µm) plotted against depth (on a logarithmic scale) in four regions around New Zealand. Polynomial trend lines for each region and overall were generated using Excel and R^2 values gives a measure of goodness of fit.

At mid shelf depths (50-100 m) around New Zealand, planktics comprise 0-36% of the foraminifera (Fig. 12). At outer shelf depths (100-200 m) the range increases to 15-60% of the foraminifera, mostly within 20-50%. At upper bathyal depths (200-600 m) the relative abundance of planktics increases to 22-92% and at mid bathyal (600-1000 m) to 35-97%. At lower bathyal to mid abyssal depths (1000-4000 m) planktics comprise 63-99% of the foraminifera. Below 4000 m, the effects of carbonate dissolution start to kick in (Weaver *et al.* 1997, Hayward *et al.* 2002), with the relative abundance mostly within the range 50-92% with outliers at 99% (S64, 4138 m) and 17% in the deepest site (S68, 5000 m).

The trend lines for each of the four regions are remarkably similar (Fig. 12) with the overall trend line indicating an average increase from 12% at 50m through 22% at 100 m and 45% at 200 m, reaching 90% by 1000 m. Ninety percent of shelf faunas (<200 m) have less than 50% planktics, and 90% of mid bathyal-mid abyssal faunas (600-4000 m) have more than 90% planktics. In between, the upper bathyal (200-600 m) has the widest spread of planktic percentages. This may reflect the variable impact of oceanic water on the upper slope due to different widths of the shelf, and possibly some downslope transport of benthic-rich faunas.

The percentage-depth plot (Fig. 12) shows that many faunas at mid shelf depths off the west coast of New Zealand have much lower relative abundances than the

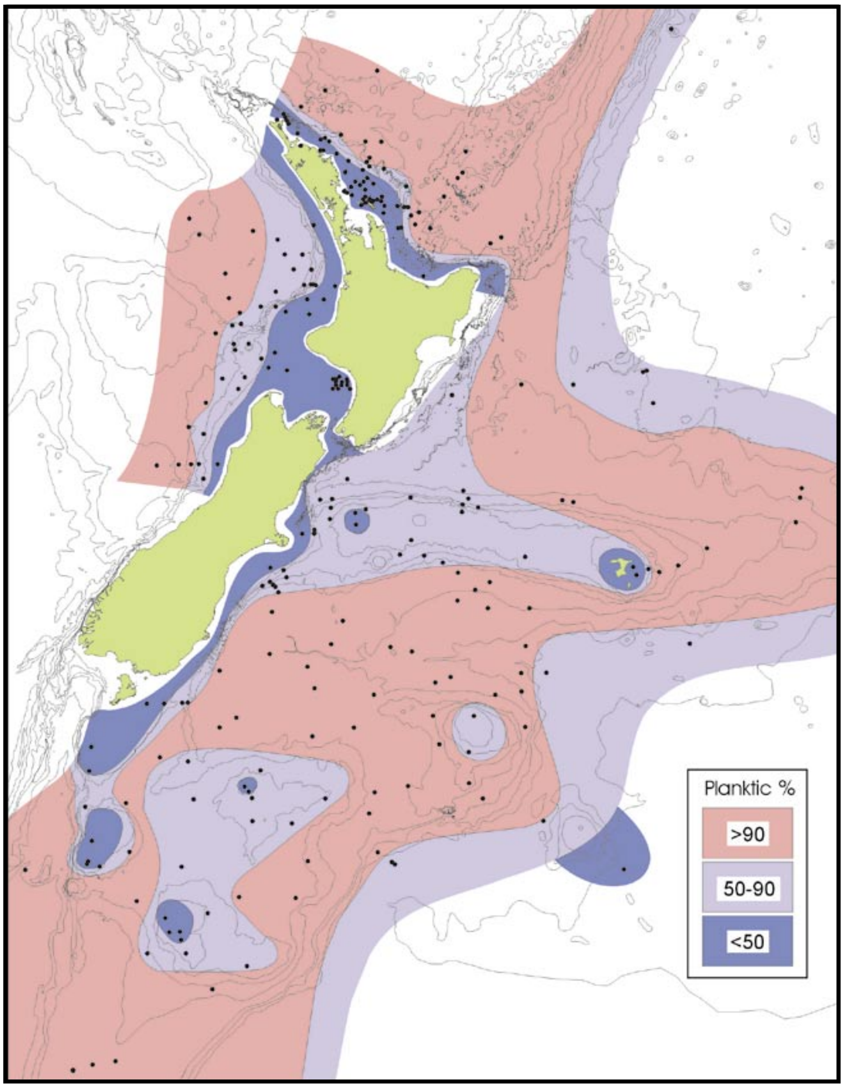


Figure 13. Contoured map of the relative abundance of planktic forms as a percentage of total foraminifera faunas (>63 μm) in the seafloor sediment around New Zealand, deeper than 50 m.

country-wide mean. Most of these low values (0-20%) occur in the more sheltered and enclosed Wanganui Bight (Fig. 13), where oceanic water seldom reaches. The plot also shows a greater proportion of mid shelf faunas east of northern New Zealand with more abundant planktics (>20%) than usual. This probably reflects the more frequent incursions of oceanic water across the shelf in this region emanating from the strong East Auckland Current (Fig. 5). At outer shelf depths, the percentage-depth plot (Fig. 12) shows six southern stations with planktic foraminiferal abundances significantly lower than the country-wide trend line. These occur around Auckland and Campbell Islands and on the continental shelf off Stewart Island and may reflect strong currents sweeping away suspended and recently settled planktic tests. Some support for this inference might be derived from the relatively strong positive correlation between planktic % and mud % (r = 0.50, Table 4).

At mid-upper bathyal depths the trend line for the north-east region is lower than the others (Fig. 12) because of a group of stations north of 35˚ 30’S with lower than normal planktic abundances. The reason is not clear but could be a result of the narrower shelf width and higher current speeds, which might be winnowing some of the planktic rain and bedload, as reflected in the sandier and more gravelly sediment. Five samples at mid bathyal-upper abyssal depths east of New Zealand have much lower abundances of planktic foraminifera than usually expected (Figs 12-13). The reasons here may be due to downslope transport or unusually elevated levels of dissolution at these depths.

Our studies east of central and southern New Zealand debunk the hypothesis that planktic percentage is more strongly correlated with distance from the mainland coast (i.e. oceanicity) rather than depth (Gibson 1989). The Chatham Islands and subantarctic seamounts, 500-800 km offshore, have the same depth-related trends as recorded adjacent to the main islands. Thus at mid-outer shelf depths (50-200 m) on the crests of the four major subantarctic seamounts and around the Chathams (Fig. 13), planktic forms comprise 13-60% of the foraminiferal faunas, similar to the values off the North and South Islands. There is no neritic water around these outlying island groups, so the depth-related increase in planktic percentage needs additional explanation. There are several possibilities, all of which may be involved. The first is that planktic foraminifera live at depths ranging from the surface down to 600 m and thus only stations deeper than this are likely to be receiving the full rain of dead foraminiferal tests falling out of suspension to the sea floor. Secondly, strong currents sweeping around these outlying seamounts could be winnowing some of the planktic rain and bedload resulting in lower abundances of planktics relative to the benthics, many of which are infaunal and less likely to be winnowed out of the sediment. Thirdly, benthic foraminiferal productivity may be considerably higher at shelf and upper bathyal depths as a result of the much higher organic carbon flux (Jz) and this would also lower the relative abundance of planktics around the seamounts.

The weak positive correlation between planktic % and latitude and sea surface temperature (r = 0.29 and 0.19, Table 4) is probably mostly driven by the greater number of shallow water stations in this study in the north than the south. Close examination of the trend lines on the plot (Fig. 12) however does suggest that mid bathyal and deeper faunas off southern New Zealand do have slightly higher relative abundances of planktic foraminifera than those at similar depths further north.

Table 4. Correlation coefficients between environmental proxies and relative abundance of deep-sea benthic foraminifera that characterise the species associations recognised from around New Zealand (Table 12). Only correlation coefficients that have more than 95% confidence of statistical correlation (P test, Moore and McCabe 1993) are printed.

	Lat	Depth	Long	ngsed	Mud	Plank	FI	Chl -ann	Chl -spr	Chl -sum	Seas	Jz	SST	Bot temp	Sal	O_2	P
Depth	0.14																
Longitude	-0.22	**0.45**															
Benthics flux ngsed	-0.12	-0.38	-0.16														
% mud	-0.36	**0.44**	0.20	-0.21													
% planktics	0.29	**0.56**	0.16	-0.23	**0.47**												
Fragmentation Index		0.24	0.33			-0.33											
Chl-ann	-0.27	**-0.36**			-0.16	**-0.54**	0.30										
Chl-spr	**-0.47**	**-0.38**				**-0.58**	0.21	**0.88**									
Chl-sum		**-0.44**			-0.39	**-0.60**	0.28	**0.65**	**0.69**								
Seasonality Index	0.28		0.12			0.16		-0.18	-0.24	-0.24							
Jz	-0.17	-0.21			-0.13	-0.36	0.17	**0.89**	**0.73**	0.37							
SST	**-0.99**	-0.14	0.19	0.13	0.37	-0.30		0.26	0.49		0.29	0.18					
Bottom temperature	**-0.42**	**-0.75**	-0.15	**0.40**	**-0.50**	**-0.82**	0.14	**0.57**	**0.68**	**0.64**	0.14	0.38	**0.43**				
Salinity	**-0.52**	-0.38	0.12	0.13	-0.23	**-0.71**	0.34	**0.54**	**0.66**	**0.56**	0.13	0.37	**0.52**	**0.85**			
Oxygen	**0.48**	-0.32		0.23	**-0.61**	-0.33	0.24	0.18		**0.46**			**-0.49**	0.33			
Phosphate	**0.91**	0.13	-0.34		-0.42	0.26		-0.29	-0.47		-0.24	-0.14	**-0.91**	-0.35	**-0.46**	**0.51**	
Alpha	**-0.54**		0.27		0.13			0.13	0.23			0.12	**0.54**	0.16	0.31	-0.24	**-0.45**
H	**-0.57**		0.16		0.23			0.17	0.30			0.15	**0.58**	0.29	0.37	-0.30	**-0.50**
E	**-0.44**	-0.17			0.23	-0.15		0.18	0.30			0.15	**0.45**	0.30	0.32	-0.23	**-0.41**
Species association 1		**0.61**	0.17	-0.22		0.18	0.34	-0.15	-0.19	-0.18			-0.17	-0.33			0.25
Globocassidulina subglobosa		**0.60**	0.18	-0.25		0.34	0.13	-0.18	-0.22	-0.19				-0.39	-0.13	-0.18	0.15
Fissurina spp.	0.19	0.21			-0.14						0.17		-0.19				0.27
Species association 2	0.38	-0.13	-0.14		**-0.53**			-0.10	-0.18				-0.38			0.25	**0.44**
Trifarina angulosa	0.32	-0.22	-0.14		**-0.55**				-0.13	0.13			-0.32			0.35	0.34
Species association 3	-0.24	0.35	0.14	-0.30	**0.55**	0.39		-0.18		-0.34		-0.16	0.25	-0.39	-0.28	**-0.52**	-0.31
Uvigerina peregrina sl	-0.15	0.39	0.24	-0.25	0.38	0.31		-0.16		-0.24	0.12	-0.12	0.15	-0.35	-0.20	-0.38	-0.21
Gyroidina danvillensis	-0.19		0.19		0.38	0.17	0.23					-0.12	0.18			-0.17	-0.25
Species association 4		**0.63**	0.33	-0.35	**0.50**	**0.54**		-0.27	-0.29	-0.33		-0.18	-0.14	**-0.63**	-0.35	**-0.40**	
Epistominella exigua	0.15	**0.63**	0.32	-0.27	0.34	**0.43**		-0.25	-0.31	-0.28		-0.13	-0.19	**-0.52**	-0.24	-0.20	
Bulimina marginata f. *aculeata*		0.22		-0.24	0.32	**0.44**	-0.13	-0.20	-0.20	-0.28	0.25	-0.14		**-0.43**	-0.34	**-0.41**	
Cassidulina reniforme		0.18		-0.15	0.28									-0.18		-0.24	-0.13
Species association 5	0.12	0.27			**0.54**	**0.63**	-0.16	-0.27	-0.27	-0.33		-0.21	-0.12	**-0.51**	**-0.51**	-0.26	
Alabaminella weddellensis		**0.42**	0.18		**0.56**	**0.58**		-0.30	-0.28	-0.38		-0.20		**-0.50**	-0.39	-0.31	
Abditodentrix pseudothalmanni					0.31	0.38		-0.14	-0.15	-0.16		-0.13		-0.33	-0.36	-0.17	
Trifarina occidentalis	0.23				0.17	**0.44**	-0.16	-0.18	-0.20	-0.19	-0.25	-0.14	-0.23	-0.26	**-0.46**		0.17
Species association 6	-0.21	**-0.42**	-0.14		**-0.58**	**-0.62**	0.17	**0.40**	**0.41**	**0.42**		0.33	0.21	**0.64**	**0.58**	0.23	-0.14
Cibicides dispars s.l.		-0.29	-0.23		**-0.56**	-0.27								0.32	0.26	0.22	
Spiroplectinella proxispira	-0.25	-0.30			-0.32	-0.57	0.17	0.37	0.42	0.38		0.28	0.24	**0.50**	**0.49**		-0.22
Species association 7	-0.22	**-0.65**	-0.26	**0.42**	-0.36	**-0.58**		0.31	**0.40**	0.32		0.23	0.25	**0.72**	**0.52**	0.28	-0.17
Gavelinopsis praegeri	0.15	**-0.50**	-0.28	0.37	**-0.44**	-0.39		0.17	0.16	0.23	-0.12	0.18	-0.13	**0.46**	0.21	**0.51**	0.20
Bulimina marginata f. *marginata*		**-0.46**			-0.13	**-0.48**		**0.41**	**0.54**	**0.40**		0.30	0.28	**0.61**	0.54		-0.26
Discorbinella bertheloti	**-0.46**	**-0.47**		0.46	-0.26	**-0.61**		**0.40**	**0.51**	0.30		0.32	0.46	0.72	0.68		-0.38
Globocassidulina canalisuturata		-0.20	-0.26	0.18	-0.35		-0.14									0.27	0.23
Bolivina robusta		-0.19		0.25	-0.17												
Species association 8		-0.42	-0.26	0.35	-0.39	-0.26				0.19			-0.15	0.17		0.34	
Cassidulina carinata	0.12	**-0.42**	-0.26	0.35	**-0.40**	-0.28				0.20			-0.14	0.18		0.34	

PLANKTIC FORAMINIFERAL FRAGMENTATION INDEX

The planktic foraminiferal fragmentation index (FI) is one of the most commonly used methods for assessing carbonate dissolution of seafloor sediment (e.g., Berger 1968, Le & Shackleton 1992, Martinez 1994). Seafloor carbonate dissolution is believed to be largely controlled by a combination of the degree of $CaCO_3$ saturation of the bottom waters and seafloor sediment pH as influenced by the abundance of organic carbon content (Martinez 1994, Wiener *et al.* 1997). Oxidation reactions with organic carbon in seafloor sediment releases CO_2, which results in increased carbonate dissolution (Emerson & Bender 1981), which is independent of water depth. It is also influenced by factors such as sedimentation rate (speed of burial of carbonate particles) and presence of bottom currents that stir corrosive solutions around sedimented carbonate particles (Le & Shackleton 1992).

The depth at which carbonate saturated waters begin to become undersaturated is close to the foraminiferal lysocline (defined as the depth which separates well-preserved from poorly-preserved planktic foraminiferal assemblages, Berger 1968). The calcium carbonate compensation depth (CCD) is the depth below which carbonate dissolution exceeds carbonate input resulting in carbonate-free sediment (Bramlette 1961). The depth of the CCD east of New Zealand has previously been determined as c.4750 m (McCave & Carter 1997), slightly shallower than our deepest carbonate-bearing sample (S68, 5000 m).

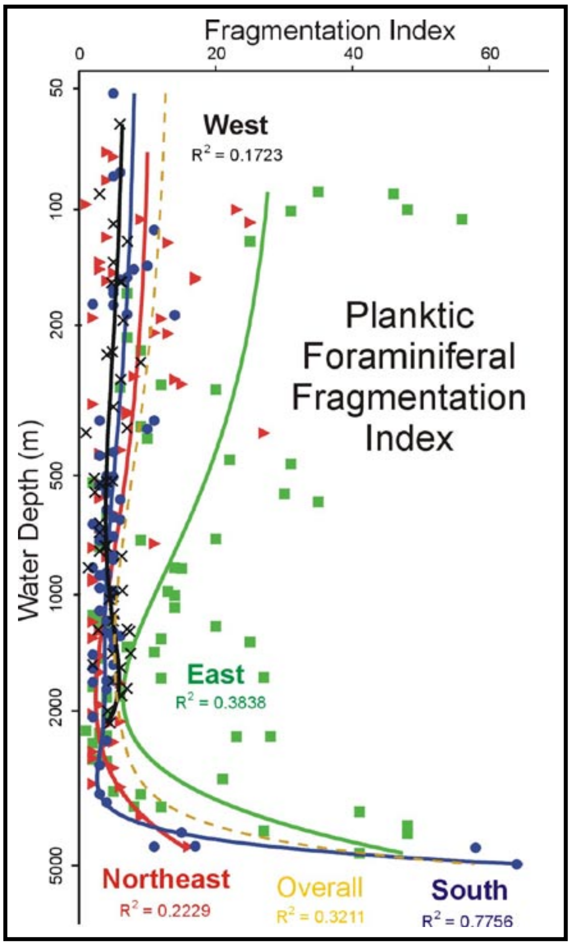


Figure 14. The planktic foraminiferal (>63 µm) Fragmentation Index plotted against depth (on a logarithmic scale) for the New Zealand region. Polynomial trend lines for each region and overall were generated using Excel and R^2 values gives a measure of goodness of fit.

Thus, dissolution of carbonate is a proxy representing two mixed signals: carbonate saturation (in deep water) and total organic carbon within the sediment. A variety of methods have been suggested for estimating carbonate dissolution in seafloor sediment (Thunnell 1976, Berger 1970) - planktic foraminiferal percent, calcium carbonate percent of the sediment, species composition of the planktic foraminiferal fauna with respect to their dissolution susceptibility (Berger dissolution index), and the ratio of fragmented to whole planktic foraminiferal tests. Most of these measures are influenced by factors in addition to dissolution, and comparative studies suggest that planktic foraminiferal fragmentation (FI) provides the best estimate of dissolution (Le & Shackleton 1992, Martinez 1994).

There is no significant correlation between FI and latitude in our study implying no significant north-south trends or changes. FI has its strongest correlation with water mass and depth indicators (Table 4), especially bottom temperature (r = -0.82), salinity (r = -0.71) and depth (r = 0.30).

Mid shelf to mid abyssal faunas (50-4000 m) in our study (>63 µm) mostly have FI values less than 10%, especially in the west and southern regions (Fig. 14), indicating little or low levels of carbonate dissolution. At shelf depths (50-200 m), there are two regions (north-east and east) with numerous samples having higher FI values (Figs 14-15). These shallow sites with elevated FI values (up to 25) occur close to the shelf break at ~200 m, or on the Mernoo Bank or around Chatham Islands on the Chatham Rise. These are clearly unrelated to carbonate dissolution and are probably the result of physical fragmentation in relatively high energy bottom current conditions.

Unusually high FI values at bathyal-mid abyssal depths (200-4000 m) are widespread east of central New Zealand but not in the other three regions (Fig. 14). When plotted on a map (Fig. 15) there is clearly an area of higher values (12-35%) on the north side of the western half of the Chatham Rise, with more usual lower values (<8%) in the Bounty Trough and around the eastern end of the Chatham Rise. A similar pattern was reported by Weaver *et al.* (1997) from the 17 samples they studied in the same area. Since the same deep water masses bathe the seafloor on the north side of the eastern and western ends of the Chatham Rise, the difference in the fragmentation ratio is unlikely to be explained by differences in the corrosiveness of the bottom waters. Weaver *et al.* (1997) suggested that the explanation might lie in the organic carbon content of the sediments. Most samples with elevated fragmentation ratios on the north-west flanks of the Chatham Rise are hemipelagic

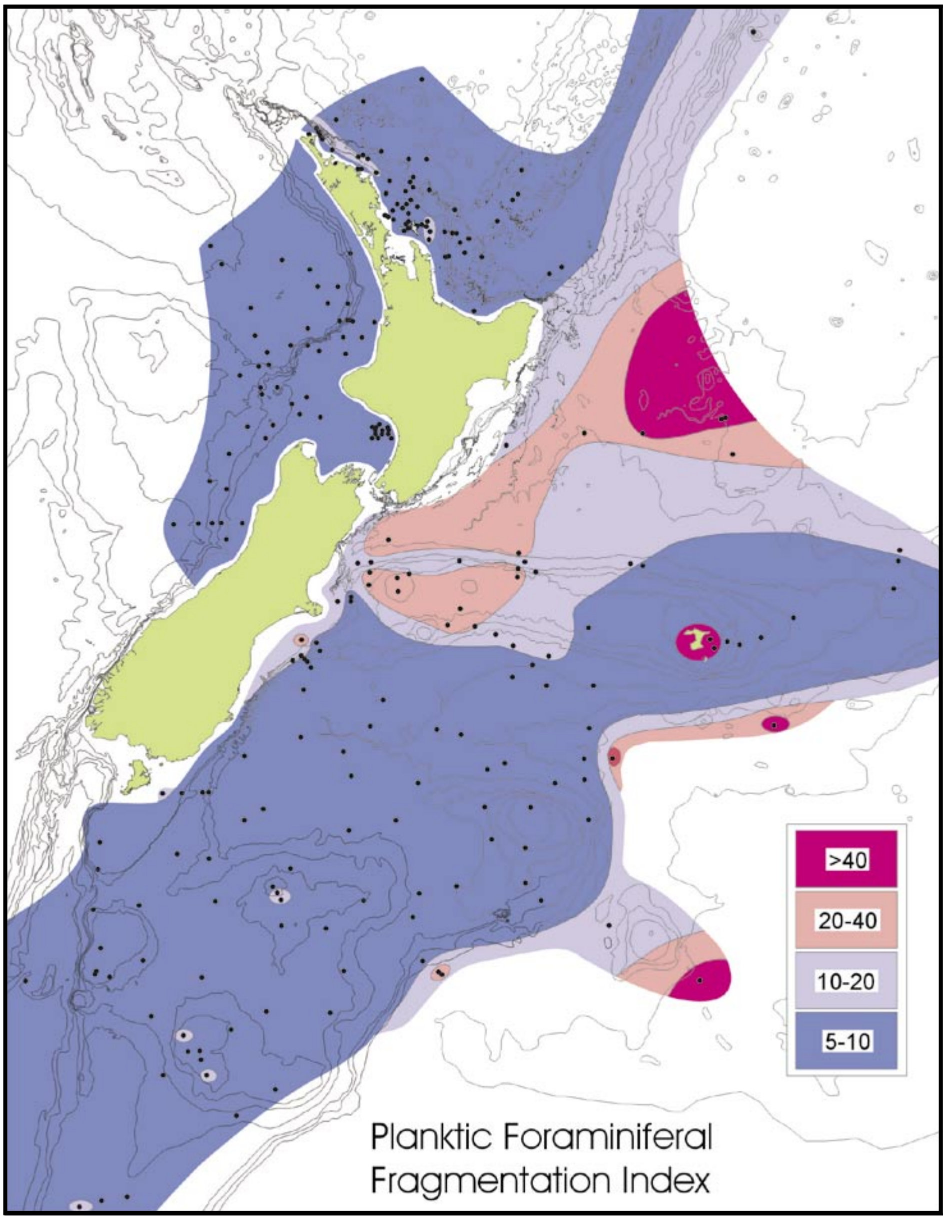


Figure 15. Contoured map of planktic foraminiferal (>63 µm) fragmentation index (>63 µm) for the New Zealand region.

suggesting sediment organic carbon may have some influence. However, all are associated with Hikurangi channel turbidite deposits or sediment drifts deposited by deep flow, suggesting that physical fragmentation could also produce these higher values.

The deepest samples (lower abyssal) in all regions (except west, where the deepest sample is only 2150 m), exhibit a trend towards increasing FI with increasing depth (Fig. 14). The flexure point where FI starts to increase is at ~3200-3600 m in all three study regions east of New Zealand and marks the top of the planktic foraminiferal lysocline, which has previously been identified by similar planktic foraminiferal fragmentation study by Weaver *et al*. (1997) as occurring at ~3500 m in the Bounty Trough. In the bathyal and abyssal, FI values only exceed 40% when depths are >3600 m.

It would appear that carbonate dissolution may be having an impact on the composition of the benthic foraminiferal faunas at all depths in and around the Chatham Rise and elsewhere at depths greater than 3500 m.

ABSOLUTE ABUNDANCE OF BENTHIC FORAMINIFERA

The absolute abundance of benthic foraminiferal tests per gram of total sediment may be a proxy for productivity of the benthos as a response to increased food supply (organic carbon flux), or it may reflect differences in terrigenous or pelagic sediment input and sedimentation rate. The lack of information about sedimentation rates prevents the calculation of benthic foraminiferal test accumulation rates per unit time, which is a better proxy for productivity and carbon flux (e.g., Herguera 1992).

In the present study, maximum absolute abundances of benthic foraminiferal tests in each of the four regions (20,000-60,000 tests g^{-1} sediment) occur at upper-mid bathyal depths (200-1000 m). The higher overall absolute abundances of benthic tests at depths shallower than 1000 m (Fig. 16) quite probably does reflect greater benthic productivity than deeper water, because of the much greater organic carbon food flux at shallower depths.

Trend lines on the abundance-depth plot (Fig. 16) indicate that absolute abundances are uniformly high from mid shelf to mid bathyal (50-750 m) off north-eastern and southern New Zealand. These are the two largest regions of elevated absolute abundances around New Zealand (Fig. 17). Off the north-east coast they coincide with a belt of sandier sediment (Fig. 6) along the outer shelf and upper continental slope, which together may be a result of winnowing of finer particles by the strong East Auckland Current. Throughout the study absolute abundance of benthics has moderate negative correlation with mud % (r = -0.25). Off southern New Zealand, peak bathyal abundances are mostly on the Campbell Plateau, but also around the peaks of the Pukaki and Bounty seamounts. These may reflect a combination of strong currents sweeping over the plateau and naturally enhanced benthic productivity as a result of the nutrient-rich waters above.

West and east of central New Zealand however, trend lines (Fig. 16) indicate that absolute abundances are lower on the shelf and increase down to deep upper-mid bathyal depths. In the west there is a belt of enhanced absolute abundance that runs along the upper parts of the continental slope and outer Taranaki shelf in sand and sandy mud substrates. This may be an area of relative sediment starvation during the high sea level of the Holocene, or it may reflect actual higher benthic productivity related to nutrient upwelling along the West Coast of the South Island (e.g., Foster & Battaerd 1985). Foraminiferal faunas here have relatively high abundances of opportunistic, higher flux indicator taxa, such as *Bolivina* spp., *Cassidulina carinata*, *Trifarina angulosa*, and *Neouvigerina* spp. In the east the peak bathyal abundances are mostly on the upper slopes of the Chatham Rise, particularly around the central and western parts (Fig. 17). As these lie beneath the STF their high values may in part reflect greater benthic productivity and in part stronger bottom currents winnowing away sinking and bedload terrigenous and pelagic particles.

Benthic foraminiferal absolute abundance has a moderate negative correlation with depth (r = -0.38). In each of the eastern regions (Figs 16-17) there is a steady decrease in benthic foraminiferal absolute abundance from the mid bathyal maximum down through lower bathyal to minimum values at abyssal depths (>2000 m, mostly <1000 tests g^{-1} sediment). West of central New Zealand there is a slight increase from lower bathyal to upper abyssal depths at the head of the New Caledonia Basin (Fig. 17). This trend within the calcareous pelagic mud substrate probably reflects decreasing terrigenous mud supply with increasing distance from land.

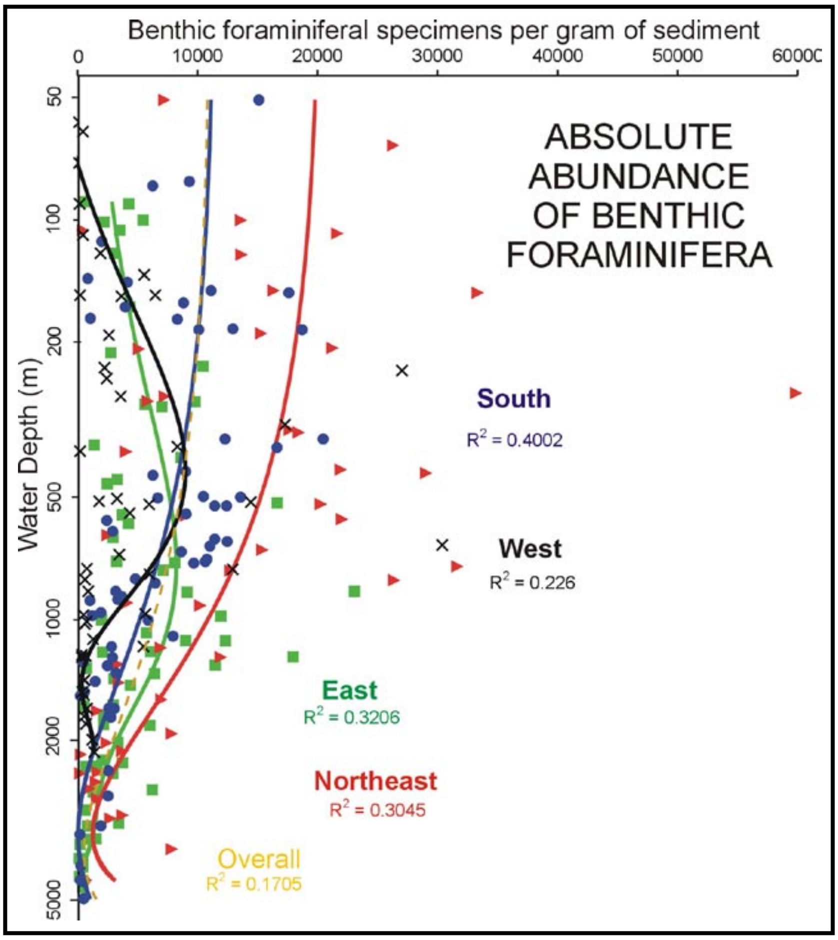


Figure 16. Absolute abundance of benthic foraminiferal tests (>63 μm) in seafloor sediment (as number of specimens per g of total sediment) plotted against depth for the four regions around New Zealand. Polynomial trend lines for each region and overall were generated using Excel and R^2 values gives a measure of goodness of fit.

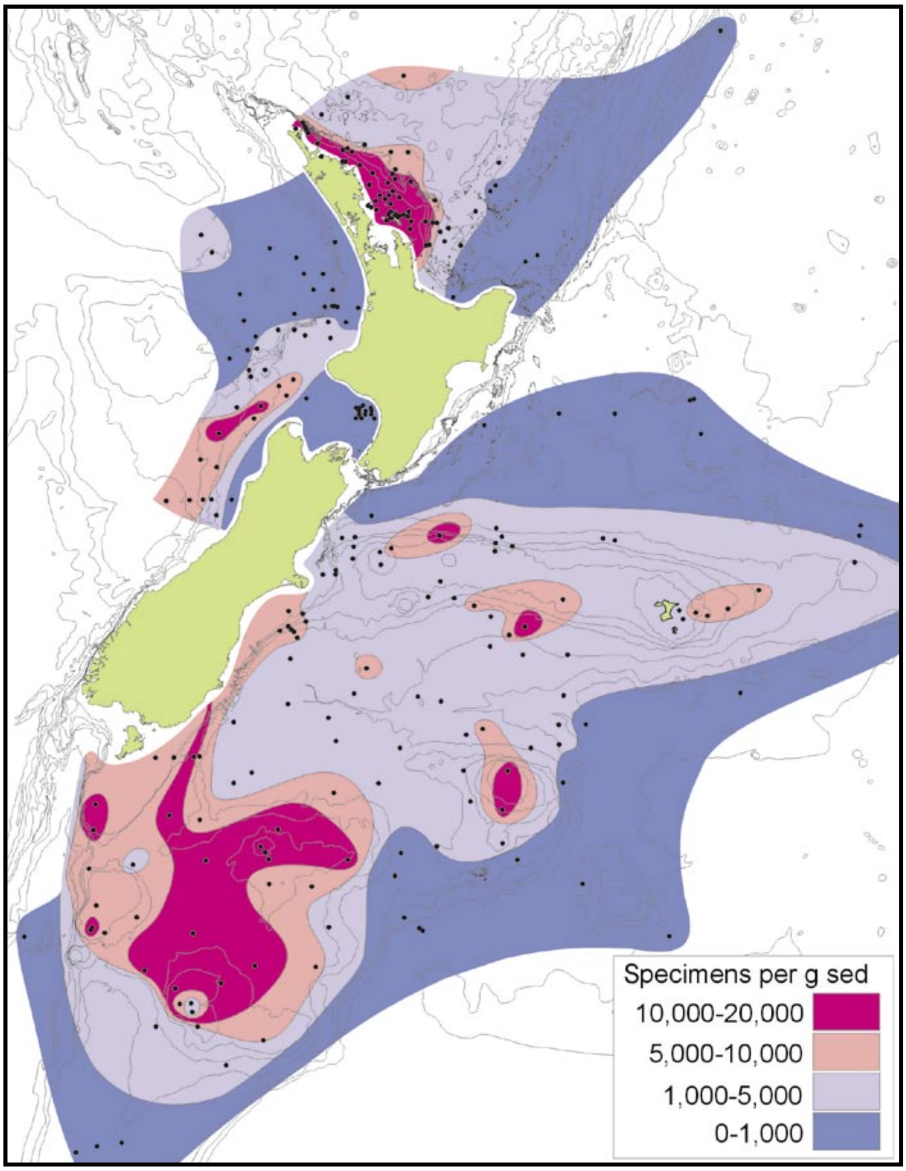


Figure 17. Contoured map of the absolute abundance of benthic foraminiferal tests (>63 µm) in seafloor sediment (as number of specimens per g of total sediment) at depths >50 m in the New Zealand region.

BENTHIC FORAMINIFERAL SAMPLE ASSOCIATIONS

Inspection of the dendrogram produced by Q-mode cluster analysis (Chord distance matrix) on full census data (Fig. 18) shows the existence of seven high level groups of samples (Associations A-G). At a lower level on the dendrogram, six of these associations (A, C–G) can be divided into a number of subassociations (e.g., C1, C2, C3 …). Each association or subassociation consists of two or more samples that are grouped together because of the similarity of their foraminferal faunas and particularly their dominant taxa. At the higher, association level, three samples (W1, S2, N69) are unclustered. The mean faunal composition and other characteristics of the associations are summarised in Fig. 19 and Tables 5-6, and their geographic and bathymetric distribution around New Zealand mapped in Figs 20 and 21. The faunal composition and other characteristics of the subassociations are summarised and their distribution mapped in Figs 1, 22-30 and Tables 7-10.

Association A: *Nuttallides umbonifera - Globocassidulina subglobosa*

STATIONS: E20, E21, E31, E67, N76, S63, S64, S65, S67, S68 = 10

WATER DEPTH: 3452-5000 m (mean = 4168 m)

SEDIMENT: Muddy sand to mud (10-97% mud; mean 66%).

DIVERSITY: Alpha = 4-19 (mean 13); H = 1.5-3.1 (mean 2.7); E = 0.29-0.67 (mean 0.47).

FAUNAL COMPOSITION (Fig. 19): This association is co-dominated by *Nuttallides umbonifera* (mean relative abundance 14%), *Globocassidulina subglobosa* (11%) and *Epistominella exigua* (11%). Subdominant are *Alabaminella weddellensis* and *Fissurina* spp. (5-8% each).

NEW ZEALAND DISTRIBUTION (Figs 20, 21): This association occurs in the deepest water around New Zealand at mid-lower abyssal depths (>3400 m) to the south-east of the Campbell and Bounty Plateaux, on

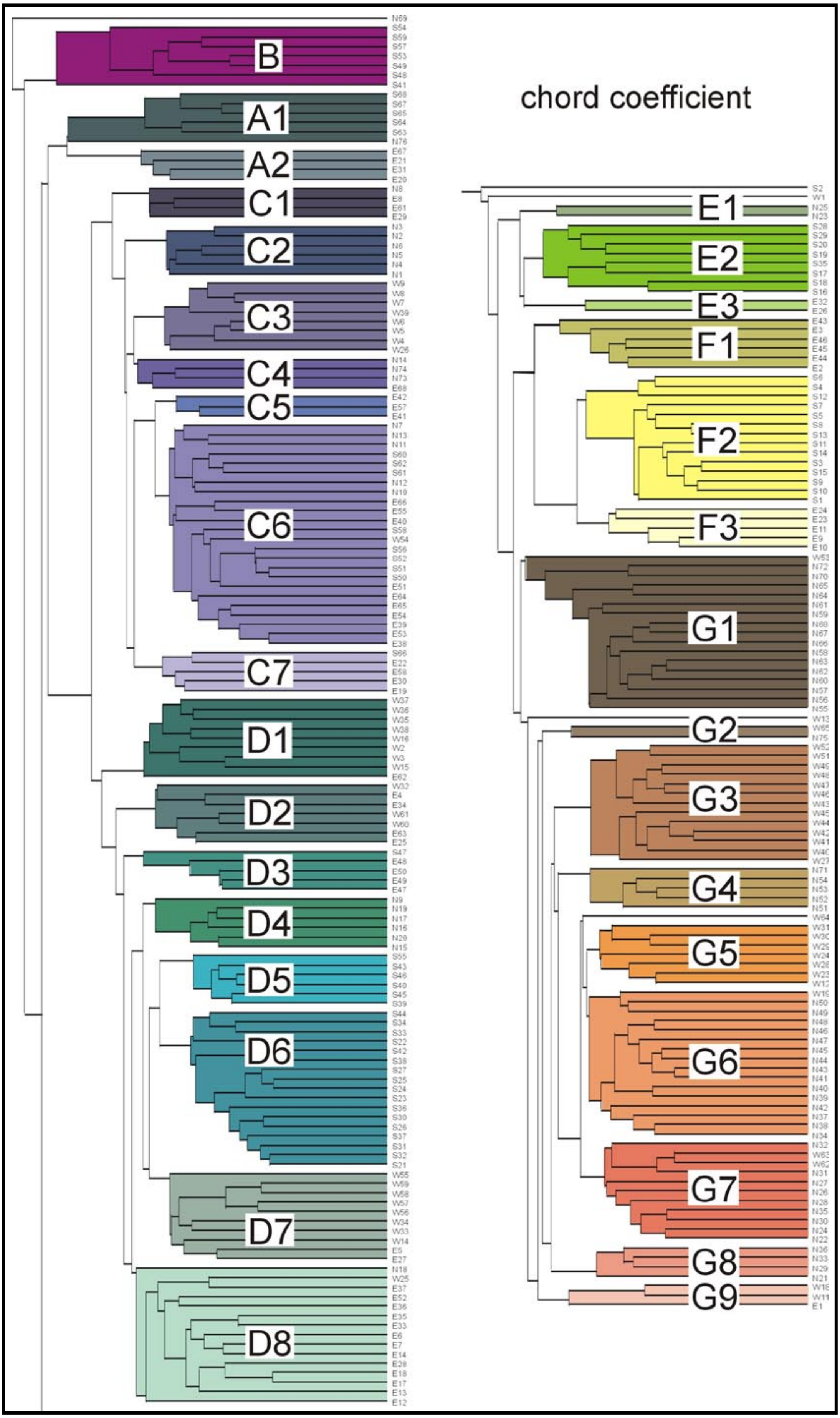


Figure 18. Dendrogram classification of New Zealand deep-water (>50 m) benthic foraminiferal sample associations (A-G) and subassociations (C1, C2, C3 …) produced by cluster analysis using chord distance based on full census data. The associations and subassociations were selected after inspection of the dendrogram.

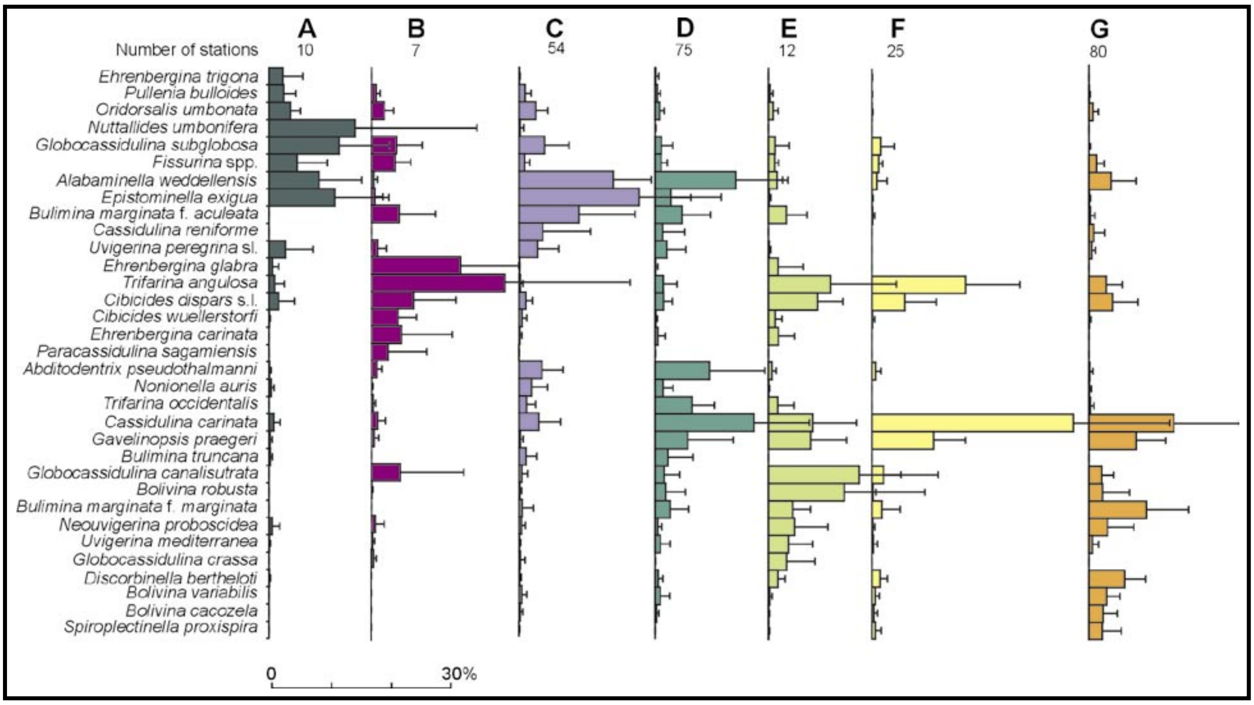


Figure 19. Histograms of mean relative abundance of the common species (>2% in one association) in the deep-water benthic foraminiferal associations (A-G) identified from the chord cluster analysis dendrogram (Fig. 18), based on full census data. Standard deviation around the mean values are shown as bars.

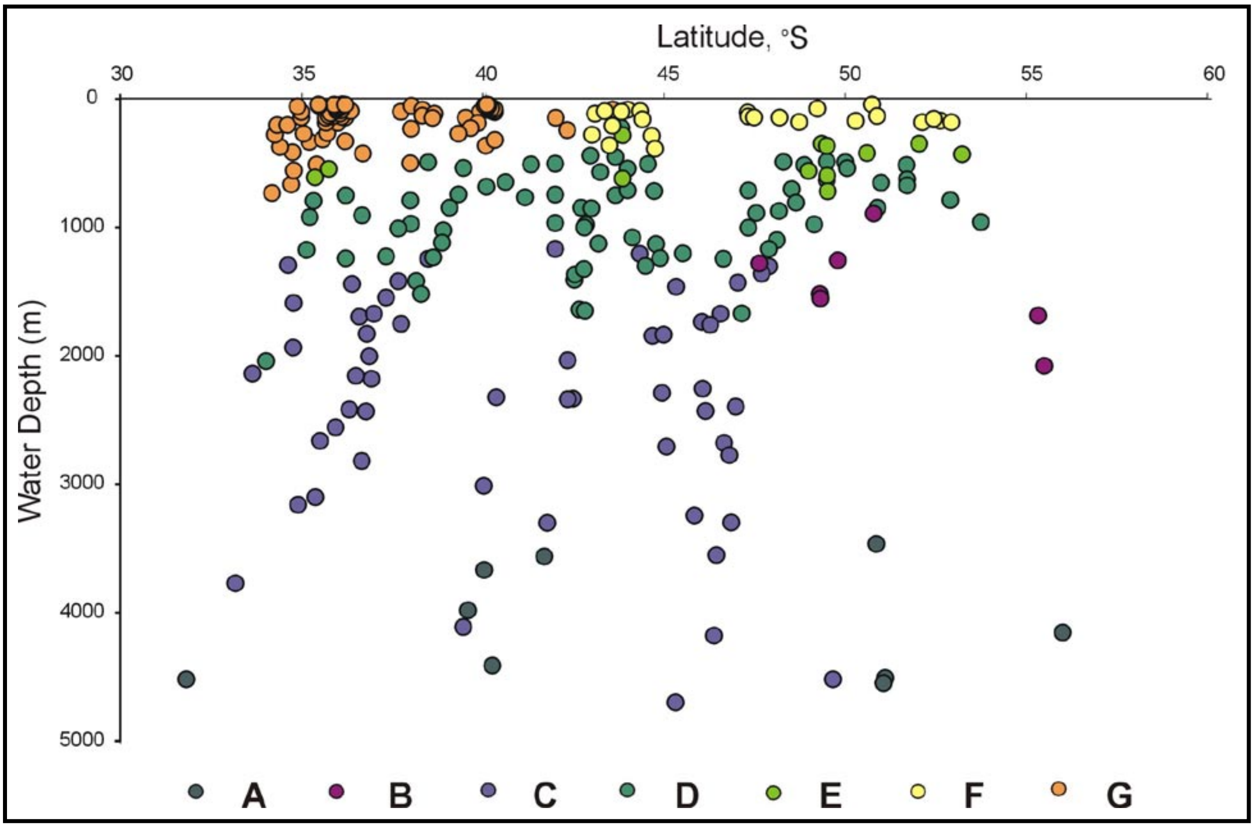


Figure 20. Depth and latitude distribution of deep-water benthic foraminiferal sample associations (A-G, from Fig. 18) through the New Zealand region.

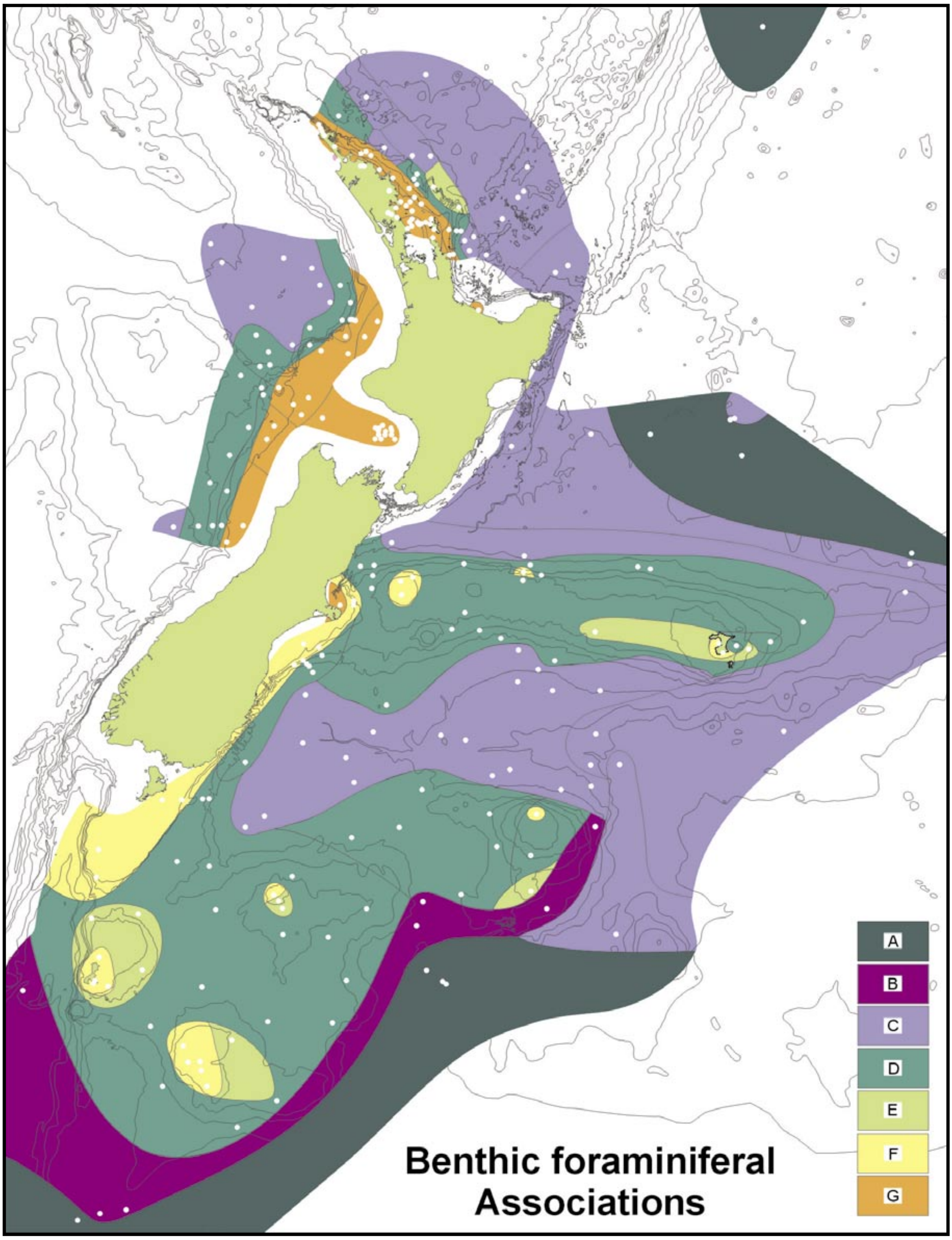


Figure 21. Mapped distribution around New Zealand of the deep-water benthic foraminiferal sample associations identified from the chord cluster analysis dendrogram (Fig. 18), based on full census data.

Hikurangi Plateau and in the Kermadec Trench in the north-east. It appears to occur in sediments that show the dissolution effects of carbonate-corrosive lower Circumpolar Deep Water that flows around the edge of the New Zealand microcontinent and into the Kermadec Trench as the Deep Western Boundary Current.

OVERSEAS COMPARISONS: All the dominant and co-dominant taxa are globally widespread with associations dominated by *N. umbonifera* and *G. subglobosa* occurring in deep, cold, oxic, oligotrophic, carbonate-corrosive water, below 3000 m water depth between the foraminiferal lysocline and the CCD. It is often linked to Antarctic Bottom Water and has been recorded from the North Atlantic (e.g., Phleger *et al*. 1953, Weston & Murray 1984), South Atlantic (e.g., Mackensen *et al*. 1995), Pacific (Resig 1981) and Indian Oceans (Corliss 1983, Gupta 1997).

SUBASSOCIATIONS: Two subassociations can be

Table 5. Summary of faunal composition, bathymetric, geographic and water mass range of deep-water benthic foraminiferal sample associations and subassociations based on full census data (Fig. 18).

[1] North-east, south, east and west of New Zealand. In brackets = minor representation in this region.

Dominant species	No stns	Depth	Regions[1]	Water mass
A: *Nuttallides umbonifera - Globocassidulina subglobosa*	10	mid-lower abyssal	S, E, NE	lower CPDW
A1: *Nuttallides umbonifera - Globocassidulina subglobosa*	6	mid-lower abyssal	S, NE	lower CPDW
A2: *Epistominella exigua - A. weddellensis –* diverse agglutinates	4	mid-lower abyssal	E	lower CPDW
B: *Trifarina angulosa - Ehrenbergina glabra*	7	mid-lower bathyal	S	upper CPDW
C: *Epistominella exigua - Alabaminella weddellensis*	54	lower bathyal-abyssal	NE, W, E, S	CPDW
C1: Cassidulina reniforme - A. weddellensis	4	upper abyssal	E, NE	upper CPDW
C2: *A. weddellensis - E. exigua*	6	upper - mid abyssal	NE	CPDW
C3: *Bulimina marginata f. aculeata - A. weddellensis*	8	lower bathyal	W	upper CPDW
C4: *A. weddellensis - Bulimina m. f. aculeata*	4	lower bathyal - upper abyssal	NE, (E)	upper CPDW
C5: *E. exigua*	3	mid-lower abyssal	E	lower CPDW
C6: *E. exigua - A. weddellensis - Bulimina m. f. aculeata*	23	lower bathyal - mid abyssal	NE, E, S, (W)	CPDW
C7: *E. exigua - A. weddellensis*	5	mid-lower abyssal	E, (S)	lower CPDW
D: *Cassidulina carinata - Alabaminella weddellensis*	75	bathyal	E, NE, S, W	AAIW, CPDW
D1: *Bulimina truncana - C. carinata*	9	lower bathyal	W, (E)	AAIW, uCPDW
D2: *C. carinata - Bolivina robusta*	7	upper bathyal	E, W	STW, SAMW
D3: *C. carinata - Abditodentrix pseudothalmanni*	5	mid-lower bathyal	E, (S)	AAIW
D4: *C. carinata - A. weddellensis - A. pseudothalmanni*	6	mid-lower bathyal	NE	AAIW, uCPDW
D5: *A. weddellensis - C. carinata*	6	mid-lower bathyal	S	AAIW
D6: *Gavelinopsis praegeri - A. weddellensis - C. carinata*	17	mid bathyal	S	SAMW
D7: *C. carinata - A. weddellensis*	10	mid bathyal	W, (E)	AAIW
D8: *A. pseudothalmanni - A. weddellensis - C. carinata*	15	mid-lower bathyal	E, (NE, W)	AAIW, uCPDW
E: *Globocassidulina canalisuturata - Bolivina robusta*	12	upper-mid bathyal	S, NE, E	SAMW, AAIW
E1: *B. robusta - G. canalisuturata*	2	upper-mid bathyal	NE	AAIW
E2: *G. canalisuturata - B. robusta*	8	upper-mid bathyal	S	SAMW
E3: *T. angulosa - B. robusta*	2	upper bathyal	E	SAMW
F: *Cassidulina carinata - Trifarina angulosa*	25	mid shelf-uppermost bathyal	E, S	SAW, SAMW
F1: *C. carinata - T. angulosa*	6	outer shelf-uppermost bathyal	E	SAW
F2: *C. carinata - T. angulosa - Gavelinopsis praegeri*	14	mid-outer shelf	S	SAW
F3: *C. carinata - Cibicides dispars s.l. - Gavelinopsis praegeri*	5	outer shelf	E	SAW
G: *Cassidulina carinata - Bulimina marginata f. marginata*	80	mid shelf-mid bathyal	NE, W, (E)	STW, ?SAW
G1: *B. m. f. marginata - Gavelinopsis praegeri*	16	mid shelf	NE	STW
G2: *B. m. f. marginata - Sphaeroidina bulloides*	2	outer shelf	N, W	STW
G3: *C. carinata - B. m. f. marginata - Gavelinopsis praegeri*	13	mid shelf	W	STW
G4: *Eilohedra vitrea - Gavelinopsis praegeri*	5	mid shelf	NE	STW
G5: *C. carinata - B. m. f. marginata - Discorbinella bertheloti*	7	outer shelf-uppermost bathyal	W	STW
G6: *Gavelinopsis praegeri - C. carinata*	16	outer shelf-uppermost bathyal	NE, (W)	STW
G7: *C. carinata - B. robusta*	11	upper-mid bathyal	N, W	STW
G8: *C. carinata - Cibicides dispars s.l.*	4	upper-mid bathyal	N	STW
G9: *Cibicides dispars s.l. - B. m. f. marginata - C. carinata*	3	mid shelf	W, (E)	STW, ?SAW

recognised within Association A (Fig. 22, Table 7) on the chord dendrogram (Fig. 18). The distribution of these subassociations is mappable and each (with the exception of sample N76) occurs in a separate geographically- and bathymetrically-defined region (Fig. 23).

Subassociation A1: *Nuttallides umbonifera - Globocassidulina subglobosa*

STATIONS: N76, S63, S64, S65, S67, S68 = 6

WATER DEPTH: 3452-5000 m (mean = 4352 m)

SEDIMENT: Muddy sand to slightly sandy mud (10-84% mud; mean 47%).

DIVERSITY: Alpha = 4-13 (mean 10); H = 1.5-3.0 (mean 2.5); E = 0.29-0.54 (mean 0.40).

FAUNAL COMPOSITION (Fig. 22): This association is co-dominated by *Nuttallides umbonifera* (mean relative abundance 23%), *Globocassidulina subglobosa* (16%). Subdominant are *Alabaminella weddellensis*, *Fissurina* spp. and *Epistominella exigua* (5-8% each).

NEW ZEALAND DISTRIBUTION (Fig. 23): Occurs in the deepest water around New Zealand at mid-lower abyssal depths (>3400 m) to the south-east of the Campbell and Bounty Plateaux, and in the Kermadec Trench in the north-east. It appears to occur in sediments that show the dissolution effects of carbonate-corrosive lower Circumpolar Deep Water that flows around the edge of the New Zealand microcontinent and into the Kermadec Trench as the Deep Western Boundary Current.

Table 6. Mean and standard deviation (SD) for physical, chemical and species diversity values for deep-sea benthic foraminiferal sample associations.

Chord Associations **Number of stations**	**A** **10**	SD	**B** **7**	SD	**C** **54**	SD	**D** **75**	SD	**E** **12**	SD	**F** **25**	SD	**G** **80**	SD
Depth (metres)	4168	504	1466	372	2329	870	918	348	504	137	172	86	170	149
Alpha	13.0	4.5	11.2	5.3	13.2	5.2	10.7	2.9	10.7	5.9	8.8	3.7	13.8	3.5
Shannon-Wiener Index, H	2.7	0.5	2.5	0.5	2.7	0.4	2.7	0.3	2.6	0.5	2.3	0.5	3.0	0.3
Evenness, E	0.47	0.11	0.39	0.09	0.44	0.08	0.46	0.09	0.46	0.09	0.37	0.09	0.51	0.08
% mud	66	32	10	21	80	16	66	24	18	11	12	13	28	26
% planktic foraminifera	69	27	97	2	92	8	88	7	80	18	37	15	30	21
Fragmentation Index	28	22	4	2	8	9	7	7	5	3	15	15	5	7
Chlorophyll-a	0.22	0.06	0.20	0.02	0.27	0.08	0.46	0.20	0.29	0.09	0.47	0.18	0.55	0.21
Chlorophyll-a mean spring	0.29	0.15	0.19	0.02	0.34	0.14	0.15	0.22	0.33	0.11	0.46	0.25	0.81	0.37
Chlorophyll-a mean summer	0.19	0.05	0.24	0.03	0.27	0.16	0.35	0.20	0.34	0.17	0.72	0.26	0.56	0.32
Seasonality Index	0.24	0.10	0.19	0.03	0.29	0.06	0.26	0.08	0.25	0.09	0.33	0.08	0.27	0.08
Flux, Jz	0.05	0.02	0.14	0.06	0.14	0.08	0.56	0.52	0.75	0.56	4.60	3.10	10.5	10.2
Sea surface temperature, SST	12.5	4.7	8.6	1.4	14.6	3.4	13.2	3.3	11.5	3.7	10.8	1.7	16.0	4.0
Bottom temperature	1.1	0.3	3.1	1.3	2.3	0.8	5.9	2.2	8.2	2.1	11.6	3.2	23.6	3.9
Salinity	34.7	0.0	34.5	0.1	34.6	0.1	34.5	0.2	34.6	0.3	34.9	0.5	35.4	0.3
Bottom oxygen (ml/l)	4.7	0.4	4.3	0.3	4.0	0.6	4.6	0.9	5.6	0.6	6.2	0.5	4.6	0.5
Surface phosphate (umol/l)	0.7	0.5	1.1	0.3	0.5	0.2	0.5	0.3	0.7	0.3	0.7	0.2	0.3	0.0

Subassociation A2: *Epistominella exigua - Alabaminella weddellensis* – diverse agglutinates

STATIONS: E20, E21, E31, E67 = 4

WATER DEPTH: 3550-4394 m (mean = 3891 m)

SEDIMENT: Mud (88-97% mud; mean 94%).

DIVERSITY: Alpha = 16-19 (mean 17); H = 2.95-3.38 (mean 3.13); E = 0.44-0.67 (mean 0.54).

FAUNAL COMPOSITION (Fig. 22): This subassociation is dominated by *E. exigua* (mean relative abundance 19%) with subdominant *A. weddellensis* (9%) and a wide diversity of agglutinated species, including common *Recurvoidatus parcus*, *Adercotryma glomerata*, *Spiroplectammina carteri* and *Paratrochammina challengeri*.

NEW ZEALAND DISTRIBUTION (Fig. 23): Only occurs at mid-lower abyssal depths (3500-4500 m) on the Hikurangi Plateau east of the North Island, where it is bathed in lower CPDW and the sediment is dominantly pelagic mud.

Association B: *Trifarina angulosa - Ehrenbergina glabra*

STATIONS: S41, S48, S49, S53, S54, S57, S59 = 7

WATER DEPTH: 896-2074 m (mean = 1466 m)

SEDIMENT: Sandy mud to sand (2-51% mud; mean 14%).

DIVERSITY: Alpha = 7-23 (mean 11); H = 1.74-3.28 (mean 2.50); E = 0.23-0.51 (mean 0.39).

FAUNAL COMPOSITION (Fig. 19): This association is co-dominated by *Trifarina angulosa* (mean relative abundance 22%) and *Ehrenbergina glabra* (14%). Subdominant are *Cibicides dispars* and *Ehrenbergina carinata* (5-7% each).

NEW ZEALAND DISTRIBUTION (Figs 20-21): This association only occurs in the south-east of the New Zealand region, where it forms a linear belt at lower bathyal depths beneath upper Circumpolar Water along the crest and upper slopes of the steep south-east flanks of the Campbell and Bounty Plateaux. This belt is swept by strong bottom currents associated with Antarctic Circumpolar Current (ACC) beneath the deep-reaching Subantarctic Front, which result in the dominance of sandy to shelly substrates. This association is unusual in that elsewhere in the region *T. angulosa* is restricted to shallower depths, whereas the co-dominant *E. glabra* is a Southern Ocean species not found at lower latitudes.

OVERSEAS COMPARISONS: This *T. angulosa-E. glabra* association occurs in similar current-swept, sandy or

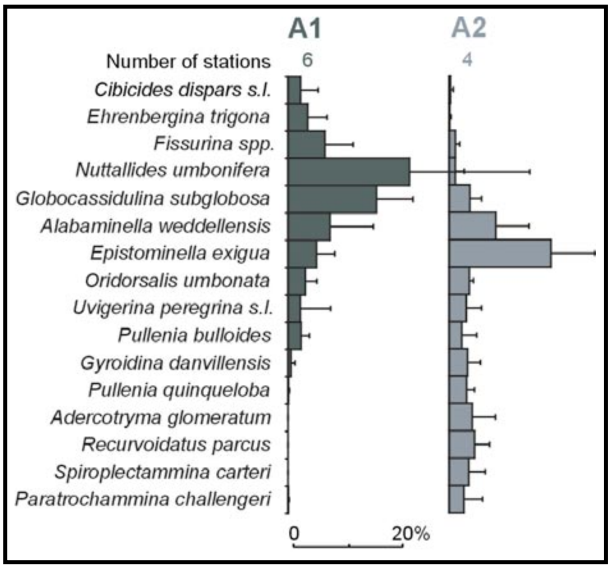


Figure 22. Mean relative abundance and standard deviation of the common species (>2% in one subassociation) in the subassociations of Association A identified from the chord cluster analysis dendrogram (Fig. 18), based on full census data.

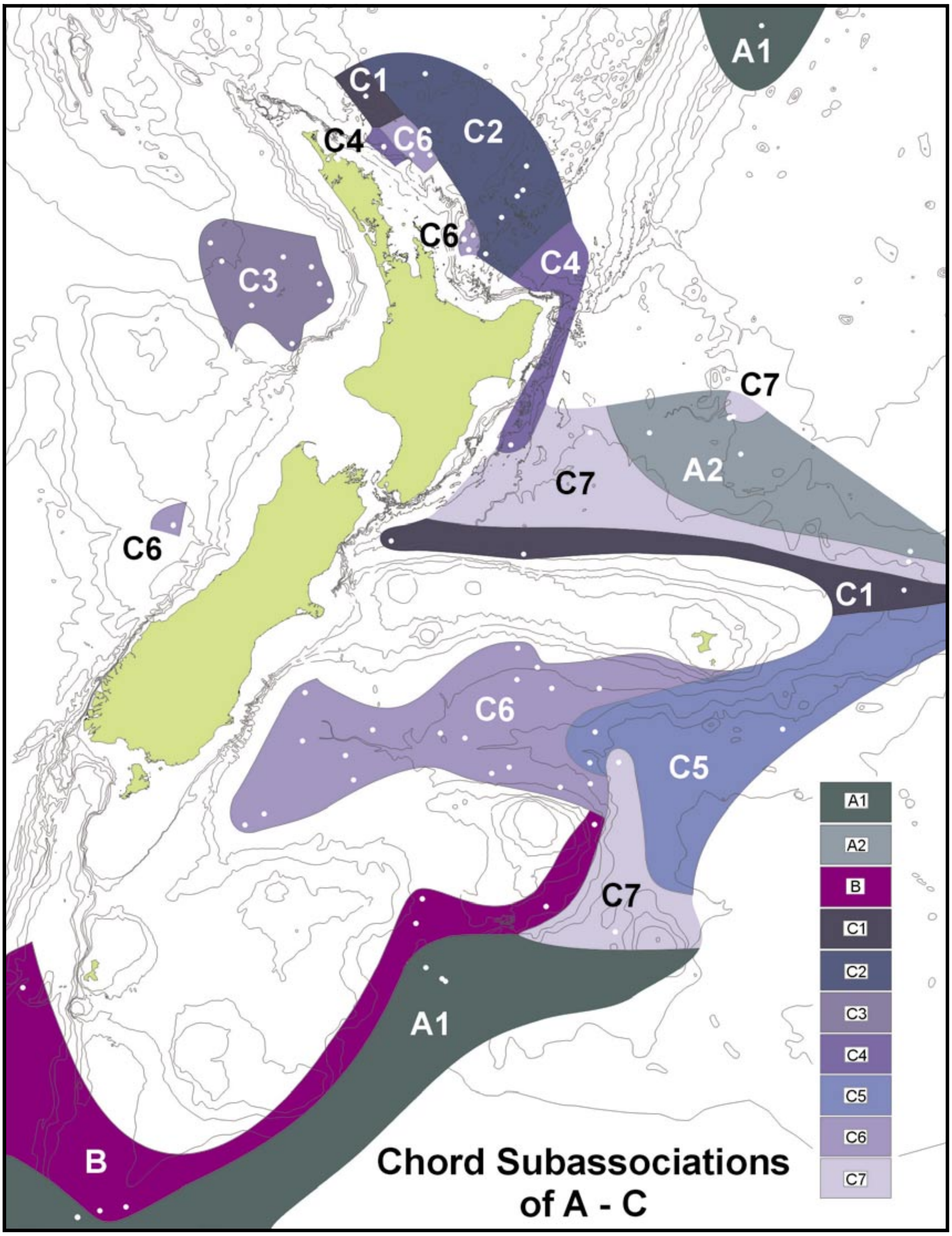


Figure 23. Distribution around New Zealand of the subassociations of foraminiferal sample associations A and C identified from the chord cluster analysis dendrogram (Fig. 18), based on full census data.

gravelly substrates below the ACC around the fringes of the Southern Ocean, but at slightly shallower outer shelf and upper bathyal depths (100-800 m, Echols 1971, Ward *et al*. 1987, Mackensen *et al*. 1990, Harloff & Mackensen 1997).

Association C: *Epistominella exigua - Alabaminella weddellensis*

STATIONS: E8, E19, E22, E29, E30, E38, E39, E40, E41, E42, E51, E53, E54, E55, E57, E58, E61, E64, E65, E66, E68, N1, N2, N3, N4, N5, N6, N7, N8, N10, N11, N12, N13, N14, N73, N74, S50, S51, S52, S56, S58, S60, S61, S62, S66, W4, W5, W6, W7, W8, W9, W26, W39, W54 = 55

WATER DEPTH: 1206-4680 m (mean = 2329 m)

SEDIMENT: Muddy sand to mud (35-98% mud; mean 80%).

DIVERSITY: Alpha = 6-26 (mean 13); H = 1.95-3.58 (mean 2.71); E = 0.30-0.63 (mean 0.44).

FAUNAL COMPOSITION (Fig. 19): This association is co-dominated by *Epistominella exigua* (mean relative abundance 20%) and *Alabaminella weddellensis* (15%). Subdominant are *Bulimina marginata* f. *aculeata*, *Cassidulina reniforme*, *Abditodentrix pseudothalmanni* and *G. subglobosa* (4-10% each).

NEW ZEALAND DISTRIBUTION (Figs 20, 21): This association occurs over a wide range of lower bathyal to abyssal depths (1000-4700 m) off the east coast of north and central New Zealand and the west coast of central New Zealand. Off the east coast this association is entirely confined to that part of the seafloor that is bathed in Circumpolar Deep Water (>1400 m). Off the west coast however, the upper depth limit of association C is at 1150 m, which is generally considered to be into the lower part of Antarctic Intermediate Water (Fig. 8). The substrate is largely pelagic, foraminiferal-bearing, nannofossil calcareous mud indicative of relatively low bottom current energy.

OVERSEAS COMPARISONS: This association is common and widespread at bathyal and abyssal depths around the globe – in the Southern Ocean (e.g., Pflum 1966, Echols 1971), Indian (e.g., Burmistrova 1976), and Atlantic Oceans (Schafer & Cole 1982, Mackensen *et al*. 1995). Faunas dominated by *Epistominella exigua*, commonly in association with *Alabaminella weddellensis*, have been linked to highly seasonal supply of phytodetrital carbon flux (Gooday 1993, Smart *et al*. 1994, Loubere 1998, Nees & Struck 1999).

SUBASSOCIATIONS: Seven subassociations (Fig. 24, Table 7) can be recognised within Association C on the chord dendrogram (Fig. 18). The distribution of these subassociations is mappable and each (except C5) occurs in a separate geographically- and bathymetrically-defined region (Fig. 23). C5 and C7 occur east of central New Zealand; C3 occurs off the west; C1, C2 and C4 east of the North Island and northern South Island. C6 occurs in the Bounty Trough and near the base of the continental slope of both the north-east and west coasts.

Subassociation C1: *Cassidulina reniforme - Alabaminella weddellensis*

STATIONS: E8, E29, E61, N8 = 4

WATER DEPTH: 2030-2332 m (mean = 2206 m)

SEDIMENT: Slightly sandy mud to mud (80-96% mud; mean 87%).

DIVERSITY: Alpha = 7-18 (mean 14); H = 1.95-3.09 (mean 2.74); E = 0.32-0.52 (mean 0.43).

FAUNAL COMPOSITION (Fig. 24): This subassociation is dominated by *C. reniforme* (mean relative abundance 22%) with subdominant *A. weddellensis* (13%), *B. marginata* f. *aculeata* (8%) and *Nonionella auris* (7%).

NEW ZEALAND DISTRIBUTION (Fig. 23): Occurs at upper abyssal depths (2000-2400 m) beneath upper CPDW on the northern slopes of the Chatham Rise and also north-east of New Zealand.

Subassociation C2: *Alabaminella weddellensis – Epistominella exigua*

STATIONS: N1, N2. N3, N4, N5, N6 = 6

WATER DEPTH: 2550-3757 m (mean = 3002 m)

SEDIMENT: Sandy mud to mud (72-96% mud; mean 89%).

DIVERSITY: Alpha = 13-26 (mean 19); H = 2.70-3.58 (mean 3.13); E = 0.38-0.63 (mean 0.51).

FAUNAL COMPOSITION (Fig. 24): This subassociation is co-dominated by *A. weddellensis* (18%) and *E. exigua* (12%) with subdominant *Globocassidulina subglobosa* (8%).

NEW ZEALAND DISTRIBUTION (Fig. 23): Occurs at upper and mid abyssal depths off the east coast of northern Northland beneath CPDW.

Subassociation C3: *Bulimina marginata* f. *aculeata - Alabaminella weddellensis*

STATIONS: W4, W5, W6, W7, W8, W9, W26, W39 = 8

WATER DEPTH: 1244-2150 m (mean = 1700 m)

SEDIMENT: Mud (89-97% mud; mean 95%).

DIVERSITY: Alpha = 6-12 (mean 10); H = 2.45-2.84 (mean 2.67); E = 0.45-0.55 (mean 0.49).

FAUNAL COMPOSITION (Fig. 24): This subassociation

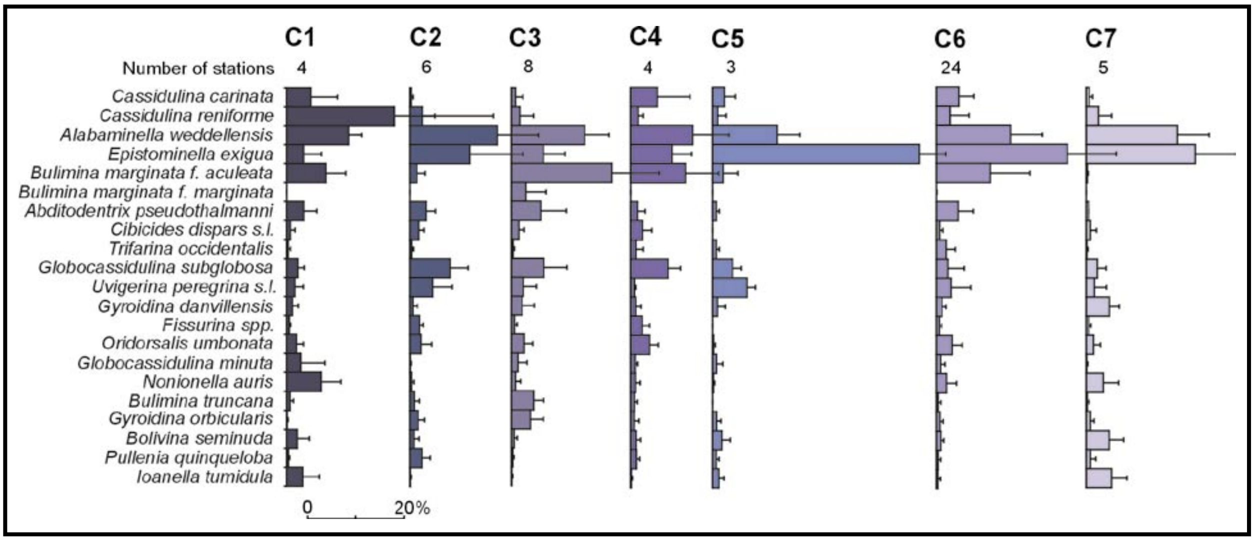


Figure 24. Mean relative abundance and standard deviation of the common species (>2% in one subassociation) in the subassociations of Association C identified from the chord cluster analysis dendrogram (Fig. 18), based on full census data.

is codominated by *B. marginata* f. *aculeata* (mean relative abundance 21%) and *A. weddellensis* (15%), with subdominant *G. subglobosa*, *E. exigua* and *A. pseudothalmanni* (each 6-7%).

NEW ZEALAND DISTRIBUTION (Fig. 23): C3 is the deepest subassociation west of New Zealand, where it occurs at lower bathyal-upper abyssal depths (1200-2200 m) beneath upper CPDW.

OVERSEAS COMPARISONS: A faunal association dominated by *B. m.* f. *aculeata* occurs at similar lower bathyal depths in the Gulf of Mexico (e.g., Pflum & Frerichs 1976).

Subassociation C4: ***Alabaminella weddellensis - Bulimina marginata* f. *aculeata***

STATIONS: N14, N73, N74, E68 = 4

WATER DEPTH: 1295-2427 m (mean = 2054 m)

SEDIMENT: Muddy sand to mud (38-98% mud; mean 68%).

DIVERSITY: Alpha = 20-24 (mean 22); H = 3.16-3.34 (mean 3.27); E = 0.44-0.59 (mean 0.52).

FAUNAL COMPOSITION (Fig. 24): This subassociation is co-dominated by *A. weddellensis* (mean relative abundance 13%) and *B. marginata* f. *aculeata* 11%), with subdominant *E. exigua* (8%).

NEW ZEALAND DISTRIBUTION (Fig. 23): Occurs at lower bathyal and upper abyssal depths east of the North Island.

Subassociation C5: ***Epistominella exigua***

STATIONS: E41, E42, E57 = 3

WATER DEPTH: 3232-4680 m (mean = 3817 m)

SEDIMENT: Sandy mud (57-80% mud; mean 65%).

DIVERSITY: Alpha = 8-19 (mean 13); H = 2.13-2.75 (mean 2.36); E = 0.30-0.33 (mean 0.32).

FAUNAL COMPOSITION (Fig. 24): This subassociation is strongly dominated by *E. exigua* (mean relative abundance 42%), with subdominant *A. weddellensis* (13%) and *U. peregrina* (7%).

NEW ZEALAND DISTRIBUTION (Fig. 23): Occurs at mid to lower abyssal depths (3000-5000 m) in the Bounty Trough, east of central New Zealand.

Subassociation C6: ***Epistominella exigua - Alabaminella weddellensis - Bulimina marginata* f. *aculeata***

STATIONS: E38, E39, E40, E51, E53, E54, E55, E64, E65, E66, N7, N10, N11, N12, N13, S50, S51, S52, S56, S58, S60, S61, S62, W54 = 24

WATER DEPTH: 1168-3287 m (mean = 1941 m)

SEDIMENT: Muddy sand to mud (35-90% mud; mean 73%).

DIVERSITY: Alpha = 6-21 (mean 11); H = 2.00-3.19 (mean 2.53); E = 0.32-0.51 (mean 0.40).

FAUNAL COMPOSITION (Fig. 24): This subassociation is strongly dominated by *E. exigua* (mean relative abundance 27%) with subdominant *A. weddellensis* (15%) and *B. marginata* f. *aculeata* (11%). No other species exceed 5% in relative abundance.

NEW ZEALAND DISTRIBUTION (Fig. 23): Occurs at lower bathyal to mid abyssal depths (1000-3300 m) mainly in the Bounty trough, east of the southern South Island, but also on the continental slope east of northern North Island. One sample occurs off the west coast of the South Island.

Subassociation C7: ***Epistominella exigua - Alabaminella weddellensis***

STATIONS: E19, E22, E30, E58, S66 = 5

WATER DEPTH: 3003-4500 m (mean = 3810 m)

SEDIMENT: Slightly sandy mud to mud (83-92% mud; mean 89%).

DIVERSITY: Alpha = 12-20 (mean 15); H = 2.51-3.22 (mean 2.82); E = 0.37-0.52 (mean 0.44).

FAUNAL COMPOSITION (Fig. 24): This subassociation is co-dominated by *E. exigua* (mean relative abundance 23%) and *A. weddellensis* (19%). No other species exceed 6% in relative abundance.

NEW ZEALAND DISTRIBUTION (Fig. 23): Occurs at mid to lower abyssal depths (3000-4500 m) east of central New Zealand, on both sides of Chatham Rise.

Association D: ***Cassidulina carinata - Alabaminella weddellensis***

STATIONS: E4, E5, E6, E7, E12, E13, E14, E17, E18, E25, E27, E28, E33, E34, E35, E36, E47, E48, E49, E50, E52, E62, E63, N9, N15, N16, N17, N18, N19, N20, S21, S22, S23, S24, S25, S26, S27, S30, S31, S32, S33, S34, S36, S37, S38, S39, S40, S42, S43, S44, S45, S46, S47, S55, W14, W15, W16, W2, W3, W25, W32, W33, W34, W35, W36, W37, W38, W55, W56, W57, W58, W59, W60, W61 = 75

WATER DEPTH: 232-2036 m (mean = 909 m)

SEDIMENT: Slightly muddy sand to mud (13-98% mud; mean 66%).

DIVERSITY: Alpha = 6-18 (mean 11); H = 2.10-3.32 (mean 2.68); E = 0.27-0.66 (mean 0.46).

FAUNAL COMPOSITION (Fig. 19): This association is co-dominated by *Cassidulina carinata* (mean relative abundance 17%) and *Alabaminella weddellensis* (14%). Subdominant are *A. pseudothalmanni*, *Trifarina occidentalis* and *Gavelinopsis praegeri* (6-9% each).

NEW ZEALAND DISTRIBUTION (Figs 20-21): This association occurs all around New Zealand mostly at bathyal depths (450-2050 m), except for one station (E25, 232 m). Off north-east New Zealand, Association D occurs between 750 and 2050 m depth. Further south off east central and southern New Zealand the association is 300 m shallower where it occurs between 450 and 1700 m. Off the west coast this association occurs between 500 and 1500 m depth. In all regions, this association roughly occupies the area of seafloor bathed by AAIW and extends down into the upper half of the oxygen-minimum zone of upper CPDW. On the Campbell Plateau in the south, on the deeper parts of the Chatham Rise in the east and along the continental slope in the west and east, this association extends upwards into upper bathyal depths (<600 m) to also underlie Subantarctic Mode Water (SAMW).

OVERSEAS COMPARISONS: The two dominant species of this association are widespread globally, although *C. carinata* is sometimes assigned to other taxa. They are

Table 7. Mean and standard deviation (SD) or physical, chemical and species diversity values for subassociations in deep-sea benthic foraminiferal Associations A and C.

Chord Associations	A1	SD	A2	SD	C1	SD	C2	SD	C3	SD	C4	SD	C5	SD	C6	SD	C7	SD
Number of stations	6		4		4		6		8		4		3		23		5	
Depth (metres)	4352	519	3891	379	2206	150	3002	439	1700	298	2054	516	3817	763	2026	569	3810	633
Alpha	10.1	3.3	17.3	1.4	13.7	4.9	19.0	5.6	9.9	1.7	22.1	1.8	12.6	5.4	11.5	3.7	14.9	3.1
Shannon-Wiener Index, H	2.50	0.54	3.13	0.18	2.74	0.55	3.13	0.39	2.67	0.14	3.27	0.08	2.36	0.34	2.64	0.32	2.82	0.29
Evenness, E	0.42	0.10	0.54	0.09	0.43	0.10	0.51	0.10	0.49	0.03	0.52	0.06	0.32	0.02	0.42	0.06	0.44	0.07
% mud	47	28	94	4	87	10	89	9	95	3	68	27	65	13	76	15	89	6
% planktic foraminifera	76	30	58	23	83	16	95	2	89	7	93	4	91	12	99	2	87	12
Fragmentation Index	29	25	25	19	15	12	4	3	6	1	4	1	18	20	4	4	23	16
Chlorophyll-a	0.32	0.10	0.31	0.05	0.42	0.21	0.23	0.02	0.23	0.01	0.30	0.11	0.41	0.10	0.55	0.19	0.37	0.08
Flux, Jz	0.09	0.04	0.09	0.02	0.25	0.17	0.07	0.02	0.13	0.03	0.17	0.07	0.15	0.07	0.46	0.26	0.12	0.04
Sea surface temperature, SST	10.2	4.8	16.0	1.1	15.3	2.6	18.6	0.4	17.4	0.3	17.9	0.8	11.7	0.9	13.2	3.2	13.5	3.1
Bottom temperature	1.1	0.4	1.1	0.2	2.2	0.2	1.9	0.1	2.9	0.6	2.6	1.1	1.1	0.3	2.7	0.8	1.2	0.3
Salinity	34.7	0.0	34.7	0.0	34.6	0.2	34.7	0.0	34.6	0.0	34.6	0.1	34.7	0.0	36.1	0.1	34.7	0.0
Bottom oxygen (ml/l)	4.64	0.51	4.88	0.10	3.85	0.17	3.60	0.00	2.93	0.13	3.75	0.24	4.83	0.06	4.34	0.38	4.78	0.19
Surface phosphate (umol/l)	0.95	0.42	0.25	0.03	0.34	0.04	0.28	0.01	0.29	0.02	0.27	0.06	0.57	0.10	0.60	0.19	0.47	0.31

Table 8. Mean and standard deviation (SD) for physical, chemical and species diversity values for subassociations in deep-sea benthic foraminiferal Association D.

Chord Associations	D1	SD	D2	SD	D3	SD	D4	SD	D5	SD	D6	SD	D7	SD	D8	SD
Number of stations	9		7		5		6		6		17		10		15	
Depth (metres)	1170	195	468	113	969	334	1155	475	1113	295	676	162	782	91	1106	357
Alpha	9.9	2.5	12.2	2.3	13.8	3.4	15.5	2.3	9.7	0.9	9.2	1.6	11.6	2.2	9.3	2.5
Shannon-Wiener Index, H	2.77	0.21	2.93	0.25	2.58	0.16	2.97	0.24	2.65	0.13	2.56	0.21	2.78	0.24	2.52	0.24
Evenness, E	0.54	0.08	0.53	0.06	0.34	0.04	0.48	0.08	0.47	0.05	0.43	0.07	0.48	0.10	0.45	0.05
% mud	91	14	58	23	47	18	79	11	33	17	51	17	81	15	75	18
% planktic foraminifera	85	11	85	5	84	6	93	2	95	1	90	4	89	9	87	9
Fragmentation Index	6	3	15	14	4	3	3	1	4	1	4	1	5	4	13	9
Chlorophyll-a	0.27	0.10	0.44	0.19	0.79	0.05	0.23	0.01	0.58	0.06	0.49	0.16	0.31	0.14	0.52	0.16
Flux, Jz	0.26	0.19	1.34	0.74	1.67	0.78	0.22	0.09	0.82	0.12	1.08	0.49	0.47	0.33	0.76	0.43
Sea surface temperature, SST	16.6	1.0	14.5	1.4	11.3	0.4	18.3	0.2	9.5	0.4	9.2	0.9	15.3	1.5	13.8	1.9
Bottom temperature	4.5	1.1	10.2	1.9	6.1	2.8	5.4	1.9	3.3	0.6	5.9	0.9	7.1	0.7	5.0	2.1
Salinity	34.5	0.0	34.8	0.2	34.5	0.1	34.5	0.1	34.4	0.1	34.3	0.0	34.5	0.0	34.5	0.3
Bottom oxygen (ml/l)	3.31	0.43	4.83	1.06	4.94	0.74	4.40	0.52	4.66	0.28	5.54	0.37	3.81	0.73	4.47	0.69
Surface phosphate (umol/l)	0.28	0.01	0.36	0.08	0.70	0.02	0.30	0.02	0.84	0.05	0.89	0.14	0.32	0.06	0.40	0.12

considered to be characteristic of relatively high labile carbon flux with a seasonal phytodetrital component. It has not been recorded as commonly as some other associations, in part possibly because most *A. weddellensis* and many *C. carinata* are smaller than 150 µm, and would not be picked up by the many studies that were restricted to only larger sized tests. Faunas dominated by *C. carinata* have most commonly been reported from outer shelf and bathyal depths in the North Atlantic and Mediterranean Sea (e.g., Mackensen *et al*. 1985, de Rijk *et al*. 2000).

SUBASSOCIATIONS: Eight subassociations (Fig. 25, Table 8) can be readily recognised within Association D on the chord cluster analysis dendrogram (Fig. 18). These can be mapped in geographically- and bathymetrically-defined regions (Fig. 26). D4 is confined to off north-east New Zealand; D3 occurs along the continental slope east of the South Island; and D5 and D6 are confined to the Campbell and Bounty Plateaux in the south. D1 and D7 are largely confined to off the west coast, but both have one or two stations on the Chatham Rise to the east. D8 is widespread over the crest and upper slopes of the Chatham Rise but also has two stations off north-east New Zealand. D2 occurs in scattered pockets east (Chatham Rise) and west of central New Zealand.

Subassociation D1: *Bulimina truncana - Cassidulina carinata*

STATIONS: E62, W2, W3, W15, W16, W35, W36, W37, W38 = 9

WATER DEPTH: 974-1518 m (mean = 1170 m)

SEDIMENT: Sandy mud to mud (53-98% mud; mean 91%).

DIVERSITY: Alpha = 8-15 (mean 10); H = 2.57-3.22 (mean 2.77); E = 0.37-0.66 (mean 0.54).

FAUNAL COMPOSITION (Fig. 25): This subassociation is co-dominated by *Bulimina truncana* and *C. carinata* (mean relative abundance 11% each) with subdominant *A. weddellensis*, *Uvigerina peregrina*, *A. pseudothalmanni* and *B. marginata* f. *aculeata* (6-9% each).

NEW ZEALAND DISTRIBUTION (Fig. 26): Most of D1 occurs at lower bathyal depths (1000-1500 m) on the lower continental slope off the west coast of the North Island, with one station at the same depth on the northern slopes of the Chatham Rise.

OVERSEAS COMPARISONS: A similar faunal association dominated by *B. truncana* (as *B. alazanensis*) occurs at similar depths in the Gulf of Mexico (e.g., Phleger 1951, Pflum and Frerichs 1976).

Subassociation D2: *Cassidulina carinata - Bolivina robusta*

STATIONS: E4, E25, E34, E63, W32, W60, W61 = 7

WATER DEPTH: 232-574 m (mean = 468 m)

SEDIMENT: Muddy sand to mud (28-92% mud; mean 58%).

DIVERSITY: Alpha = 10-15 (mean 12); H = 2.56-3.26 (mean 2.93); E = 0.43-0.60 (mean 0.53).

FAUNAL COMPOSITION (Fig. 25): This subassociation is dominated by *C. carinata* (mean relative abundance 17%) with subdominant *B. robusta* (9%), *A. weddellensis* (7%), *T. occidentalis* (7%) and *B. marginata* f. *marginata* (6%).

NEW ZEALAND DISTRIBUTION (Fig. 26): Occurs at upper bathyal depths (200-600 m) on the continental slopes west of the South Island and on the crest of the Chatham Rise.

Subassociation D3: *Cassidulina carinata - Abditodentrix pseudothalmanni*

STATIONS: E47, E48, E49, E50, S47 = 5

WATER DEPTH: 511-1244 m (mean = 969 m)

SEDIMENT: Muddy sand to sandy mud (27-71% mud; mean 47%).

DIVERSITY: Alpha = 9-18 (mean 14); H = 2.37-2.83 (mean 2.58); E = 0.27-0.37 (mean 0.34).

FAUNAL COMPOSITION (Fig. 25): This subassociation

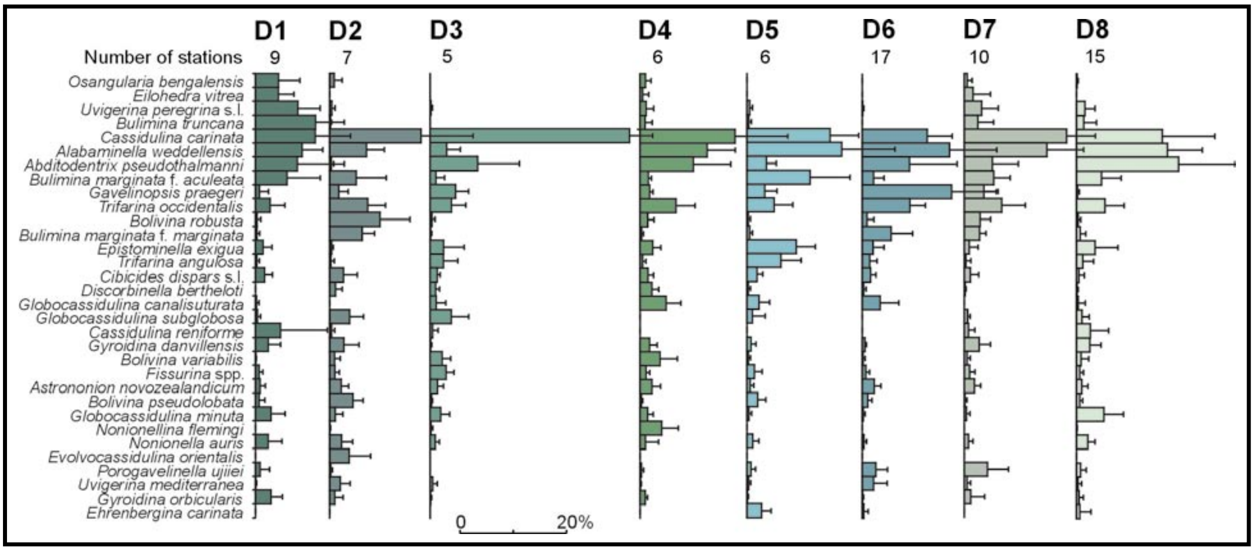


Figure 25. Mean relative abundance and standard deviation of the common species (>2% in one subassociation) in the subassociations of Association D identified from the chord cluster analysis dendrogram (Fig. 18), based on full census data.

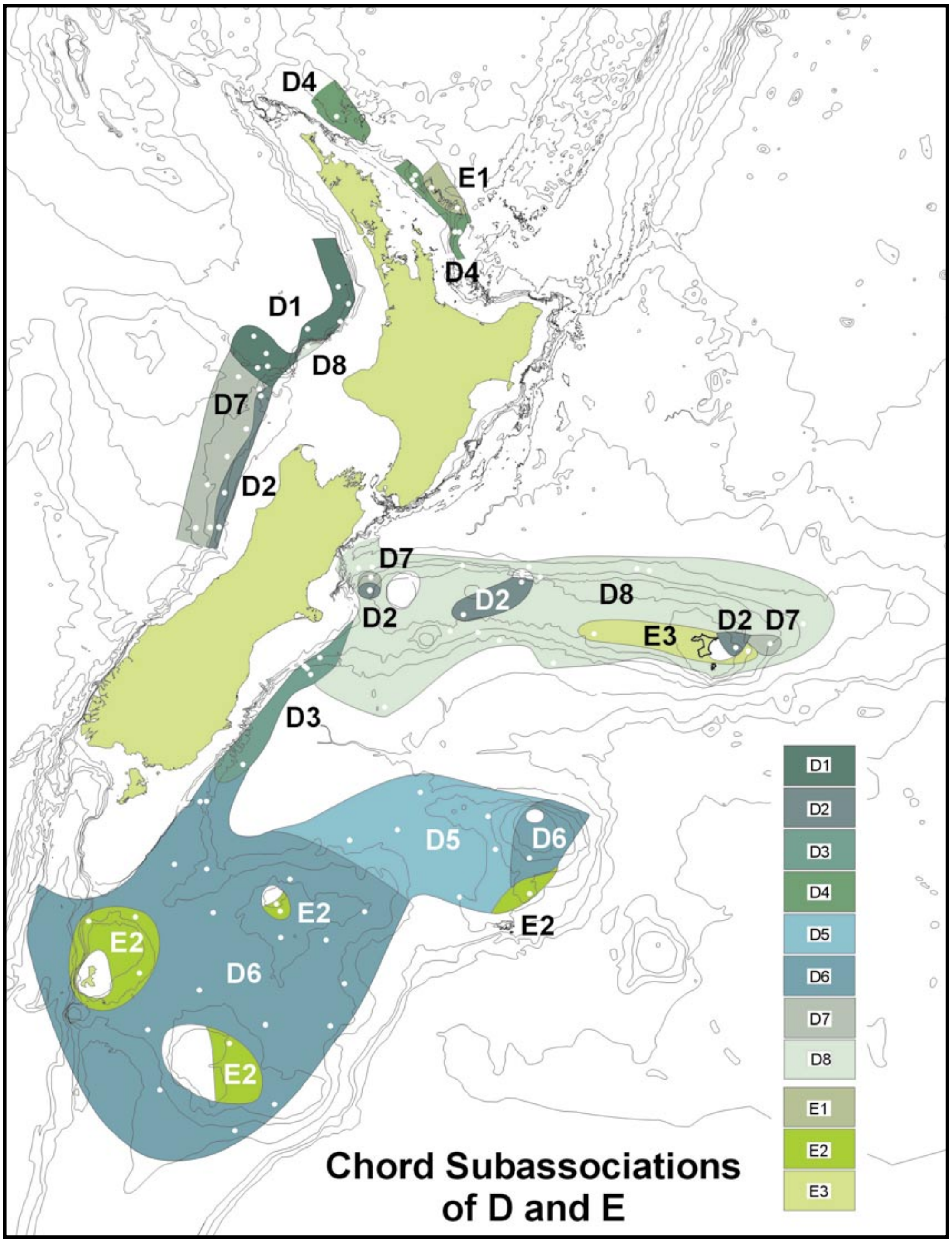


Figure 26. Distribution around New Zealand of the subassociations of foraminiferal sample associations D and E identified from the chord cluster analysis dendrogram (Fig. 18), based on full census data.

is strongly dominated by *C. carinata* (mean relative abundance 37%), with subdominant *A. pseudothalmanni* (9%) and *G. praegeri* (5%).

NEW ZEALAND DISTRIBUTION (Fig. 26): Confined to mid-lower bathyal depths (500-1300 m) on the continental slope off the southern half of the South Island.

Subassociation D4: *Cassidulina carinata - Alabaminella weddellensis - Abditodentrix pseudothalmanni*

STATIONS: N9, N15, N16, N17, N19, N20 = 6

WATER DEPTH: 754-2036 m (mean = 1155 m)

SEDIMENT: Sandy mud to mud (65-93% mud; mean 79%).

DIVERSITY: Alpha = 12-18 (mean 15); H = 2.62-3.23 (mean 2.97); E = 0.34-0.56 (mean 0.48).

FAUNAL COMPOSITION (Fig. 25): This subassociation is co-dominated by *C. carinata* (mean relative abundance 18%), *A. weddellensis* (13%) and *A. pseudothalmanni* (10%), with subdominant *T. occidentalis*, *Globocassidulina canalisuturata* and *Bolivina variabilis* (4-7% each).

NEW ZEALAND DISTRIBUTION (Fig. 26): Occurs at mid-lower bathyal depths on the continental slope east of northern New Zealand.

Subassociation D5: *Alabaminella weddellensis - Cassidulina carinata*

STATIONS: S39, S40, S43, S45, S46, S55 = 6
WATER DEPTH: 875-1668 m (mean = 1113 m)
SEDIMENT: Slightly muddy sand to sandy mud (13-62% mud; mean 33%).
DIVERSITY: Alpha = 8-10 (mean 10); H = 2.45-2.81 (mean 2.65); E = 0.40-0.53 (mean 0.47).
FAUNAL COMPOSITION (Fig. 25): This subassociation is co-dominated by *A. weddellensis* (mean relative abundance 18%), *C. carinata* (16%) and *B. marginata* f. *aculeata* (12%), with subdominant *E.* exigua, *T.. angulosa*, and *T. occidentalis* (5-9% each).
NEW ZEALAND DISTRIBUTION (Fig. 26): Occurs at lower bathyal depths on the Campbell and Bounty Plateaux, subantarctic New Zealand.

Subassociation D6: *Gavelinopsis praegeri - Alabaminella weddellensis - Cassidulina carinata*

STATIONS: S21, S22, S23, S24, S25, S26, S27, S30, S31, S32, S33, S34, S36, S37, S38, S42, S44 = 17
WATER DEPTH: 492-1004 m (mean = 676 m)
SEDIMENT: Slightly muddy sand to slightly sandy mud (18-81% mud; mean 51%).
DIVERSITY: Alpha = 6-12 (mean 9); H = 2.24-2.87 (mean 2.56); E = 0.30-0.59 (mean 0.43).
FAUNAL COMPOSITION (Fig. 25): This subassociation is dominated by *G. praegeri* (mean relative abundance 17%), A. *weddellensis* (16%) and *C. carinata* (12%), with subdominant *T. occidentalis* and *A. pseudothalmanni* (9% each).
NEW ZEALAND DISTRIBUTION (Fig. 26): Occurs at mid bathyal depths (500-1000 m) over the Campbell Plateau.
OVERSEAS COMPARISONS: *G. praegeri* is commonly a subdominant member of foraminiferal shelf-depth associations in many places around the globe (e.g., Murray 1991), but we have found no other records of it as a co-dominant species at mid bathyal depths as we have here.

Subassociation D7: *Cassidulina carinata - Alabaminella weddellensis*

STATIONS: E5, E27, W14, W33, W34, W55, W56, W57, W58, W59 = 10
WATER DEPTH: 651-968 m (mean = 782 m)
SEDIMENT: Sandy mud to mud (54-97% mud; mean 81%).
DIVERSITY: Alpha = 7-15 (mean 12); H = 2.42-3.13 (mean 2.78); E = 0.32-0.65 (mean 0.48).
FAUNAL COMPOSITION (Fig. 25): This subassociation is co-dominated by *C. carinata* (mean relative abundance 19%) and *A. weddellensis* (16%), with subdominant *T. occidentalis*, *Bulimina marginata* f. *aculeata*, *A. pseudothalmanni*, *Porogavelinella ujiiei* and *G. praegeri* (4-7 % each).
NEW ZEALAND DISTRIBUTION (Fig. 26): Occurs at mid bathyal depths (600-1000 m) on the lower continental slope off the west coast and at similar depths on the upper slopes of the Chatham Rise.

Subassociation D8: *Abditodentrix pseudothalmanni - Alabaminella weddellensis - Cassidulina carinata*

STATIONS: E6, E7, E12, E13, E14, E17, E18, E28, E33, E35, E36, E37, E52, N18, W25 = 15
WATER DEPTH: 498-1646 m (mean = 1106 m)
SEDIMENT: Muddy sand to mud (24-97% mud; mean 75%).
DIVERSITY: Alpha = 6-15 (mean 9); H = 2.10-2.92 (mean 2.52); E = 0.37-0.55 (mean 0.45).
FAUNAL COMPOSITION (Fig. 25): This subassociation is co-dominated by *A. pseudothalmanni* (mean relative abundance 19%), *A. weddellensis* (17%) and *C. carinata* (16%), with subdominant *T. occidentalis*, *Globocassidulina minuta* and *B. marginata* f. *aculeata* (5% each).
NEW ZEALAND DISTRIBUTION (Fig. 26): Occurs at a wide range of mid-lower bathyal depths (500-2000 m) on the northern and southern upper slopes of the Chatham Rise with two stations on the continental slope one east and one west of the North Island.
OVERSEAS COMPARISONS: Although *A. pseudothalmanni* is relatively common around the world, we have not yet come across other records of it being a co-dominant species in an association.

Association E: *Globocassidulina canalisuturata - Bolivina robusta*

STATIONS: E26, E32, S16, S17, S18, S19, S20, S28, S29, S35, N23, N25 = 12
WATER DEPTH: 289-722 m (mean = 537 m)
SEDIMENT: Sand to muddy sand (3-34% mud; mean 19%).
DIVERSITY: Alpha = 5-22 (mean 11); H = 1.78-3.28 (mean 2.6); E = 0.26-0.58 (mean 0.46).
FAUNAL COMPOSITION (Fig. 19): This association is co-dominated by *Globocassidulina canalisuturata* (mean relative abundance 15%) and *Bolivina robusta* (13%). Subdominant are *C. dispars*, *C. carinata*, *Gavelinopsis praegeri* and *Trifarina angulosa* (5-10% each).
NEW ZEALAND DISTRIBUTION (Figs 20-21): This association occurs at mid-upper bathyal depths (250-750 m water depth) off the east coast of New Zealand. It has not been recorded to date from off the west coast. These sites are bathed by the upper part of AAIW and on the Campbell Plateau and Chatham Rise by SAMW. Samples are characterised by relatively low mud content.
OVERSEAS COMPARISONS: This may be a west Pacific association, as similar faunas dominated by *B. robusta – Globocassidulina* spp. occur at mid and upper bathyal depths in the South China Sea (Polski 1959) and a *B. robusta* association has been reported from mid bathyal depths in Indonesia (Van Marle 1988).
SUBASSOCIATIONS: Three subassociations (Fig. 27, Table 9) can be recognised within Association E on the chord cluster analysis dendrogram (Fig. 18). The largest (E2) is confined to the Campbell and Bounty Plateaux off southern New Zealand, whereas the two samples in E1 occur on the bathyal slopes east of Northland and E3 occurs on the bathyal slopes of the east Chatham Rise (Fig. 26). The three subassociations are discriminated largely on the basis of the relative abundance of their subdominant

species with southern faunas having more abundant *G. praegeri*, *Neouvigerina proboscidea*, *Bulimina striata*, *Globocassidulina crassa* and *Ehrenbergina* spp., eastern faunas having more *Trifarina angulosa*, *Bolivina robusta*, *Uvigerina mediterranea*, *Discorbinella subcomplanata* and *Bolivina pseudolobata* and the northern faunas having more *Globocassidulina spherica*, *Osangularia bengalensis*, *Trifarina bradyi*, *Pullenia quinqueloba* and *B. marginata* f. *aculeata.*

Subassociation E1: *Bolivina robusta - Globocassidulina canalisuturata*

STATIONS: N23, N25 = 2

WATER DEPTH: 549-615 m (mean = 582 m)

SEDIMENT: Muddy sand (21-22% mud; mean 22%).

DIVERSITY: Alpha = 21-22 (mean 21); H = 3.28 (mean 3.28); E = 0.50-0.51 (mean 0.50).

FAUNAL COMPOSITION (Fig. 27): This subassociation is co-dominated by *B. robusta* (mean relative abundance 12%) and *G. canalisuturata* (9%), with subdominant *C. carinata*, *C. dispars, Anomalinoides sphericus* and *T. angulosa* (5-7%).

NEW ZEALAND DISTRIBUTION (Fig. 26): The two stations in this subassociation occur relatively close together on the continental slope east of northern New Zealand.

Subassociation E2: *Globocassidulina canalisuturata - Bolivina robusta*

STATIONS: S16, S17, S18, S19, S20, S28, S29, S35 = 8

WATER DEPTH: 353-722 m (mean = 478 m)

SEDIMENT: Sand to muddy sand (4-34% mud; mean 20%).

DIVERSITY: Alpha = 5-14 (mean 8); H = 1.78-2.96 (mean 2.42); E = 0.26-0.58 (mean 0.45).

FAUNAL COMPOSITION (Fig. 27): This subassociation is co-dominated by *G. canalisuturata* (mean relative abundance 19%) and *B. robusta* (11%), with subdominant *G. praegeri*, *C. dispars*, *C. carinata*, *T. angulosa* and *Neouvigerina proboscidea* (5-8% each).

Table 9. Mean and standard deviation (SD) for physical, chemical and species diversity values for subassociations in deep-sea benthic foraminiferal Associations E and F.

Chord Associations	E1	SD	E2	SD	E3	SD	F1	SD	F2	SD	F3	SD
Number of stations	2		8		2		6		14		5	
Depth (metres)	582	47	478	136	456	236	255	115	148	41	141	81
Alpha	21.3	0.3	7.9	2.8	11.3	7.0	12.3	0.6	6.8	2.5	10.2	5.3
Shannon-Wiener Index, H	3.28	0.00	2.42	0.38	2.66	0.67	2.74	0.10	2.08	0.43	2.17	0.69
Evenness, E	0.50	0.01	0.45	0.11	0.48	0.11	0.45	0.05	0.36	0.08	0.31	0.11
% mud	22	1	20	11	4	1	25	21	8	6	5	3
% planktic foraminifera	85	4	76	21	90	6	50	16	32	13	35	6
Fragmentation Index	5	1	6	3	5	1	17	16	7	4	34	17
Chlorophyll-a	0.24	0.01	0.48	0.11	0.39	0.10	0.81	0.02	0.53	0.20	0.54	0.19
Flux, Jz	0.39	0.01	1.44	0.43	1.36	1.13	7.20	4.33	6.34	4.62	6.49	3.70
Sea surface temperature, SST	18.3	0.2	9.3	0.9	13.68	0.35	11.8	0.5	9.6	1.1	13.0	0.5
Bottom temperature	9.5	0.8	7.2	0.9	11.20	3.54	13.9	1.8	9.2	1.7	15.7	1.1
Salinity	34.7	0.1	34.4	0.1	34.95	0.45	35.2	0.2	34.5	0.2	35.5	0.1
Bottom oxygen (ml/l)	4.6	0.1	5.9	0.4	5.3	0.6	6.3	0.2	6.3	0.5	5.7	0.4
Surface phosphate (umol/l)	0.29	0.01	0.91	0.11	0.37	0.00	0.63	0.10	0.90	0.15	0.42	0.05

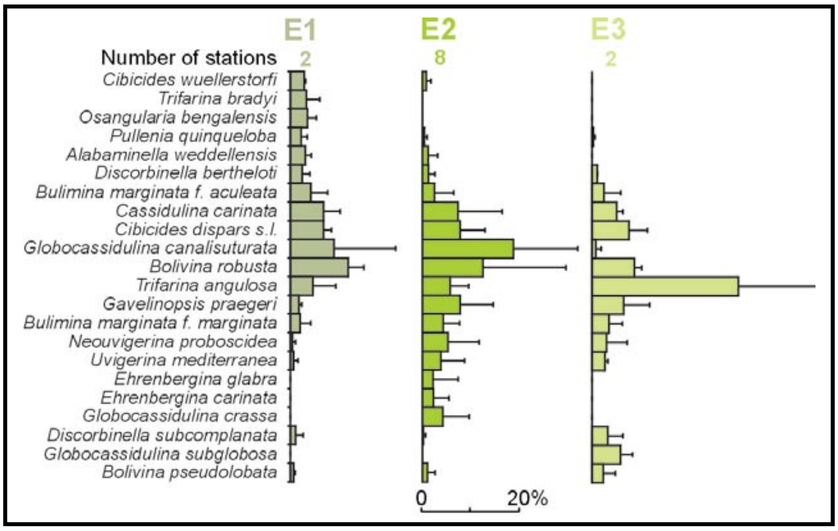


Figure 27. Mean relative abundance and standard deviation of the common species (>2% in one subassociation) in the subassociations of Association E identified from the chord cluster analysis dendrogram (Fig. 18), based on full census data.

NEW ZEALAND DISTRIBUTION (Fig. 26): Occurs on the mid to upper bathyal slopes of the Auckland, Campbell, Pukaki and Bounty seamounts on the Campbell and Bounty Plateaux off southern New Zealand.

Subassociation E3: *Trifarina angulosa - Bolivina robusta*

STATIONS: E26, E32 = 2

WATER DEPTH: 289-623 m (mean = 456 m)

SEDIMENT: Sand (3-4% mud; mean 4%).

DIVERSITY: Alpha = 6-16 (mean 11); H = 2.18-3.13 (mean 2.66); E = 0.40-0.56 (mean 0.48).

FAUNAL COMPOSITION (Fig. 27): This subassociation is strongly dominated by *T. angulosa* (mean relative abundance 30%), subdominant *B.* robusta, *C. dispars*, *G. praegeri*, *G. subglobosa* and *C. carinata* (5-9% each).

NEW ZEALAND DISTRIBUTION (Fig. 26): Confined to the eastern end of the Chatham Rise in current-swept, clean sand at upper bathyal depths.

Association F: *Cassidulina carinata - Trifarina angulosa*

STATIONS: E2, E3, E9, E10, E11, E23, E24, E43, E44, E45, E46, S1, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15 = 25

WATER DEPTH: 50-393 m (mean = 172 m)

SEDIMENT: Sand to sandy mud (2-56% mud; mean 12%).

DIVERSITY: Alpha = 2-18 (mean 9); H = 1.18-2.99 (mean 2.25); E = 0.16-0.55 (mean 0.37).

FAUNAL COMPOSITION (Fig. 19): This association is dominated by *Cassidulina carinata* (mean relative abundance 34%) with subdominant *T. angulosa* (16%), *G. praegeri* (10%) and *C. dispars* (5%).

NEW ZEALAND DISTRIBUTION (Figs 20-21): This is the shallow-water association off the east coast of the South Island, where it occurs at mid shelf to uppermost bathyal depths (50-400 m). It is bathed by Subantarctic Mode Water (SAMW), Subantarctic Water (SAW) and cool Subtropical Water (STW). As might be expected at these current-swept shallower depths, the sediment is relatively clean with a mean mud content of 12%.

OVERSEAS COMPARISONS: Associations with the same two dominants occur in current-swept environments in the North Sea (e.g., Qvale & Van Weering 1985, Qvale 1986), North Atlantic (e.g., Schnitker 1969, Caralp *et al.* 1970), Mediterranean Sea (Jorissen 1988), and North Pacific (e.g., McGlasson 1959).

SUBASSOCIATIONS: Three subassociations (Fig. 28, Table 9) can be recognised within Association F on the chord cluster analysis dendrogram (Fig. 18). These are largely separated by the relative abundance of their secondary subdominant species (Fig. 28) with F1 characterised by the most abundant *Nonionellina flemingi*, *Notorotalia profunda*, *N. zealandica*, *A. weddellensis* and *Elphidium charlottense*; F2 by most abundant *G. canalisuturata*, *Notorotalia aucklandica* and *Textularia pseudogramen*; and F3 by most abundant *Evolvocassidulina orientalis* and *Discorbinella bertheloti.*

Subassociation F1: *Cassidulina carinata - Trifarina angulosa*

STATIONS: E2, E3, E43, E44, E45, E46 = 6

WATER DEPTH: 100-393 m (mean = 255 m)

SEDIMENT: Sand to sandy mud (6-56% mud; mean 25%).

DIVERSITY: Alpha = 12-13 (mean 12); H = 2.59-2.88 (mean 2.74); E = 0.40-0.53 (mean 0.45).

FAUNAL COMPOSITION (Fig. 28): This subassociation is co-dominated by *C. carinata* (mean relative abundance 22%) and *T. angulosa* (16%), with subdominant *Nonionellina flemingi*, *B. marginata* f. *marginata* and *G. subglobosa* (5-7% each).

NEW ZEALAND DISTRIBUTION (Fig. 29): Confined to outer shelf and upper bathyal depths (100-400 m) along the crest of the continental slope east of the South Island.

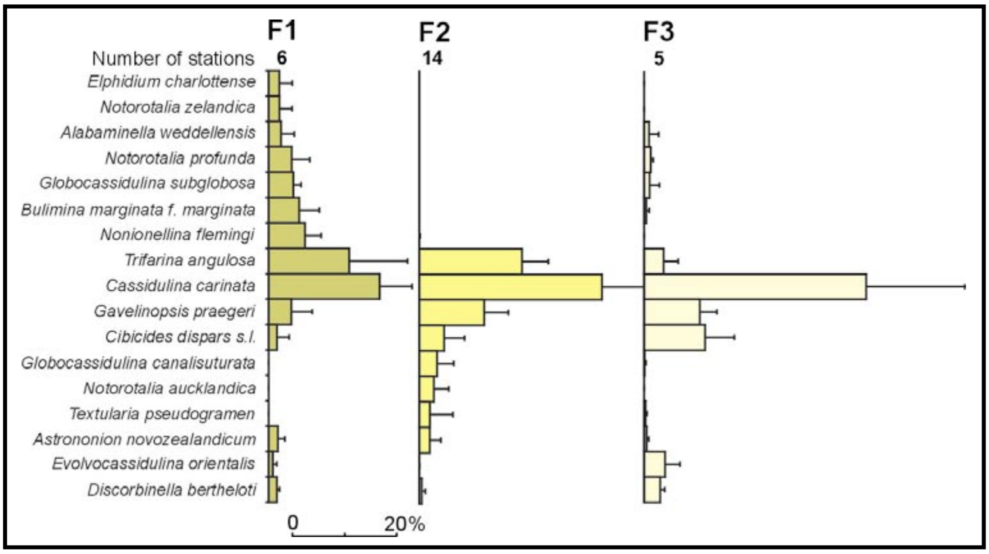


Figure 28. Mean relative abundance and standard deviation of the common species (>2% in one subassociation) in the subassociations of Association F identified from the chord cluster analysis dendrogram (Fig. 18), based on full census data.

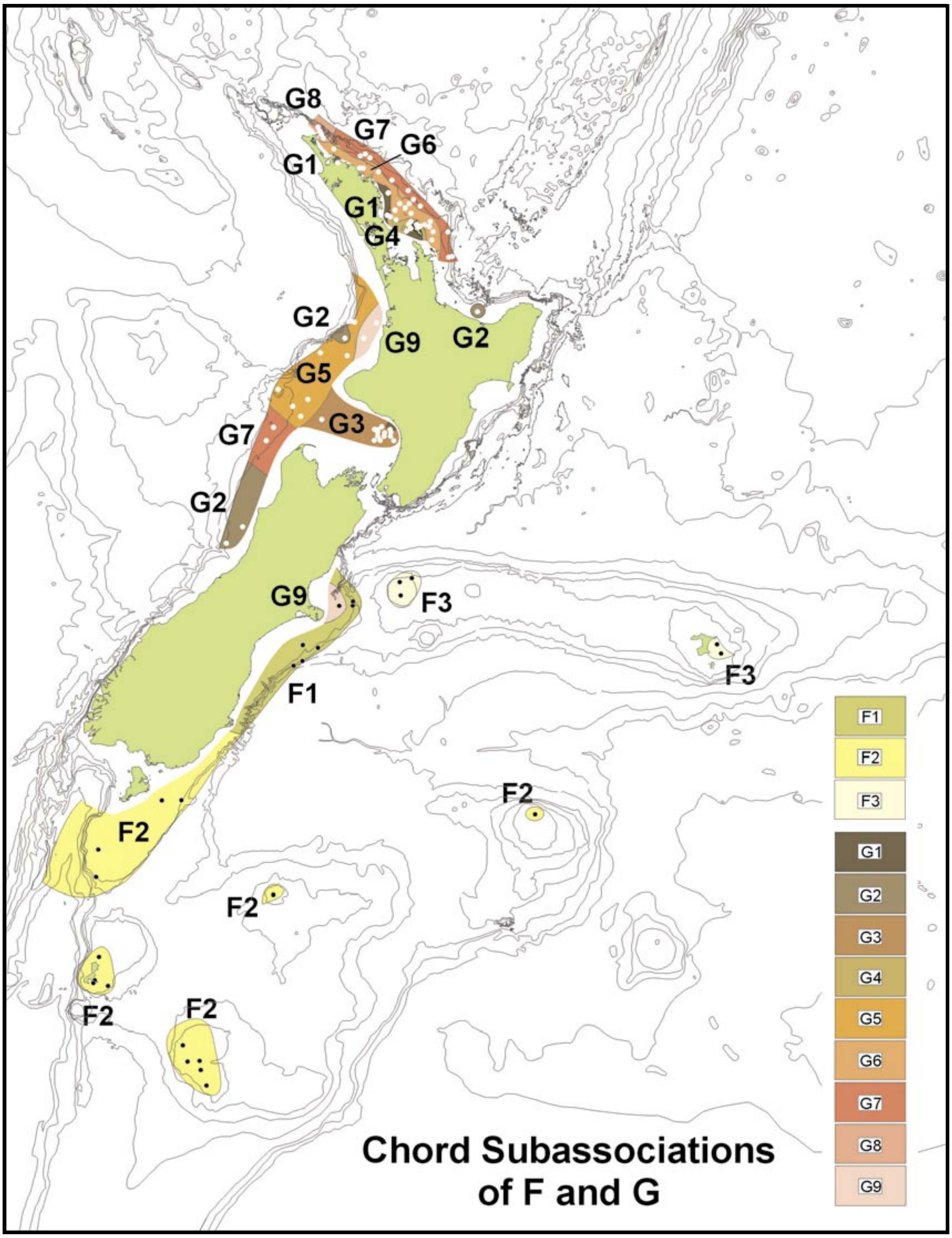


Figure 29. Distribution around New Zealand of the subassociations of foraminiferal sample associations F and G identified from the chord cluster analysis dendrogram (Fig. 18), based on full census data.

Subassociation F2: *Cassidulina carinata - Trifarina angulosa - Gavelinopsis praegeri*

STATIONS: S1, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15 = 14
WATER DEPTH: 50-188 m (mean = 148 m)
SEDIMENT: Sand to slightly muddy sand (2-21% mud; mean 8%).
DIVERSITY: Alpha = 2-10 (mean 7); H = 1.33-2.72 (mean 2.08); E = 0.23-0.55 (mean 0.36).
FAUNAL COMPOSITION (Fig. 28): This subassociation is strongly dominated by *C. carinata* (mean relative abundance 35%), with *T. angulosa* (20%) and *G. praegeri* (13%) as secondary dominants.
NEW ZEALAND DISTRIBUTION (Fig. 29): Occurs at mid-outer shelf depths in relatively clean sand near the crests of four subantarctic seamounts (Auckland, Campbell, Pukaki, and Bounty) and on the shelf south and east of Stewart Island.

Subassociation F3: *Cassidulina carinata - Cibicides dispars s.l. - Gavelinopsis praegeri*

STATIONS: E9, E10, E11, E23, E24 = 5
WATER DEPTH: 91-285 m (mean = 141 m)
SEDIMENT: Sand (3-9% mud; mean 5%).

DIVERSITY: Alpha = 5-18 (mean 10); H = 1.18-2.99 (mean 2.17); E = 0.16-0.43 (mean 0.31).

FAUNAL COMPOSITION (Fig. 28): This subassociation is strongly dominated by *C. carinata* (mean relative abundance 43%), with *C. dispars* (12%) and *G. praegeri* (11%) as secondary dominants. No other taxa comprise more than 5% of the fauna.

NEW ZEALAND DISTRIBUTION (Fig. 29): Occurs at outer shelf and uppermost bathyal depths (90-300 m) on the shallower parts of the Chatham Rise, such as adjacent to Chatham Islands.

Association G: *Cassidulina carinata - Bulimina marginata* f. *marginata*

STATIONS: E1, N21, N22, N24, N26, N27, N28, N29, N30, N31, N32, N33, N34, N35, N36, N37, N38, N39, N40, N41, N42, N43, N44, N45, N46, N47, N48, N49, N50, N51, N52, N53, N54, N55, N56, N57, N58, N59, N60, N61, N62, N63, N64, N65, N66, N67, N68, N70, N71, N72, N75, W11, W12, W13, W18, W19, W23, W24, W27, W28, W29, W30, W31, W40, W41, W42, W43, W44, W45, W46, W47, W48, W49, W51, W52, W53, W62, W63, W64, W65 = 80

WATER DEPTH: 50-736 m (mean = 166 m)

SEDIMENT: Sand to mud (2-93% mud; mean 28%).

DIVERSITY: Alpha = 7-23 (mean 14); H = 1.95-3.42 (mean 2.96); E = 0.21-0.69 (mean 0.51).

FAUNAL COMPOSITION (Fig. 19): This association is co-dominated by *C. carinata* (mean relative abundance 14%) and *Bulimina marginata* f. *marginata* (10%). Subdominant are *Gavelinopsis praegeri* (8%) and *Discorbinella bertheloti* (6%).

NEW ZEALAND DISTRIBUTION (Figs 20-21): This is the northern shallow-water association occurring around the coast of the North Island and northern half of the South Island. It is largely bathed by STW. The deepest occurrences (e.g., stns. N21, N22, N24) are on the steep continental slope off eastern Northland and could conceivably include faunas that have been transported downslope.

OVERSEAS COMPARISONS: This association also occurs at mid shelf to mid bathyal depths in the Mediterranean Sea (e.g., Jorissen 1998, Sgarrella *et al.* 1985).

SUBASSOCIATIONS: Nine subassociations (Fig. 30, Table 10) can be recognised within Association G on the chord cluster analysis dendrogram (Fig. 18). Five of these subassociations have restricted geographic occurrence with G1, G4 and G8 only present east of northern New Zealand, and G3 and G5 only present off the west coast of central New Zealand (Fig. 29). The remaining four subassociations occur off both the east and west coasts. It appears to be the relative abundance of both the dominant and secondary subdominant species that discriminates the various subassociations (Fig. 30).

Subassociation G1: *Bulimina marginata* f. *marginata - Gavelinopsis praegeri*

STATIONS: N55, N56, N57, N58, N59, N60, N61, N62, N63, N64, N65, N66, N67, N68, N70, N72 = 16

WATER DEPTH: 50-68 m (mean = 55 m)

SEDIMENT: Sand to muddy sand (3-38% mud; mean 18%).

DIVERSITY: Alpha = 11-20 (mean 17); H = 2.81-3.42 (mean 3.18); E = 0.40-0.68 (mean 0.56).

FAUNAL COMPOSITION (Fig. 30): This subassociation is co-dominated by *B. marginata* f. *marginata* (mean relative abundance 13%) and *Gavelinopsis praegeri* (9%), with subdominant *Discorbinella bertheloti* and *Spiroplectinella proxispira* (5-6%).

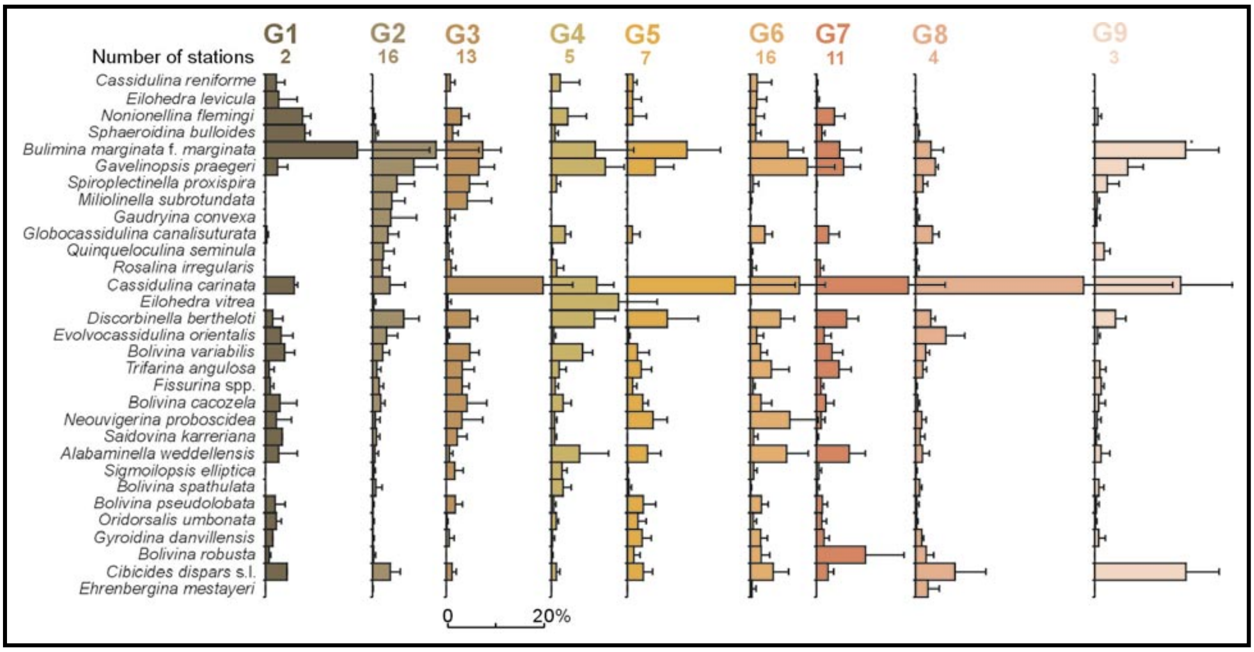


Figure 30. Mean relative abundance and standard deviation of the common species (>2% in one subassociation) in the subassociations of Association G identified from the chord cluster analysis dendrogram (Fig. 18), based on full census data.

Table 10. Mean and standard deviation (SD) for physical, chemical and species diversity values for subassociations in deep-sea benthic foraminiferal Association G.

Chord Associations	**G1**	**SD**	**G2**	**SD**	**G3**	**SD**	**G4**	**SD**	**G5**	**SD**	**G6**	**SD**	**G7**	**SD**	**G8**	**SD**	**G9**	**SD**
Number of stations	16		2		13		5		7		16		11		4		3	
Depth (metres)	55	6	130	34	84	18	75	17	196	56	152	46	414	122	403	233	80	18
Alpha	16.7	2.8	12.3	2.2	12.8	3.5	11.6	1.4	10.6	2.6	13.3	2.6	14.4	2.7	17.9	5.0	9.6	3.0
Shannon-Wiener Index, H	3.18	0.19	3.00	0.37	2.95	0.24	2.83	0.08	2.72	0.29	3.01	0.17	2.98	0.17	2.74	0.55	2.54	0.25
Evenness, E	0.56	0.08	0.59	0.15	0.53	0.06	0.49	0.01	0.48	0.08	0.54	0.04	0.49	0.06	0.37	0.12	0.43	0.06
% mud			86	10	49	18			58	27			46	15	17	10	2	1
% planktic foraminifera	14	7	24	6	12	10	20	4	41	14	37	11	62	16	31	5	19	6
Fragmentation Index			8	2					6	1	10	8	5	2	17	7	15	18
Chlorophyll-a	0.26	0.05	0.31	0.01	0.43	0.04	0.25	0.00	0.26	0.02	0.24	0.01	0.25	0.05	0.21	0.00	0.43	0.35
Flux, Jz	4.89	1.82	2.67	0.61	7.05	2.00	3.49	0.87	1.41	0.39	1.70	0.54	0.69	0.31	0.59	0.28	7.62	7.97
Sea surface temperature, SST	18.2	0.8	16.5	1.6	15.3	0.2	18.4	0.1	16.3	0.4	18.2	0.4	17.9	1.1	18.6	0.0	15.4	2.6
Bottom temperature	20.6	1.8	16.1	4.5	13.6	0.2	20.4	0.6	12.2	0.7	17.5	1.8	12.0	2.1	12.9	3.8	14.6	1.7
Salinity	35.7	0.1	35.4	0.3	35.2	0.0	35.7	0.0	35.1	0.1	35.5	0.1	34.9	0.4	35.1	0.4	35.3	0.2
Bottom oxygen (ml/l)	5.1	0.2	4.4	0.8	4.4	0.1	5.1	0.1	3.8	0.0	4.8	0.3	4.4	0.4	4.7	0.1	5.0	1.1
Surface phosphate (umol/l)	0.30	0.02	0.29	0.01	0.26	0.00	0.30	0.01	0.27	0.01	0.30	0.02	0.30	0.02	0.33	0.00	0.35	0.14

NEW ZEALAND DISTRIBUTION (Fig. 29): Confined to mid shelf depths (50-70 m) around the exposed eastern coast of northern New Zealand, from Great Barrier to Doubtless Bay.

Subassociation G2: *Bulimina marginata* f. *marginata* - *Sphaeroidina bulloides*

STATIONS: N75, W65 = 2

WATER DEPTH: 106-154 m (mean = 130 m)

SEDIMENT: Slightly sandy mud to mud (79-93% mud; mean 86%).

DIVERSITY: Alpha = 11-14 (mean 12); H = 2.74-3.27 (mean 3.00); E = 0.48-0.69 (mean 0.59).

FAUNAL COMPOSITION (Fig. 30): This subassociation is dominated by *B. marginata* f. *marginata* (mean relative abundance 19%), with *Sphaeroidina bulloides* (9%) the second-most abundant. Subdominant are *N. flemingi* and *C. carinata* (6-9%).

NEW ZEALAND DISTRIBUTION (Fig. 29): These two stations occur at outer shelf depths in relatively muddy sediment one off the west coast of the South Island and the other off the east coast (Bay of Plenty) of the North Island.

Subassociation G3: *Cassidulina carinata* - *Bulimina marginata* f. *marginata* – *Gavelinopsis praegeri*

STATIONS: W27, W40, W41, W42, W43, W44, W45, W46, W47, W48, W49, W51, W52 = 13

WATER DEPTH: 55-109 m (mean = 84 m)

SEDIMENT: Muddy sand to sandy mud (24-74% mud; mean 49%).

DIVERSITY: Alpha = 8-18 (mean 13); H = 2.53-3.32 (mean 2.95); E = 0.45-0.62 (mean 0.53).

FAUNAL COMPOSITION (Fig. 30): This subassociation is dominated by *C. carinata* (mean relative abundance 20%), with *B. marginata* f. *marginata* the second-most abundant (8%). Subdominant are *G. praegeri*, *D. bertheloti*, *B. variabilis* and *S. proxispira* (5-7% each),

NEW ZEALAND DISTRIBUTION (Fig. 29): Confined to mid shelf depths (50-110 m) in Wanganui Bight and western Cook Strait off the west coast of central New Zealand.

Subassociation G4: *Eilohedra vitrea* - *Gavelinopsis praegeri*

STATIONS: N51, N52, N53, N54, N71 = 5

WATER DEPTH: 51-96 m (mean = 75 m)

SEDIMENT: Not measured.

DIVERSITY: Alpha = 9-13 (mean 12); H = 2.70-2.90 (mean 2.83); E = 0.48-0.50 (mean 0.49).

FAUNAL COMPOSITION (Fig. 30): This subassociation is co-dominated by *Eilohedra vitrea* (mean relative abundance 14%) and *G. praegeri* (11%). Subdominant are *C. carinata*, *B. marginata* f. *marginata* and *D. bertheloti* (9% each), and *B. variabilis* and *A. weddellensis* (6% each).

NEW ZEALAND DISTRIBUTION (Fig. 29): Confined to mid shelf depths (50-100 m) in the entrance to the Hauraki Gulf and off Great Barrier Island on the east coast of northern New Zealand.

OVERSEAS COMPARISONS: Faunas dominated by *E. vitrea* are uncommon, but have been reported from the North Atlantic from similar mid shelf depths (e.g., Murray 1979).

Subassociation G5: *Cassidulina carinata - Bulimina marginata* f. *marginata – Discorbinella bertheloti*

STATIONS: W12, W23, W24, W28, W29, W30, W31 = 7
WATER DEPTH: 121-276 m (mean = 196 m)
SEDIMENT: Muddy sand to mud (32-97% mud; mean 58%).
DIVERSITY: Alpha = 7-14 (mean 11); H = 2.30-3.06 (mean 2.72); E = 0.36-0.60 (mean 0.48).
FAUNAL COMPOSITION (Fig. 30): This subassociation is co-dominated by *C. carinata* (mean relative abundance 22%) and *B. marginata* f. *marginata* (12%), with subdominant *D. bertheloti*, *G. praegeri* and *N. proboscidea* (5-8%).
NEW ZEALAND DISTRIBUTION (Fig. 29): Confined to the outer shelf and uppermost bathyal (100-300 m) on the outer half of the continental shelf off the west coast of the North Island.

Subassociation G6: *Gavelinopsis praegeri - Cassidulina carinata*

STATIONS: N34, N37, N38, N39, N40, N41, N42, N43, N44, N45, N46, N47, N48, N49, N50, W19 = 16
WATER DEPTH: 97-276 m (mean = 152 m)
SEDIMENT: Sand to muddy sand (5-47% mud; mean 32%).
DIVERSITY: Alpha = 9-17 (mean 13); H = 2.62-3.17 (mean 3.01); E = 0.43-0.61 (mean 0.54).
FAUNAL COMPOSITION (Fig. 30): This subassociation is co-dominated by *G. praegeri* and *C. carinata* (mean relative abundance 10-11% each), with subdominant *N. proboscidea*, *B. marginata* f. *marginata*, *A. weddellensis* and *D. bertheloti* (6-8% each).
NEW ZEALAND DISTRIBUTION (Fig. 29): Confined to the outer shelf and uppermost bathyal (100-300 m) along the outer part of the continental shelf off the east coast of northern New Zealand.
OVERSEAS COMPARISONS: *G. praegeri* is relatively common globally but only occurs as a dominant species in associations in a few places, such as mid-outer shelf depths in the North Atlantic (Schnitker 1969, Murray 1979) and Indian Ocean (Frerichs 1970).

Subassociation G7: *Cassidulina carinata - Bolivina robusta*

STATIONS: N22, N24, N26, N27, N28, N30, N31, N32, N35, W62, W63 = 11
WATER DEPTH: 271-669 m (mean = 414 m)
SEDIMENT: Muddy sand to sandy mud (26-74% mud; mean 46%).
DIVERSITY: Alpha = 9-19 (mean 14); H = 2.65-3.23 (mean 2.98); E = 0.42-0.59 (mean 0.49).
FAUNAL COMPOSITION (Fig. 30): This subassociation is dominated by *C. carinata* (mean relative abundance 19%) and *B. robusta* (10%), with subdominant *A. weddellensis*, *D. bertheloti*, *G. praegeri*, *B. marginata* f. *marginata* and *T. angulosa* (5-7% each).
NEW ZEALAND DISTRIBUTION (Fig. 29): Occurs at upper bathyal depths (250-700 m) along much of the continental slope east of northern New Zealand, but also in two stations in a similar setting off the north west tip of the South Island.

Subassociation G8: *Cassidulina carinata - Cibicides dispars* s.l.

STATIONS: N21, N29, N33, N36 = 4
WATER DEPTH: 210-736 m (mean = 403 m)
SEDIMENT: Sand to muddy sand (9-31% mud; mean 17%).
DIVERSITY: Alpha = 11-23 (mean 18); H = 1.95-3.19 (mean 2.74); E = 0.21-0.50 (mean 0.37).
FAUNAL COMPOSITION (Fig. 30): This subassociation is strongly dominated by *C. carinata* (mean relative abundance 35%), with subdominant *C. dispars* (8%) and *Evolvocassidulina orientalis* (6%).
NEW ZEALAND DISTRIBUTION (Fig. 29): Confined to upper bathyal depths (200-750 m) on the continental slope off the east coast of the northern tip (North Cape) of the North Island.

Subassociation G9: *Cibicides dispars* s.l. *- Bulimina marginata* f. *marginata - Cassidulina carinata*

STATIONS: E1, W11, W18 = 3
WATER DEPTH: 60-91 m (mean = 80 m)
SEDIMENT: Clean sand (1-2% mud; mean 2%).
DIVERSITY: Alpha = 7-13 (mean 10); H = 2.38-2.83 (mean 2.54); E = 0.36-0.47 (mean 0.43).
FAUNAL COMPOSITION (Fig. 30): This subassociation is co-dominated by *C. dispars*, *B. marginata* f. *marginata*, and *C. carinata* (mean relative abundance 18-19% each), with subdominant *G. praegeri* (7%).
NEW ZEALAND DISTRIBUTION (Fig. 29): This association occurs at mid bathyal depths (50-100 m) on the continental shelf west of the North Island and in one station east of the South Island (off Banks Peninsula).
OVERSEAS COMPARISONS: Similar faunas co-dominated by *C. dispars* are only reported from mid shelf depths off Argentina in the South Atlantic (Boltovskoy & Totah 1985).

Sample associations based on presence/absence data

Inspection of the dendrogram produced by Q-mode cluster analysis (Jaccard distance matrix) on presence/absence data for all species (Fig. 31) shows the existence of nine high-level groups of samples (Associations a-i), four of which (a, d, e, h) can be readily split into 2-4 subassociations each (Fig. 31). These associations and subassociations are mapped geographically and bathymetrically in Figs 32-33 and summarised in Table 11.

The associations can be ranked bathymetrically from deep to shallow, with a1, b (mid-lower abyssal) and c (upper-mid abyssal) the deepest, shallowing up through a2, d and e (bathyal-mid abyssal) then g and i (mostly upper bathyal) to f and h (mostly mid-outer shelf). This

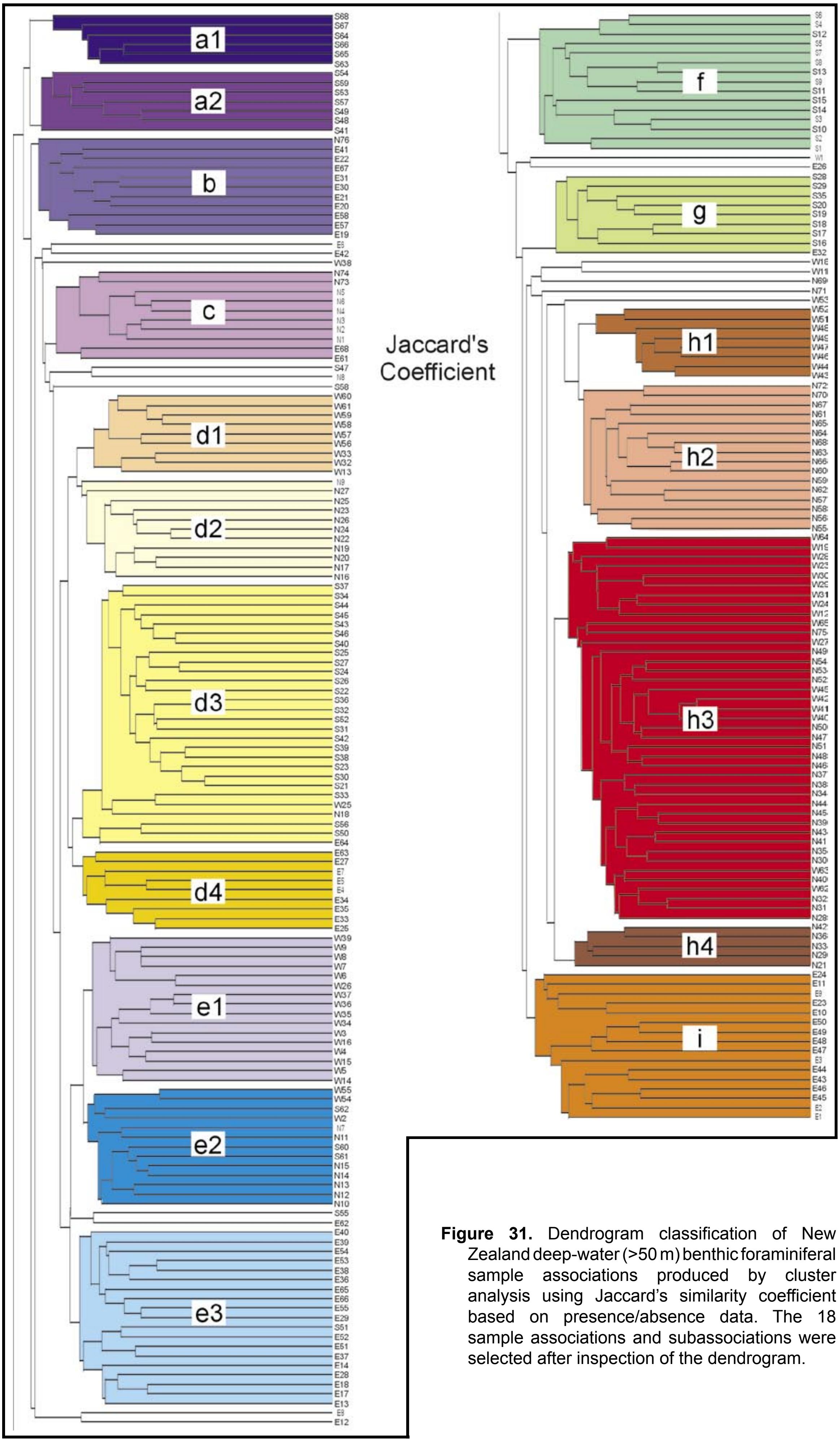


Figure 31. Dendrogram classification of New Zealand deep-water (>50 m) benthic foraminiferal sample associations produced by cluster analysis using Jaccard's similarity coefficient based on presence/absence data. The 18 sample associations and subassociations were selected after inspection of the dendrogram.

Table 11. Summary of bathymetric, geographic and water mass range of deep-water benthic foraminiferal sample associations and subassociations based on presence/absence data (Fig. 31).

[1] North-east, south, east and west of New Zealand. In brackets = minor representation in this region.

Association pres/abs data	**Similar Assoc full census data**	**No stns**	**Depth**	**Regions**	**Water mass**
a	A1, B	13	mid bathyal - lower abyssal	S	AAIW, uCPDW
a1	A1	6	mid-lower abyssal	S	lower CPDW
a2	B	7	mid-lower bathyal	S	AAIW, uCPDW
b	A2, C5, C7	11	mid-lower abyssal	E (NE)	lower CPDW
c	C1, C2, C4	10	upper-mid abyssal	NE (E)	CPDW
d	C6, D2, D4-8, E1	57	bathyal	NE, W, E, S	SAMW, AAIW, uCPDW
d1	D2, D7	9	mid bathyal	W	AAIW
d2	D4, E1, G7	11	bathyal	NE	AAIW, uCPDW
d3	C6, D5, D6, D8	28	bathyal	S (NE, E, W)	SAMW, AAIW,uCPDW
d4	D2, D7, D8	9	bathyal	E	SAMW, AAIW, uCPDW
e	C2-4, C6, D1, D8	50	mid shelf-mid abyssal	NE, E, W, S	STW, AAIW, CPDW
e1	C3, D1	16	mid shelf-bathyal	W	STW, AAIW, uCPDW
e2	C2, C4, D8	13	lower bathyal-mid abyssal	NE, S (W)	AAIW, CPDW
e3	C6, D8	19	lower bathyal-upper abyssal	E (S)	AAIW, uCPDW
f	F2	15	mid-outer shelf	S	SAW
g	E2, E3	9	upper bathyal	S, (E)	SAW, SAMW
h	G	71	mid shelf-mid bathyal	NE, W	STW, AAIW
h1	G3	8	mid shelf	W	STW
h2	G1	16	mid shelf	NE	STW
h3	G2-7	41	mid shelf-upper bathyal	NE, W	STW, AAIW
h4	G8, G6	5	outer shelf-mid bathyal	NE	STW, AAIW
i	D5, F1, G9	16	mid shelf-bathyal	E	SAW, SAMW, AAIW

bathymetric ranking parallels that in the chord-based associations, where A (mid-lower abyssal) and C (lower bathyal-abyssal) are the deepest, shallowing up through B (mid-lower bathyal) and D (bathyal) then E (upper-mid bathyal), to F and G (mid shelf-mid bathyal).

The deepest Jaccard subassociation (a1) differs from the deepest chord association (A1) by just two samples, and occurs in the deepest water, in the far south. The next deepest chord subassociation (A2) closely approximates Jaccard subassociation b. The lower bathyal abyssal chord association C is split geographically in the Jaccard analysis into a north-eastern (c) and east-west (e) association. The subantarctic half of chord association D equates to Jaccard subassociation d3, whereas the Chatham Rise half is allocated to parts of Jaccard associations i and e3. These bathyal faunas also separate along geographic lines into a southern (d3), two eastern (e3, i), a western (e1) and two northeastern (d2, e2) subassociations. The southern bathyal chord association B is identical to Jaccard association a2. In both analyses the shelf faunas are divided along geographic lines although the chord analysis recognises only two associations (northern G, southern F) whereas the Jaccard analysis recognises three (northern h, central i, southern f).

These Jaccard maps and graphs show somewhat similar patterns to those based on full census data (Figs 20-21) with strong geographic and bathymetric influence on distribution. Thus it is not only the relative abundance of the common species but also the species composition that changes bathymetrically and geographically and results in the distributional patterns we are documenting.

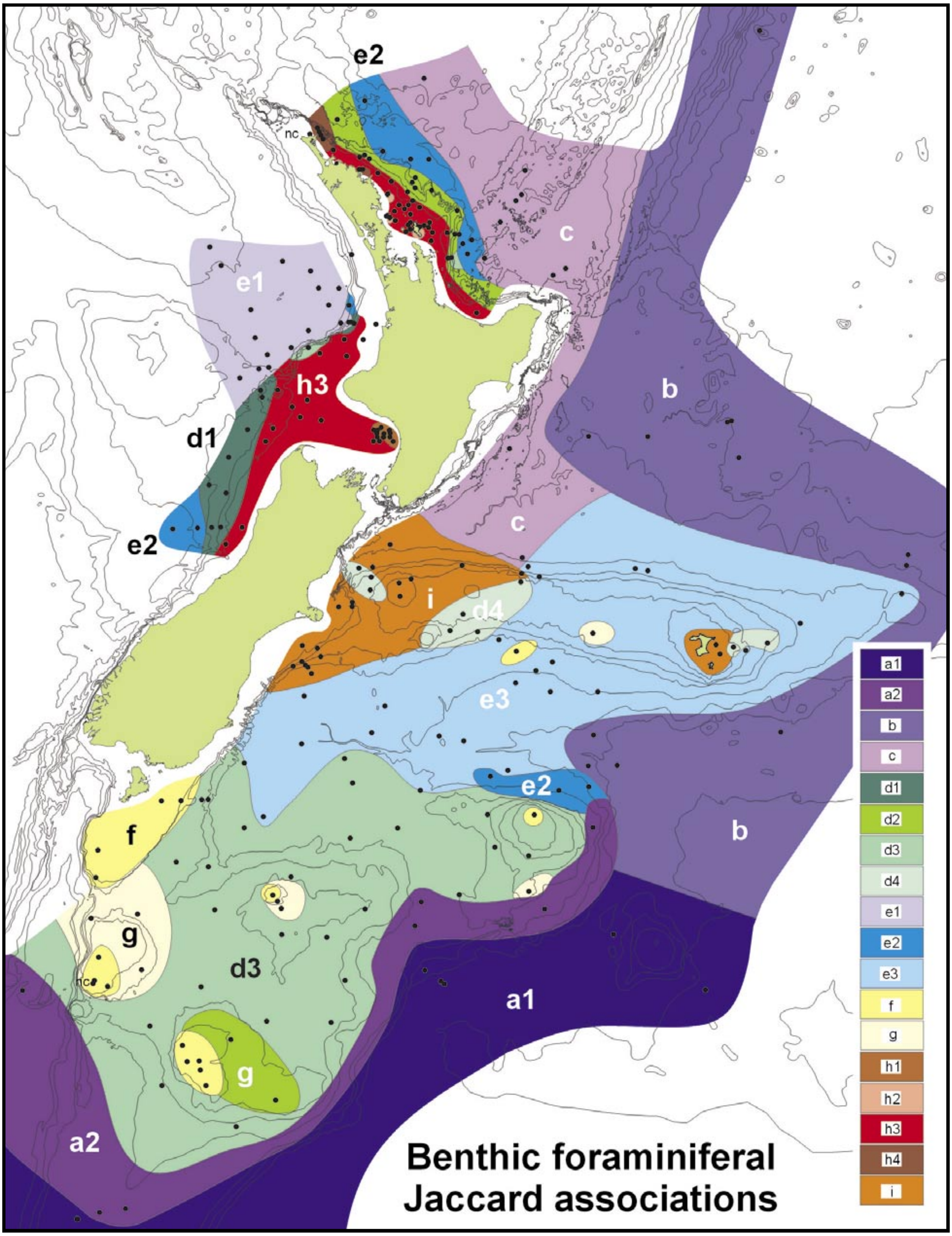


Figure 32. Mapped distribution around New Zealand of the deep-water benthic foraminiferal sample associations and subassociations identified from the Jaccard cluster analysis dendrogram (Fig. 19), based on presence/absence data.

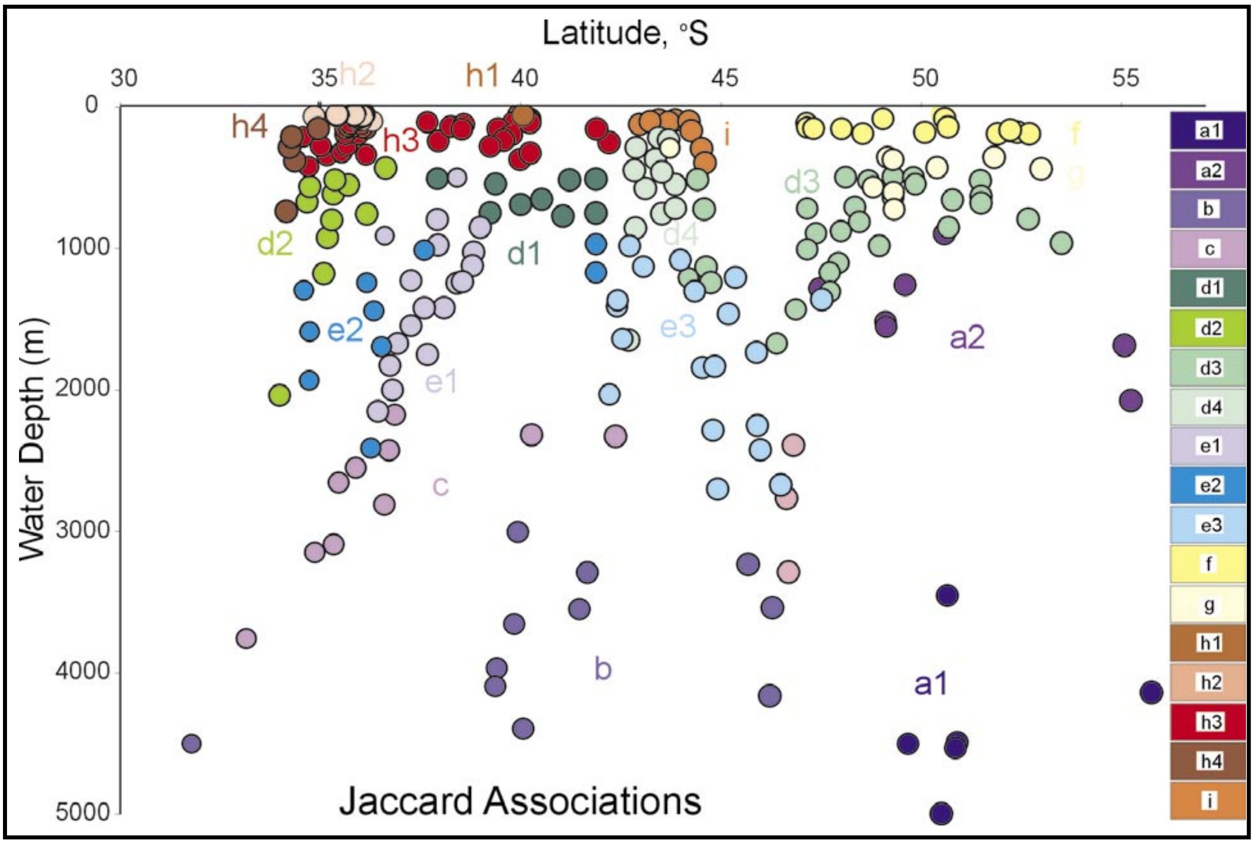


Figure 33. Depth and latitude distribution of deep-water benthic foraminiferal sample associations based on presence/absence data (a-i, from Fig. 31) through the New Zealand region.

BENTHIC FORAMINIFERAL SPECIES ASSOCIATIONS

Inspection of the dendrogram (Fig. 34) produced by R-mode cluster analysis (Pearsons product-moment distance matrix) on full census data for the 56 most common species (each >0.3% relative abundance in the full data set) shows the existence of eight groups (Associations 1-8). The relative abundance of each of these species associations around New Zealand in terms of latitude and bathymetry is mapped in Fig. 35. Their faunal composition and distribution is summarised in Table 12.

As with the sample associations, the distribution of the species associations is most strongly linked to bathymetry and secondly to geography. The species associations can be ranked from deepest to shallowest in the following order: 1 (mid-lower abyssal), 4 (lower bathyal-abyssal), 2 (lower bathyal), 3 and 5 (mid-lower bathyal), 8 (outer shelf-mid bathyal), 7 (mid shelf-upper bathyal), 6 (mid-outer shelf). Associations 1 and 2 (dominated by *Globocassidulina subglobosa* and *Trifarina angulosa* respectively) have their greatest relative abundances off southern New Zealand. Association 4 (*Epistominella exigua*) occurs primarily east of northern and central New Zealand, whereas Association 3 (*Uvigerina peregrina*) is mostly present off the west coast. Association 8 (*Cassidulina carinata*) is more common off the east and south of New Zealand than the west. Shelf and bathyal associations 5, 6 and 7 are reasonably common right around New Zealand.

RELATIONSHIP OF ASSOCIATIONS TO ENVIRONMENTAL VARIABLES

Correlation Coefficient Analysis

The relationship between environmental proxies and the relative abundances of species associations and common species in the entire database was investigated using Pearson's correlation coefficients analysis (Hammer *et al*. 2008). Moore & McCabe's (1993) P test was used to identify those relationships that have more than 95% confidence of statistical correlation (Table 4).

Environmental variables having the strongest correlation with latitude are sea surface temperature (SST) and phosphate. These are followed in decreasing strength of correlation by salinity, oxygen, spring chlorophyll-a and bottom temperature. Bottom temperature has the strongest correlation with water depth, followed in decreasing order by % planktic foraminifera, longitude, and % mud. Other strong correlations are between mud and bottom oxygen (r = -0.61), sea surface temperature with phosphate (r = -0.91), phosphate and spring chlorophyll-a (r = 0.47). Perhaps surprisingly, there is no significant correlation of our proxy for benthic foraminiferal productivity (n g^{-1} sediment) with organic carbon flux (Jz), surface phosphate, or chlorophyll-a (our proxies for phytoplankton productivity). This suggests that our proxy for benthic foraminiferal productivity is not working and is probably more strongly linked to sedimentation rate and bottom current strength (negative correlation with mud %, r =

-0.21) or maybe it works at greater depths and this relationship has been obscured by analysing all the database together.

Species associations exhibit strong correlations with water depth (deep = 1, 4; shallow = 6-8), % mud (muddy = 3-5; sandy = 2, 6), organic carbon flux (Jz high = 6; low = 5), surface phosphate (high = 2), annual and seasonal chlorophyll-a (high = 6, 7; low = 4, 5), salinity (high = 6, 7; low = 5), bottom oxygen (low = 3, 4), and fragmentation index (high = 1).

Trifarina angulosa, the dominant species in species association 2, is most strongly correlated with sand (% mud r = -0.55), and less so with oxic conditions (r = 0.35). This suggests that *T. angulosa* prefers areas with strong bottom currents. *Epistominella exigua* and *Bulimina marginata* f. *aculeata*, dominants in species association 4, are most strongly correlated with depth and depth-related variables, such as bottom temperature, planktic percentage and mud. Both also have significant negative correlations with bottom oxygen suggesting a preference for suboxic conditions. The three characteristic species of association 5 (*A. weddellensis*, *A. pseudothalmanni*, *T. occidentalis*) also have significant negative correlations with salinity and bottom oxygen suggesting some association with the physical characteristics of the bottom water masses. *Cibicides dispars* and *Spiroplectinella proxispira*, dominants of species association 6, have correlation coefficients indicating shallower, sandy, more oxic environments.

The three dominants of species association 7 (*G. praegeri*, *D. bertheloti*, *B. marginata* s.s.) have strong correlations with shallow water (r =>-0.45 with depth) and depth-related proxies. They also have strong correlations with sandy substrates (esp. *G. praegeri*). This latter species is the only one with strong correlation with more oxic bottom conditions (r = 0.51). *D. bertheloti* and to a lesser extent *B. marginata* s.s. have their distribution strongly skewed towards warmer northern regions, which explains their positive correlations with spring chlorophyll-a, salinity and temperature proxies. *Cassidulina carinata*, dominant of species association 8, is also strongly correlated with shallower depths and variables related to this, such as higher bottom oxygen and less mud. Its negative correlation (r = -0.26) with longitude presumably reflects its unexplained greater relative abundance off the west coast than the east.

Canonical Correspondence Analysis of all associations together

Canonical correspondence analysis, CANOCO (Ter Braak 1985), was used to relate the samples and their associations to a series of environmental variables (Table 3) using the full census data (Fig. 36). On the DECORANA ordination produced, the faunal patterns correspond most strongly with the following environmental variables (vectors) in decreasing order:

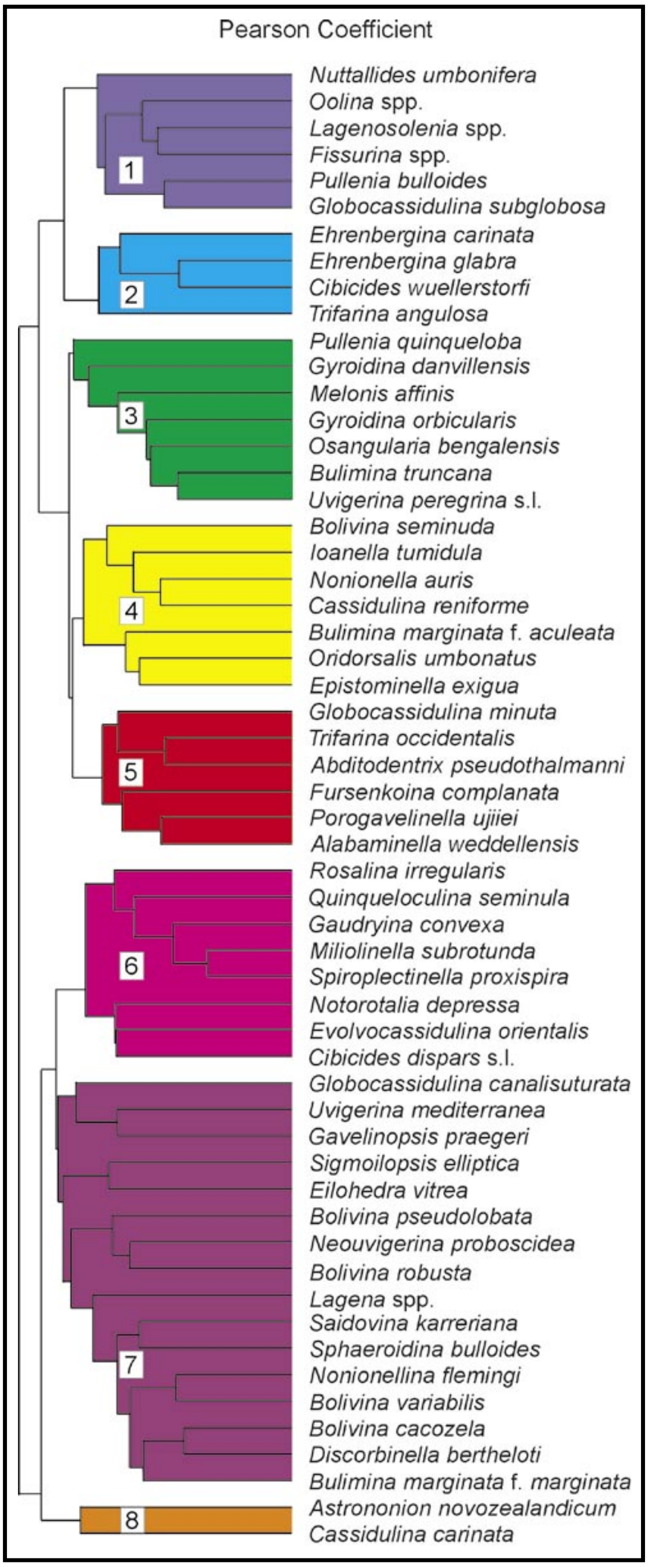


Figure 34. Dendrogram classification of New Zealand deep-water (>50 m) benthic foraminiferal species associations produced by cluster analysis using Pearson's similarity coefficient based on full census data for the 56 most common species (or unilocular genera). The species associations (1-8) were selected after inspection of the dendrogram.

Table 12. Summary of faunal composition, bathymetric, geographic and water mass range of deep-water benthic foraminiferal species associations based on full census data for the 56 most common species (Fig. 34).

[1] North-east, south, east and west of New Zealand. In brackets = minor representation in this region.

Dominant and subdominant species	No. of species	Dominant depth	Dominant regions[1]	Dominant water mass
1. ***Globocassidulina subglobosa-Fissurina*** *Nuttallides umbonifera*, *Pullenia bulloides*	6	mid-lower abyssal	S	lower CPDW
2. ***Trifarina angulosa*** *Ehrenbergina glabra*, *Ehrenbergina carinata, Cibicides wuellerstorfi*	4	lower bathyal	S	upper CPDW
3. ***Uvigerina peregrina-Gyroidina danvillensis*** *Bulimina truncana, Gyroidina orbicularis, Melonis affinis, Pullenia quinqueloba*	7	mid-lower bathyal	W	AAIW
4. ***Epistominella exigua-Bulimina marginata* f. *aculeata-Cassidulina reniforme*** *Oridorsalis umbonatus, Nonionella auris, Bolivina seminuda*	7	lower bathyal-abyssal	E, NE, (S)	CPDW
5. ***Alabaminella weddellensis-Abditodentrix pseudothalmanni-Trifarina occidentalis*** *Globocassidulina minuta, Porogavelinella ujiiei*	6	mid-lower bathyal	E, NE, S, W	AAIW
6. ***Cibicides dispars* s.l.*-Spiroplectinella proxispira*** *Evolvocassidulina orientalis*, *Miliolinella subrotundata*	8	mid-outer shelf	NE, W, E, (S)	STW, (SAW)
7. **Gavelinopsis praegeri-*Bulimina marginata* f. *marginata-Discorbinella bertheloti-Globocassidulina canalisuturata-Bolivina robusta*** *Neouvigerina proboscidea, Bolivina variabilis*, *Bolivina pseudolobata*, *Nonionellina flemingi*	16	mid shelf-upper bathyal	NE, W, S	STW, SAW, SAMW
8. ***Cassidulina carinata*** *Astronion novozealandicum*	2	outer shelf-mid bathyal	NE, E, S	STW, SAW, AAIW

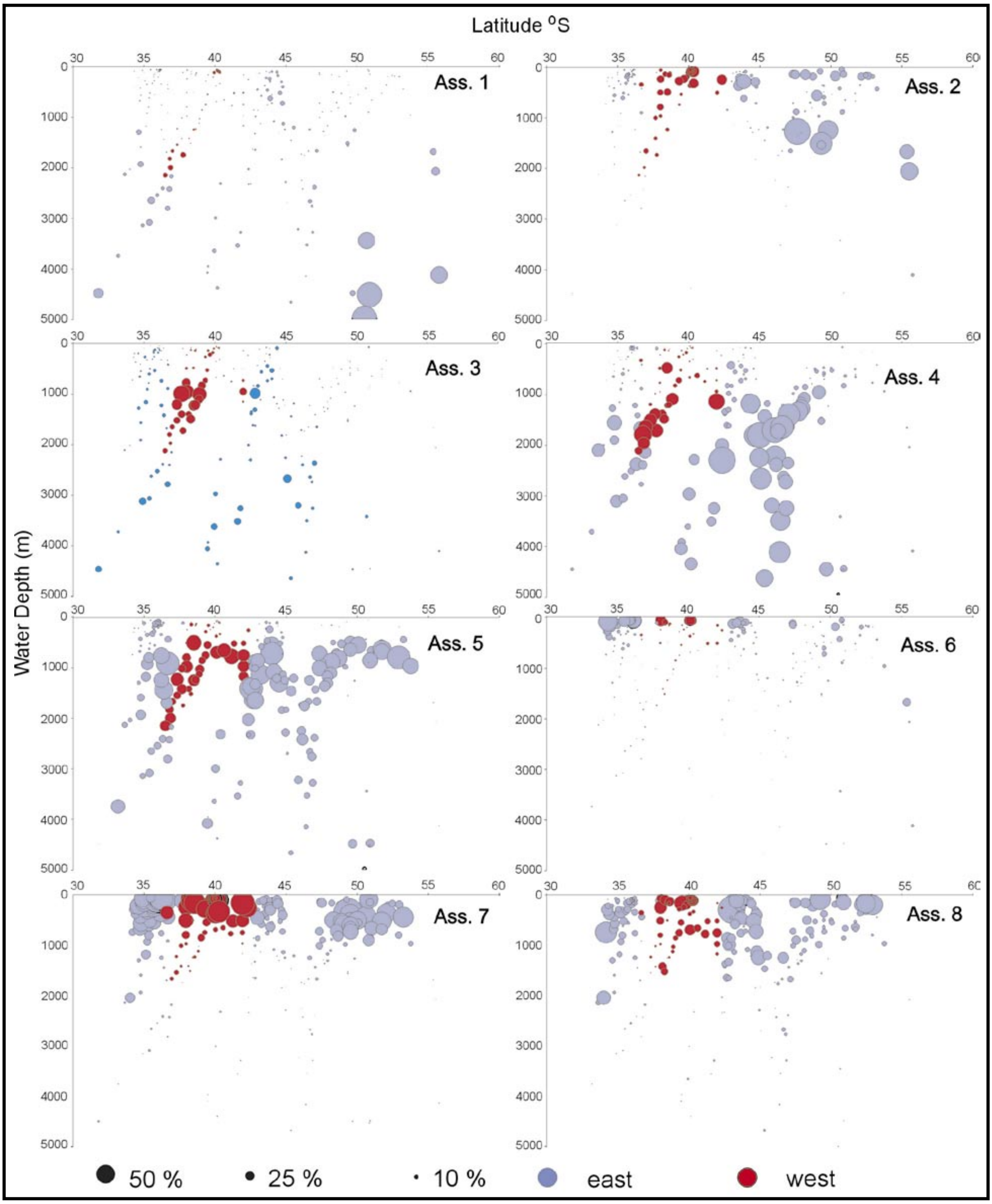


Figure 35. Depth and latitude distribution of deep-water benthic foraminiferal species associations (1-8; from Fig. 34) through the New Zealand region. Stations from east of New Zealand are coloured blue and west of New Zealand red. The relative abundance of each species association in each station is represented by the circle diameter.

bottom temperature, depth, bottom salinity, planktic percentage, bottom oxygen, longitude, carbon flux, and chlorophyll-a (mean annual). The strongest vector, bottom temperature, decreases with increasing water depth and latitude, with deeper associations (A-C) more strongly influenced by depth-related variables and shallower associations (F, G) clearly influenced by latitude-related differences in surface water characteristics, such as sea surface temperature. The five strongest vectors are all directly or indirectly related to depth. Depth itself does not produce the faunal distribution patterns, but variables that vary with depth do. Bottom temperature, salinity and oxygen are related to bottom water masses and suggest that these may influence faunal distribution. Planktic percentage also will not influence benthic faunal patterns but variables that influence the planktic percentage, such

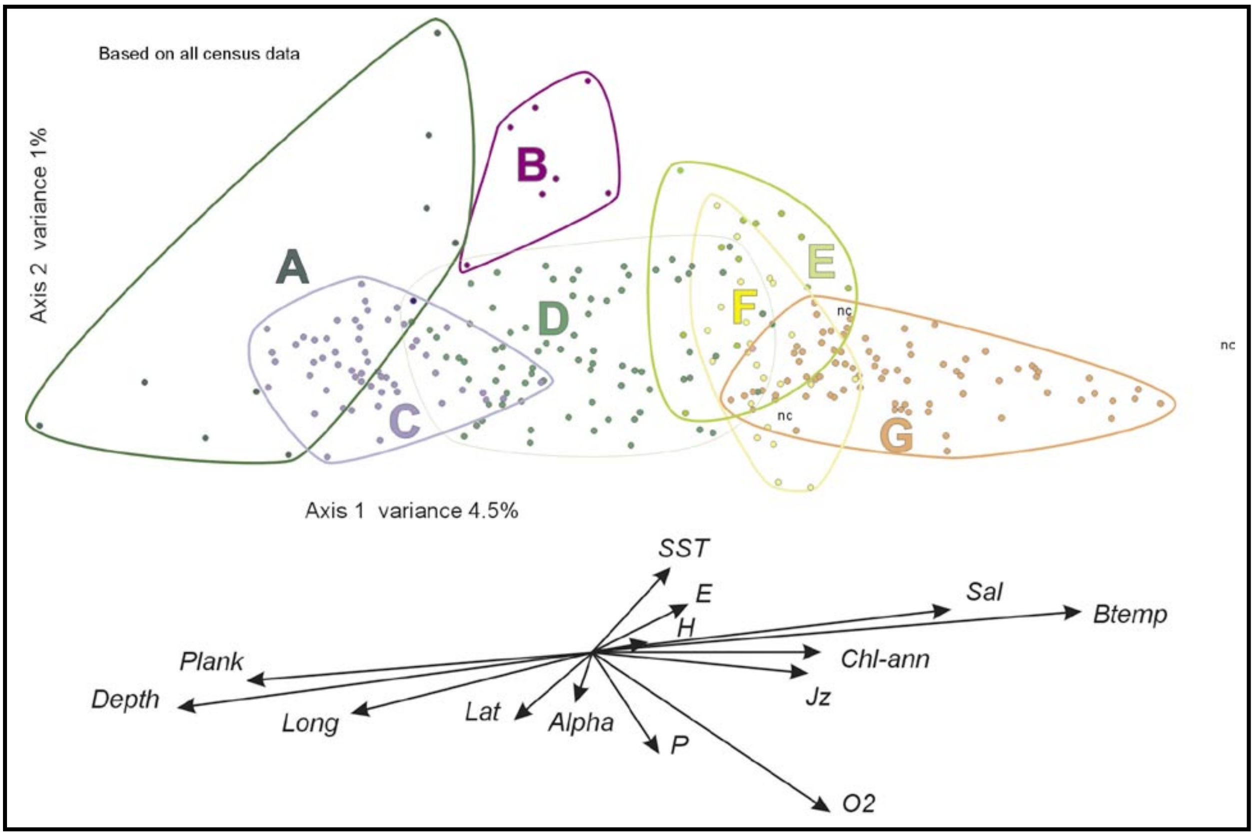


Figure 36. Two-dimensional ordination of New Zealand deep-sea foraminiferal samples produced by Detrended Correspondence Analysis (DECORANA). The vector axes of "environmental" factors and species diversity (produced by Canonical Correspondence Analysis) are superimposed. The seven sample associations (A-G) produced by cluster analysis based on full census data (Fig. 18) are shown.

as carbonate dissolution and surface water productivity may be significant drivers. The amount of food reaching the seafloor will clearly influence benthic biota as shown by our vector for organic carbon flux. This proxy, Jz, is computed from water depth and mean annual chlorophyll-a values. Proxies that might give some indication of the composition and quality of the carbon flux, such as SST, latitude and phosphate, all have short vectors, suggesting less significance. All the depth-related vectors show directional trends that are consistent with the right to left increase in depth of the associations from G and F to C and A.

Variables appearing to have the least correlation with these "big picture" faunal patterns (shortest arrows on Fig. 36) are latitude, sea surface temperature, and surface phosphate.

Canonical Correspondence Analysis of dominantly abyssal associations, A-C

CANOCO was used to relate the samples, common species and their subassociations in the dominantly abyssal sample associations A-C to a series of environmental variables (Table 3) using census data for the 56 most common species only (Fig. 37). On the DECORANA ordination produced, the faunal patterns correspond most strongly with the following environmental variables (vectors) in decreasing order: surface phosphate, mud percentage, depth, annual chlorophyll, bottom temperature, latitude, seasonality, salinity, carbon flux, and sea surface temperature. Variables appearing to have the least correlation with faunal patterns (shortest arrows on Fig. 37) are bottom oxygen, planktic foraminiferal percentage and summer chlorophyll. The strength of these environmental drivers was further investigated using correlation coefficient analysis on datasets for associations A-C and C on their own (Tables 14-15).

On the ordination Association A is separated from associations B and C along axis 2 which parallels the vectors for depth and depth-related variables such as bottom temperature, salinity, carbon flux, fragmentation index and planktic foraminiferal percentage. These latter two vectors are proxies for carbonate dissolution usually produced by carbonate corrosive bottom waters. This is probably a key driver for the faunal differences, as Assoc. A samples (close to the CCD) have been strongly impacted by carbonate dissolution. The dominant species in Assoc. A, are *N. umbonifera* and *G. subglobosa*, which elsewhere in the world have often been linked to cold, deep, oligotrophic conditions within carbonate-corrosive Antarctic Bottom Water, like that which bathes the stations here. In our study both have significant correlations with cold and deep water (Table 14) with the former having a strong correlation with fragmentation index (r=0.63) and the latter with low carbon flux (r=-0.51).

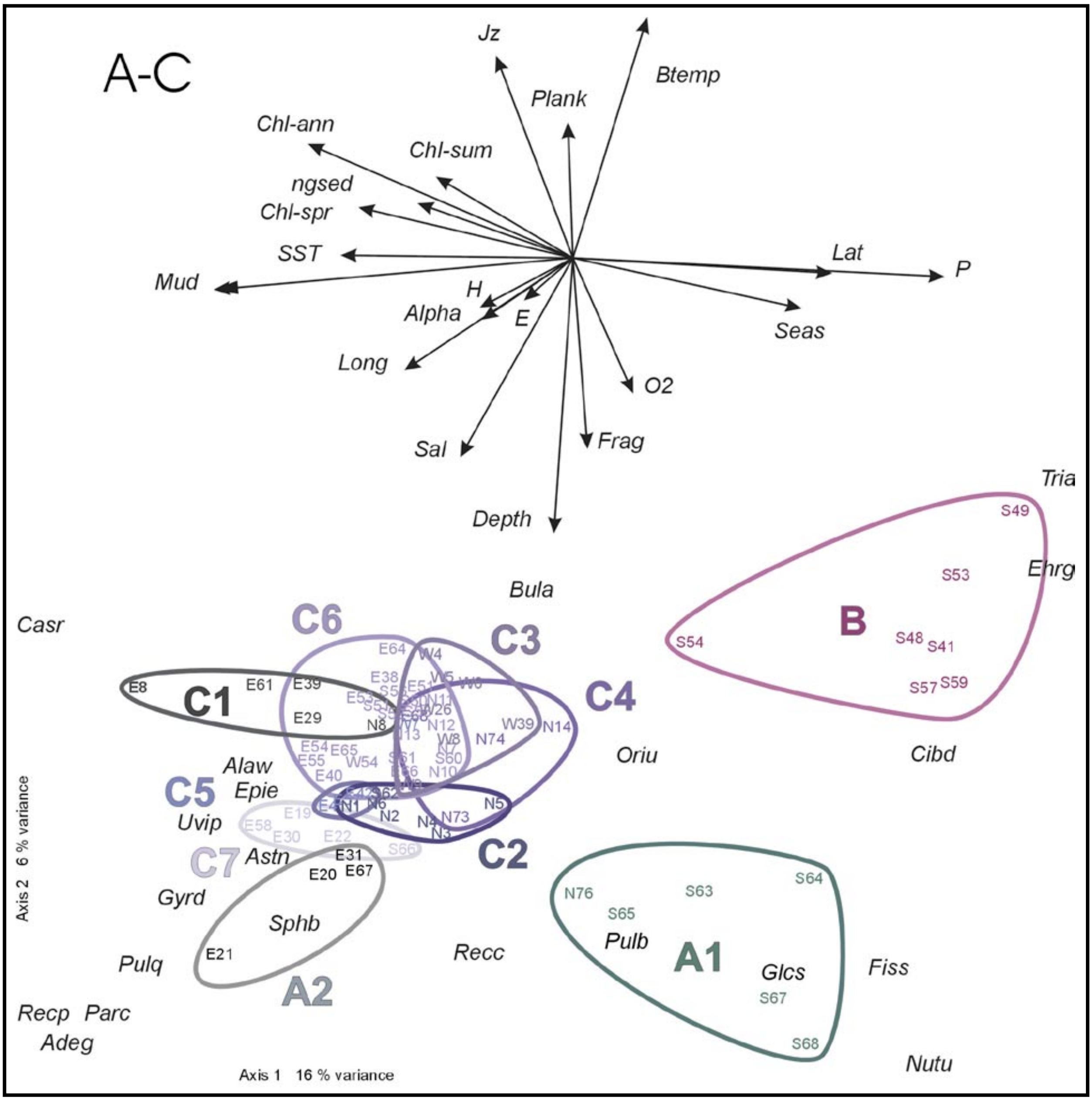


Figure 37. Two-dimensional ordination of mid bathyal-abyssal foraminiferal samples (Associations A-C) and common species produced by Detrended Correspondence Analysis (DECORANA). The vector axes of "environmental" variables and species diversity (produced by Canonical Correspondence Analysis) are superimposed. Sample association B and the nine subassociations of A (A1-A2) and C (C1-C7) produced by cluster analysis based on full census data (Fig. 18) are shown. 3-4 letter abbreviations of species are given in Table 13.

Table 13. Abbreviations of common benthic foraminiferal species used in the DCCA ordination plots (Figs 37-40).

Abdp	*Abditodentrix pseudothalmanni*	Cibd	*Cibicides dispars*	Parc	*Paratrochammina challengeri*
Adeg	*Adercotryma glomeratum*	Disb	*Discorbinella bertheloti*	Pulb	*Pullenia bulloides*
Alaw	*Alabaminella weddellensis*	Ehrg	*Ehrenbergina glabra*	Pulq	*Pullenia quinqueloba*
Astn	*Astrononion novozealandicum*	Epie	*Epistominella exigua*	Recc	*Recurvoides contortus*
Bolc	*Bolivina cacozela*	Fiss	*Fissurina* spp.	Recp	*Recurvidatus parcus*
Bolr	*Bolivina robusta*	Gauc	*Gaudryina convexa*	Rosi	*Rosalina irregularis*
Bolv	*Bolivina variabilis*	Gavp	*Gavelinopsis praegeri*	Spip	*Spiroplectinella proxispira*
Bula	*Bulimina marginata* f. *aculeata*	Glcc	*Globocassidulina canalisuturata*	Tria	*Trifarina angulosa*
Bulm	*Bulimina marginata* f. *marginata*	Glcs	*Globocassidulina subglobosa*	Trio	*Trifarina occidentalis*
Casc	*Cassidulina carinata*	Nutu	*Nuttallides umbonifera*	Uvim	*Uvigerina mediterranea*
Casr	*Cassidulina reniforme*	Oriu	*Oridorsalis umbonatus*	Uvip	*Uvigerina peregrina*

Table 14. Correlation coefficients between environmental proxies and relative abundance of common deep-sea benthic foraminifera of sample associations A-C (Figs 19, 22, 24). Only correlation coefficients that have more than 95% confidence of statistical correlation (P test, Moore and McCabe 1993) are printed. Bolded values are the more significant.

	Lat	Depth	Long	ngsed	% mud	% plank	FI	Chl -ann	Chl -spr	Chl -sum	Seas	Jz	SST	Btemp	Sal	O	P
Abditodentrix pseudothalmanni	-0.25	-0.48	-0.25	0.30	0.26		-0.24					0.23		0.48	-0.38	-0.40	-0.23
Alabaminella weddellensis	-0.35			0.34	**0.55**								0.34				-0.39
Bulimina marginata f. *aculeata*	-0.32	-0.42			0.34			0.27	0.34				0.33	0.37	-0.30	**-0.58**	-0.36
Bulimina marginata f. *marginata*	0.23	-0.37										**0.51**	-0.28		-0.27		
Bulimina truncana	-0.41	-0.33	-0.27		0.33				0.36		0.38	-0.24	0.43	0.36	-0.27	**-0.67**	-0.37
Cassidulina carinata		-0.32		0.49								0.34		0.24	-0.36		
Cassidulina reniforme								0.75	**0.55**	0.48					0.03		
Cibicides dispars s.l.	0.31		-0.45		**-0.60**			-0.30	-0.25		-0.29		-0.26				0.50
Ehrenbergina glabra	0.46		-0.32	-0.23	**-0.70**			-0.24	-0.28		-0.32		-0.42				**0.58**
Epistominella exigua				0.32					-0.26			0.28			0.24	0.31	
Fissurina spp.	0.39	0.29	-0.26	-0.25	-0.50			-0.41	-0.32		-0.38		-0.36				**0.54**
Globocassidulina canalisuturata	-0.24	-0.30		-0.32							0.26		**0.52**	-0.34			
Globocassidulina subglobosa		0.39			-0.26			-0.42		-0.39		**-0.51**		-0.31	0.31		
Gyroidina danvillensis			0.28		0.34				0.30								-0.32
Nonionella auris			0.25					0.42	0.28	0.29							
Nuttallides umbonifera	0.31	0.47				-0.47	**0.63**				-0.32		-0.28	-0.32		0.30	0.33
Oridorsalis umbonatus																	
Pullenia bulloides		0.27		-0.26								-0.37					
Pullenia quinqueloba	-0.34	0.32	0.35		0.31						0.36	-0.28	0.36	-0.28	0.26		-0.37
Trifarina angulosa	0.32	-0.23			**-0.57**						-0.35		-0.32		-0.27		0.36
Trifarina occidentalis		-0.47		0.40						0.33		0.39		**0.51**	-0.46		
Uvigerina peregrina sl.			0.31												0.25		-0.27

Table 15. Correlation coefficients between environmental proxies and relative abundance of common deep-sea benthic foraminifera of sample association C (Fig. 24). Only correlation coefficients that have more than 95% confidence of statistical correlation (P test, Moore and McCabe 1993) are printed. Bolded values are the more significant.

	Lat	Depth	Long	ngsed	% mud	% plank	FI	Chl -ann	Chl -spr	Chl -sum	Seas	Jz	SST	Btemp	Sal	O	P
Abditodentrix pseudothalmanni		-0.49	-0.35											0.56	-0.43	-0.29	
Alabaminella weddellensis																	
Bolivina seminuda		**0.51**	0.39			-0.31	**0.52**				-0.28					0.41	
Bulimina marginata f. *aculeata*		-0.46	-0.28		0.27				0.29		**0.56**			0.45	-0.37	**-0.53**	-0.31
Bulimina marginata f. *marginata*	0.34	-0.35	-0.35									0.53	-0.35		-0.27		0.42
Bulimina truncana	-0.41	-0.38	-0.39		0.37				0.35		0.37	-0.30	0.43	0.45	-0.33	**-0.67**	-0.43
Cassidulina carinata		-0.32	-0.23	0.43	**-0.52**							0.36		0.28	-0.44		0.29
Cassidulina reniforme						-0.49	0.31	**0.77**	**0.58**	0.47							
Cibicides dispars s.l.	**-0.52**							-0.35		-0.29		-0.38	0.50			-0.35	-0.29
Epistominella exigua	**0.68**				-0.37				**-0.62**		-0.45	0.40	**-0.70**	-0.29		**0.60**	**0.70**
Fissurina spp.	-0.44									-0.32		-0.37	0.43				-0.31
Globocassidulina minuta																	
Globocassidulina subglobosa	**-0.52**							-0.32		-0.45		**-0.52**	**0.50**			-0.38	-0.35
Gyroidina danvillensis							0.32										
Ioanella tumidula		0.45	**0.52**			-0.39	**0.60**	0.33	0.28		-0.38			-0.37	0.31	0.37	
Nonionella auris			0.36					0.36									
Oridorsalis umbonatus																	
Pullenia quinqueloba	-0.30	0.37									0.35	-0.29	0.29				
Trifarina occidentalis		**-0.51**		0.31						0.29		0.40		**0.61**	**-0.53**		
Uvigerina peregrina s.l.															0.29		

Table 16. Ecologic characteristics of common benthic foraminiferal species that dominate the deep-sea associations and subassociations around New Zealand, as recorded elsewhere in the Southern Ocean (Uchio, 1960; Echols, 1971; Anderson, 1975; Quilty, 1985; Mead and Kennett, 1987; Ward *et al.*, 1987; Murray, 1991; Gooday, 1993; Mackensen *et al.*, 1990, 1995; Schmiedl *et al.*, 1997; Harloff and Mackensen, 1997; Hayward *et al.*, 2002).

Species	**Geographic distribution**	**Dominant water depth**	**Microhabitat**	**Food flux**	**Bottom oxygen**	**Substrate and currents**	**Other**
Abditodentrix pseudothalmanni	cosmopolitan	500-3000 m	infaunal				
Alabaminella weddellensis	cosmopolitan	500-3500 m	epifaunal	seasonal phytodetritus	suboxic	quiet, muddy	-
Bolivina robusta	cosmopolitan	200-900 m	infaunal	-	-	-	-
Bulimina marginata f. *aculeata*	cosmopolitan	200-2600 m	infaunal	sustained high flux	suboxic	quiet, muddy	-
Bulimina marginata s.s.	cosmopolitan	50-800 m	infaunal		oxic		
Bulimina truncana	cosmopolitan	800-3000 m	infaunal		suboxic	quiet, muddy	
Cassidulina carinata	cosmopolitan	50-1600 m	shallow infaunal	sustained high flux	suboxic	-	-
Cassidulina reniforme		1000-3500 m	shallow infaunal		suboxic		
Cibicides dispars	S Hemisphere	0-600 m	epifaunal				
Discorbinella bertheloti	cosmopolitan	30-600 m			oxic		
Ehrenbergina glabra	Southern Ocean	200-800 m	-	-	oxic	strong currents,	beneath ACC sandy-gravelly
Epistominella exigua	cosmopolitan	700-4000 m	epifaunal	seasonal phytodetritus	-	-	-
Gavelinopsis praegeri	cosmopolitan	50-800 m	epifaunal	sustained moderate flux	oxic	-	-
Globocassidulina canalisuturata	SW Pacific	50-1200 m	infaunal	-	-	-	-
Globocassidulina subglobosa	cosmopolitan	1500-4000 m	infaunal	low flux, seasonal	oxic	strong currents, sandy	-
Nuttallides umbonifera	cosmopolitan	3000-4200 m	-	low flux	-	-	carbonate corrosive
Sphaeroidina bulloides	cosmopolitan	50-600 m					
Trifarina angulosa	cosmopolitan	50-1000 m	infaunal	-	oxic	strong currents, sandy-gravelly	-

On the ordination, associations B and C, and the two subassociations of A, are separated along axis 1 which parallels the vectors for mud, phosphate, latitude, seasonality and chlorophyll-a. So which of these are the main drivers of the substantial faunal differences between these associations? Surface phosphate decreases progressively from high to low latitudes around New Zealand (Fig. 11) and this probably produces the strong correlation with latitude in this instance, supported in part by latitudinally-related differences in surface chlorophyll. Surface phosphate concentration strongly influences phytoplankton production (which is assessed by the chlorophyll-a proxies) and this is exported as organic carbon flux to feed the seafloor benthos. At abyssal depths the carbon flux is small and therefore whether it could have such a dramatic influence on the foraminifera is questionable. In support of this is the existence in Subassoc. A1, of one station (N76) at the lowest latitude (31˚S) in the study and a second (S64) at the highest (56˚S) latitude. These two also have the extreme lowest (0.2 µmol/l) and highest (1.52 µmol/l) surface phosphate concentrations. Mud percentage seems more likely the main proxy that explains the differences between associations B and C. Assoc. B samples have unusually sandy substrates for these depths, yet they are shallower than the lysocline and the low mud percentage cannot be ascribed to dissolution. The two dominant species of Assoc. B, *T. angulosa* and *E. glabra*, have strong negative correlations with % mud (-0.57, -0.70). Assoc. B stations are mostly at upper bathyal depths on the upper continental slope around the south-east side of Campbell and Bounty Plateaux. Here they lie within the deep-reaching Subantarctic Front which is characterised by strong currents that extend right down to the seafloor. These are presumably responsible for winnowing away many of the fines leaving behind the sand. The dominant species, *T. angulosa*, has often been associated elsewhere with areas with similar strong bottom currents (Table 16).

To better assess the environmental drivers of the faunal differences between the subassociations of C, further DCCA and correlation coefficient analyses were run on samples from this association on their own (Fig. 38, Table 15). Here many vectors have similar strengths, with depth-related variables (bottom temperature, salinity, carbon flux) appearing to be responsible for the differences between the deeper subassociations C2, C5 and C7 and the shallower subassociations C1, C3, C4 and C6.

The four shallower subassociations appear to be separated on the ordination in a direction subparallel to latitude-related vectors, especially surface phosphate, SST, seasonality and spring chlorophyll. This suggests seasonal food-related drivers with C1, C3 and C4 underlying areas of STW with strong spring phytoplankton blooms and C6 with a strong summer phytoplankton pulse (Fig. 10), underlying more phosphate-rich SAW. Assoc. C1 is characterised by the strong dominance of *Cassidulina reniforme* (Fig. 24) which has the strongest positive correlation with annual and spring chlorophyll-a productivity (0.77, 0.58). Assoc. C3 is characterised by the highest relative abundances of *Bulimia marginata* f. *aculeata* and *B. truncana*, both of which have the highest negative correlations with bottom oxygen and highest positive correlations with seasonality (Table 15). Assocs C5-C7 are all dominated by *Epistominella exigua* which has the highest negative correlation with seasonality (r=-0.45), oxygen (r=0.6) and phosphate (0.7). Thus the amount, quality and varying seasonality of the food supply is presumably the main reason for the differences in composition of subassociations within C, with bottom oxygen concentration a secondary driver. The negative

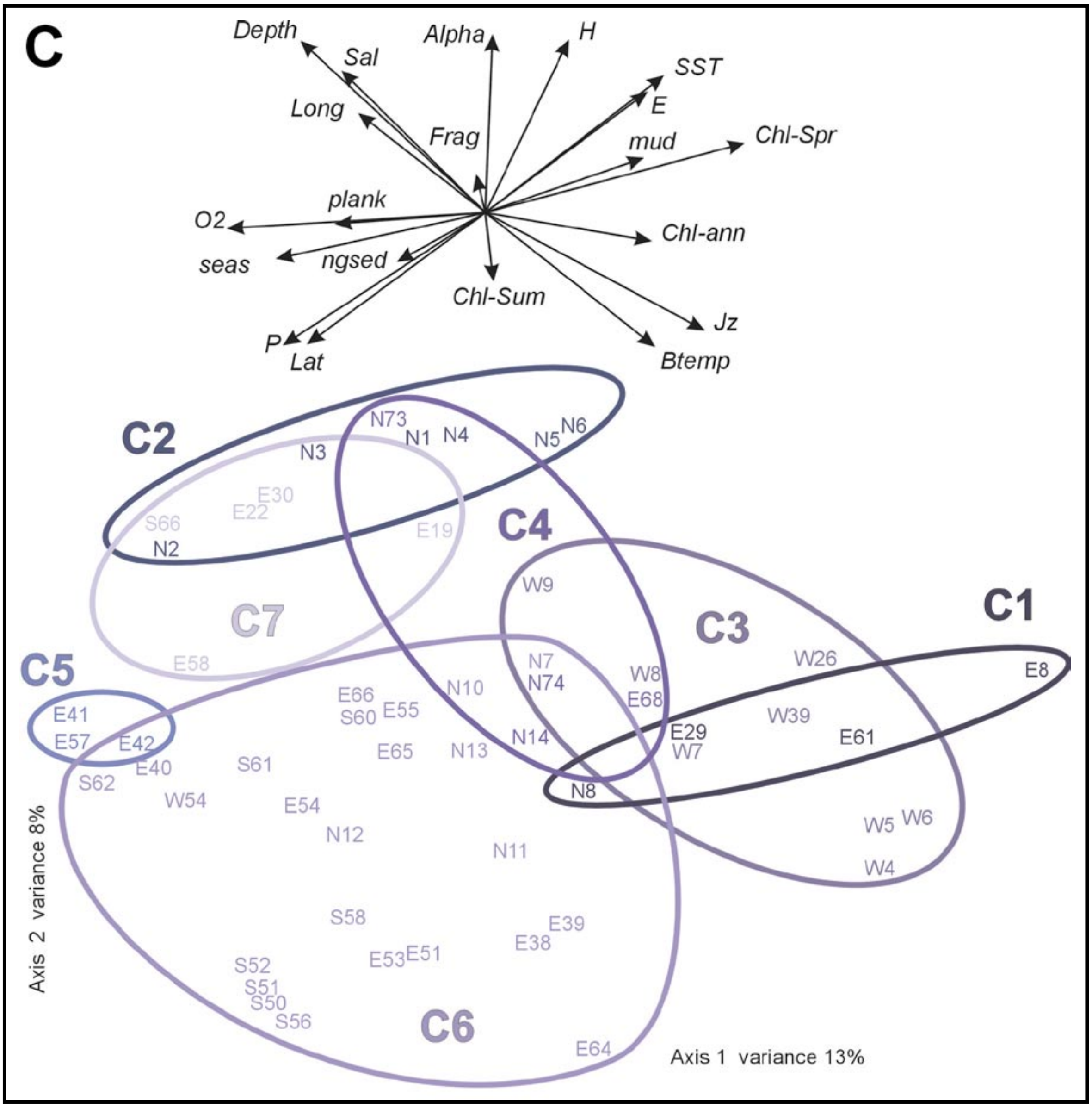


Figure 38. Two-dimensional ordination of lower bathyal-abyssal foraminiferal samples (Association C) and common species produced by Detrended Correspondence Analysis (DECORANA). The vector axes of "environmental" variables and species diversity (produced by Canonical Correspondence Analysis) are superimposed. Seven subassociations (C1-C7) produced by cluster analysis based on full census data (Fig. 18) are shown. 3-4 letter abbreviations of species are given in Table 13.

correlation with seasonality is the opposite of what has been recorded elsewhere (Table 16) and is difficult to explain.

Canonical Correspondence Analysis of dominantly bathyal associations, D-E

On the DECORANA ordination produced (Fig. 39), the faunal patterns correspond most strongly with the following environmental variables (vectors) in decreasing order: mud percentage, bottom oxygen, depth, surface phosphate, bottom temperature, latitude, sea surface temperature, spring chlorophyll, seasonality and carbon flux. Variables appearing to have the least correlation with faunal patterns (shortest arrows on Fig. 39) are longitude, summer chlorophyll, fragmentation index, bottom salinity, absolute abundance of benthic foraminifera and planktic percentage. The strength of these environmental drivers was further investigated using correlation coefficient analysis on a dataset for associations D-E on their own (Table 17).

The strongest separation of the subassociations of D and E (axis 1) parallels the vectors for mud, oxygen and depth. Percentage mud is the strongest difference between associations D (mean 68%) and E (mean 19%), with no subassociation of D having less than 33% mud (Table 8). The relatively clean, sandy nature of the substrates for E reflect the locations around the upper slopes of the subantarctic seamounts (E2 - Auckland, Campbell, Pukaki, Bounty), the southern edge of the crest of the Chatham Rise (E3) and on a protruding section of the continental slope east of Northland (E1). These locations are away from major sources of terrigenous sediment and are swept by relatively strong bottom currents that presumably carry away many of the finer pelagic particles as they sink through the water column. The four dominant species of E associations (*Bolivina robusta*, *Globocassidulina canalisuturata*, *Trifarina angulosa*, *Cibicides dispars*) presumably like these current-swept environments and may be adapted to feeding on laterally-transported larger food particles. They have the strongest negative correlation coefficients with mud (r=-0.36 to -0.52).

The relatively strong correlation with bottom oxygen reflects the water depth range of these associations with oxygen concentration dropping rapidly from 500 m depth

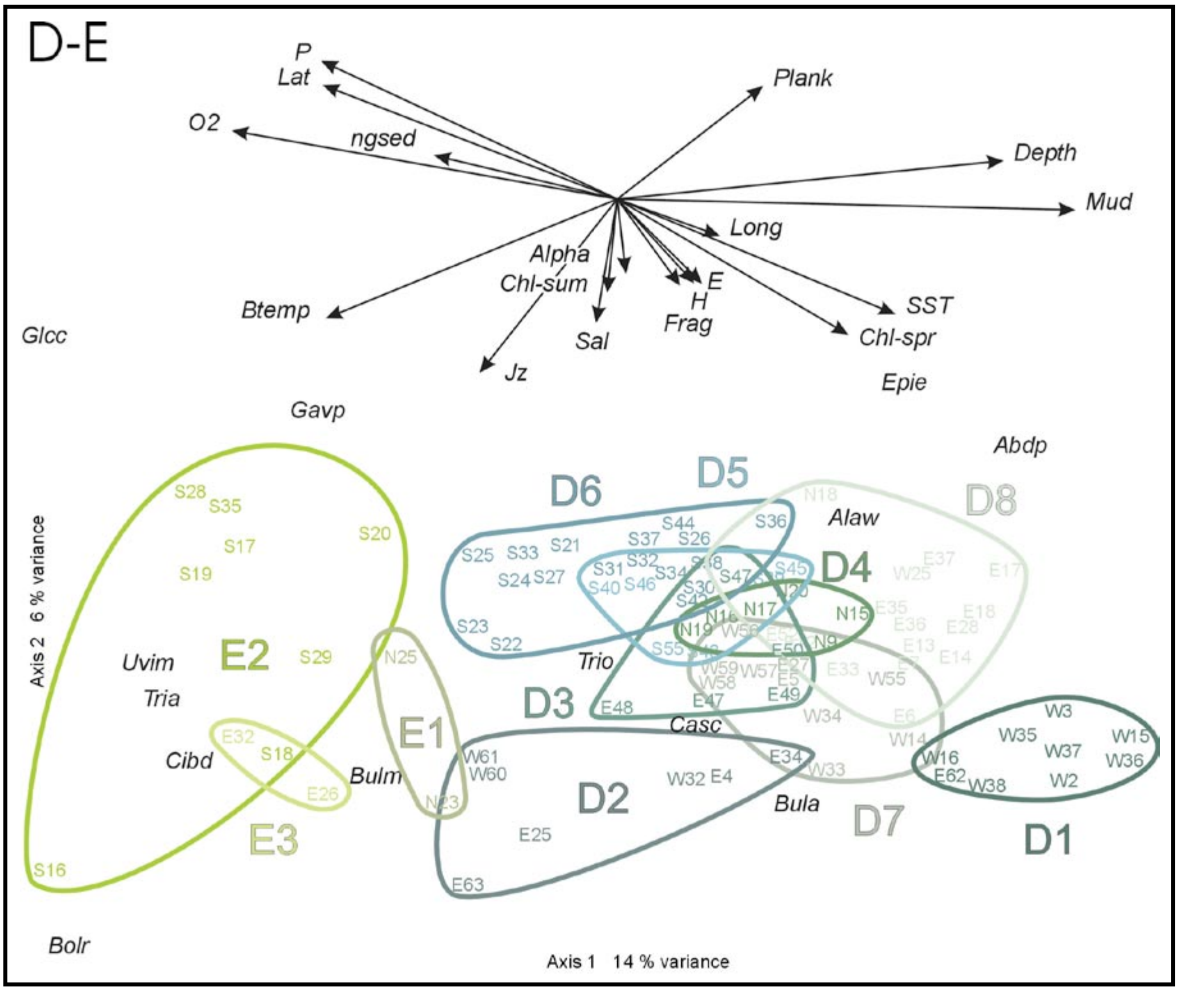


Figure 39. Two-dimensional ordination of bathyal foraminiferal samples (Associations D-E) and common species produced by Detrended Correspondence Analysis (DECORANA). The vector axes of "environmental" variables and species diversity (produced by Canonical Correspondence Analysis) are superimposed. The eight subassociations of D (D1-D8) and three of E (E1-E3) produced by cluster analysis based on full census data (Fig. 18) are shown. 3-4 letter abbreviations of species are given in Table 13.

Table 17. Correlation coefficients between environmental proxies and relative abundance of common deep-sea benthic foraminifera of sample associations D-E (Figs 25, 27). Only correlation coefficients that have more than 95% confidence of statistical correlation (P test, Moore and McCabe 1993) are printed. Bolded values are the more significant.

	Lat	**Depth**	**Long**	**ngsed**	**% mud**	**% plank**	**FI**	**Chl-ann**	**Chl-spr**	**Chl-sum**	**Seas**	**Jz**	**SST**	**Btemp**	**Sal**	**O**	**P**
Abditodentrix pseudothalmanni		0.36			0.34							-0.21		-0.36			
Alabaminella weddellensis					0.37	0.29					-0.24	-0.28		-0.24	-0.22		0.03
Astrononion novozealandicum				0.26		0.25											
Bolivina pseudolobata		-0.28			-0.24		0.26					0.30		0.38	0.35		
Bolivina robusta		-0.44			-0.36	**-0.63**						0.29		0.41		0.26	
Bolivina variabilis	-0.35	0.32											0.26				
Bulimina marginata f. *aculeata*	-0.44	0.22			0.32		0.38	0.43	**0.57**		0.35	-0.21	0.45		0.29	-0.42	**-0.54**
Bulimina marginata f. *marginata*	0.22				-0.33						-0.27		-0.26				0.22
Bulimina truncana	-0.40	0.30		-0.35	0.42				0.33		0.34	-0.37	0.42			**-0.52**	-0.42
Cassidulina carinata		0.23		0.25				0.37		0.45	0.28	0.23					
Cassidulina reniforme					0.26						0.29	-0.24	0.22				-0.26
Cibicides dispars s.l.		-0.33	-0.27		**-0.51**		-0.24	-0.23	-0.22			0.23		0.33		0.22	
Discorbinella bertheloti		-0.22		0.32	-0.29		-0.21							0.33	0.21		
Ehrenbergina carinata		0.28	0.22			0.05		0.15	0.22								-0.22
Eilohedra vitrea																	
Epistominella exigua		0.28				0.30		-0.29	-0.31	-0.25				-0.41			
Evolvocassidulina orientalis		-0.28	0.27				0.26	0.25		0.30		0.25		**0.51**	**0.53**		
Fissurina spp.											0.28						
Gavelinopsis praegeri	**0.59**	-0.38	-0.34		-0.26		-0.28	-0.47	**-0.53**	-0.26	-0.49	0.24	**-0.56**		-0.29	**0.50**	**0.60**
Globocassidulina canalisuturata	0.28	-0.28	-0.23	0.21	-0.48			-0.26	-0.31				-0.25			0.37	0.37
Globocassidulina minuta	-0.28	0.45	0.32	-0.24	0.38		0.45	0.48	0.49	0.33	0.24		0.26	-0.26		-0.24	-0.34
Globocassidulina subglobosa			0.30		-0.22		0.25	0.49	0.24	**0.64**	0.28	0.43		0.43	0.49		
Gyroidina danvillensis	-0.38			-0.21	0.47		0.42	0.40	**0.50**		0.21		0.36				-0.42
Nonionella auris	-0.28	0.34		-0.22	0.41		0.26	0.31	0.40		0.38		0.25			-0.34	-0.31
Nonionellina flemingi	-0.42	0.31										-0.26	0.37				
Osangularia bengalensis		0.29	0.43				0.28	0.37	0.36	0.34							-0.22
Porogavelinella ujiiei			-0.21		0.21	0.30	-0.24	-0.25		-0.25		-0.28					
Trifarina angulosa					**-0.52**							0.27		0.26	0.25	0.22	
Trifarina occidentalis											-0.36				-0.27		
Uvigerina mediterranea	0.36	-0.39			-0.32						0.29	0.29		0.30		0.40	0.32
Uvigerina peregrina s.l.	-0.44	0.30		-0.38	0.44				0.40			-0.40	0.46			**-0.54**	-0.45

at the top of AAIW down into the local oxygen minimum zone in upper CPDW at about 1500 m depth. Thus the shallower subassociations have better oxygenated bottom water (mean 4.4-5.9 μmol kg^{-1}), and the lowest oxygen conditions occur at mid-lower bathyal depths in the Tasman Sea west of New Zealand (D1, D7; mean 3.3-3.8 μmol kg^{-1}). Oxygen may be a driver of some faunal differences between these subassociations, particularly of the higher abundances of *Bulimina truncana* and *Uvigerina peregrina* (r=-0.52,-0.54) in the lowest oxygen subassociation, D1, and to a lesser extent in D7 (Fig. 25).

Most subassociations of D are dispersed along an oblique axis parallel to the strong vectors for latitude and the latitude-related variables - phosphate, spring chlorophyll and SST. Southern subassociations D5 and D6 underlie water with high surface phosphate (mean 0.84-0.89 μmol kg^{-1}; Fig. 11) and attendant higher summer phytoplankton productivity (Table 8). More northern-restricted subassociations D1, D4 and D7, underlie water with much lower surface phosphate (mean 0.28-0.32 μmol kg^{-1}) and chlorophyll-a (mean 0.23-0.31 μmol kg^{-1}). Subassociation D3 along the continental slope off the central South Island has moderately high phosphate (0.70 μmol kg^{-1}) and the highest mean annual chlorophyll-a (0.79 μmol kg^{-1}), which may be driving the faunal differences, such as the highest relative abundance of *Cassidulina carinata* (Fig. 25). Subassoc. D2 is separated from the others along an oblique axies parallel to depth and depth-related variables (bottom temperature, planktic percent) which suggests that variables related to its shallower location on the crest of Chatham Rise are driving the faunal differences.

Canonical Correspondence Analysis of dominantly mid-outer shelf associations, F-G

On the DECORANA ordination produced (Fig. 40), the faunal patterns correspond most strongly with the following latitude-related environmental variables (vectors) in decreasing order: sea surface temperature, bottom temperature, surface phosphate, latitude, and salinity. Variables appearing to have the least correlation with faunal patterns (shortest arrows on Fig. 40) are longitude and organic carbon flux. The indices for diversity clearly show that there is greater diversity and evenness in warmer water faunas. The strength of these environmental drivers was further investigated using correlation coefficient

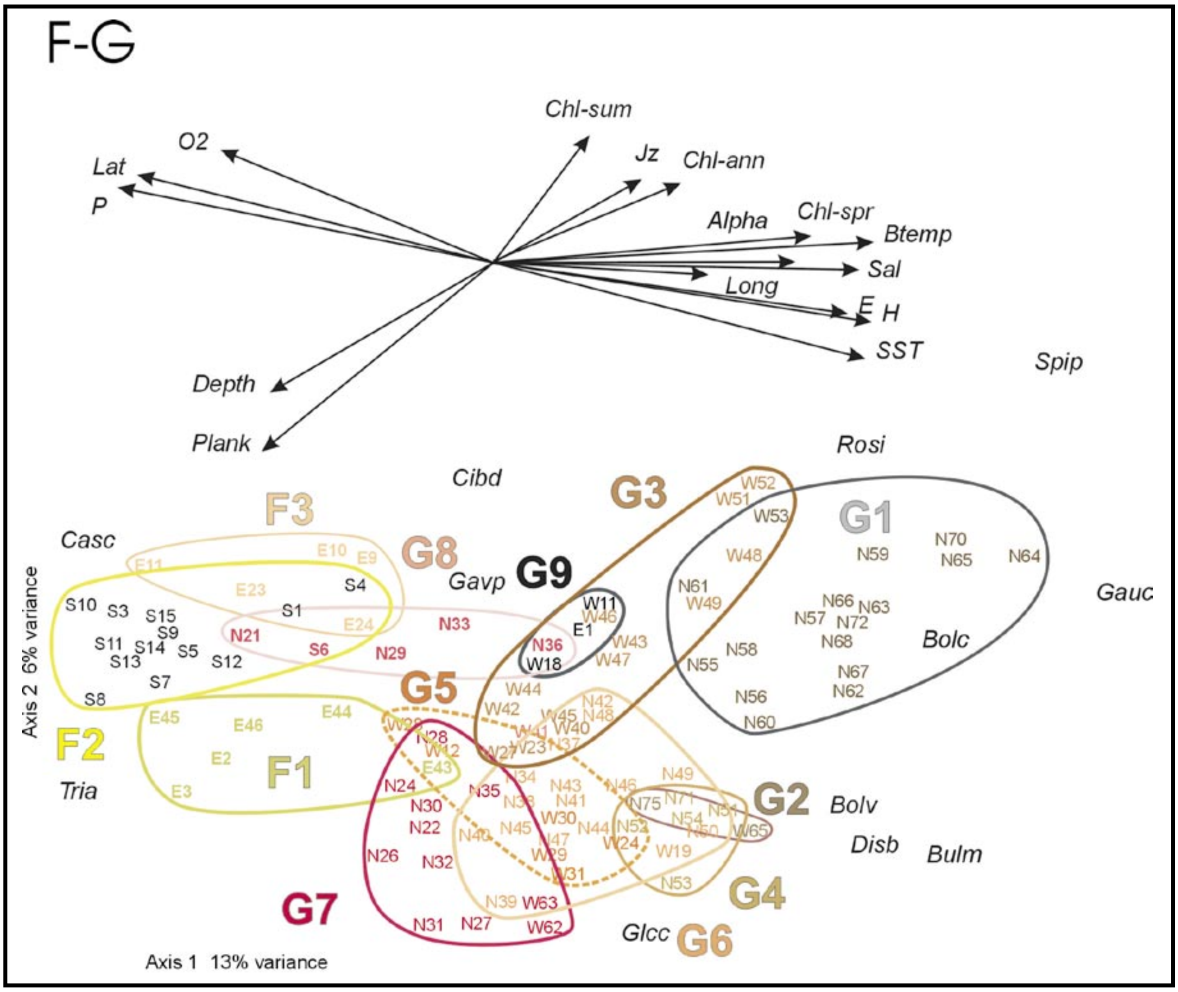


Figure 40. Two-dimensional ordination of mid shelf-upper bathyal foraminiferal samples (Associations F-G) and common species produced by Detrended Correspondence Analysis (DECORANA). The vector axes of "environmental" variables and species diversity (produced by Canonical Correspondence Analysis) are superimposed. The three subassociations of F (F1-F3) and nine of G (G1-G9) produced by cluster analysis based on full census data (Fig. 18) are shown. 3-4 letter abbreviations of species are given in Table 13.

analysis on a dataset for associations F and G separately (Tables 18-19).

Associations F and G are separated along axis 1, parallel to the strong latitude-related vectors mentioned above. These two associations are geographically separate (Fig. 29) with only one sample (E1) overlapping, otherwise G is northern-restricted beneath STW and association F southern-restricted beneath SAW. The drivers for the faunal differences between F and G are probably a combination of temperature, which is responsible for much of the biogeographic pattern of shallow water foraminifera distribution (e.g., Hayward *et al.* 1999), and quantity and character of food supply as reflected in the much higher phosphate and mean annual chlorophyll-a concentrations in southern surface waters.

The subassociations of F are dispersed in a direction parallel to axis 2 with only a relatively weak summer chlorophyll vector hinting at variables that may be driving the faunal differences. The three subassociations occur within different latitudinal ranges and thus a combination of temperature and significant differences in chlorophyll-a (Table 9) may cause the separation. Four species that are mostly limited to F1 (*A. weddellensi*, *B. marginata* f. *marginata*, *G. subglobosa*, *N. flemingi*) have the highest positive correlation coefficients with annual, spring and summer chlorophyll-a in the Assoc. F dataset (r=0.51-0.79; Table 18) suggesting that primary productivity could be driving the distinctiveness of this subassociation. The other Chatham Rise subassociation, F3, has two species (*E. orientalis*, *D. bertheloti*) that have a high fidelity to it and the highest correlation with sustained annual food supply, spring chlorophyll and low oxygen concentrations (Table 18). On the other hand F2 occurs further south than the other two subassociations and presumably temperature and biogeographic species' distributions are driving its distinctiveness.

The faunal dispersion of the subassociations of G on the ordination (Fig. 40) closely parallels their depth distribution. At these mid shelf to upper bathyal depths the main depth-related drivers are likely to be food supply (Jz vector subparallel to depth in Fig. 40) and bottom current strength. These are likely to be the strongest influences that produce the depth-related subdivision of association G off north-east New Zealand (Fig. 29) into an upper bathyal G7, outer shelf G6, deep mid shelf G4 and shallow mid shelf G1, with progressively increasing organic carbon flux (Jz). Species characterising the deeper subassociations (positive correlation with depth, negative with Jz; Table 19) are *Bolivina robusta*, *C. carinata*, and *A. weddellensis*). Depth-related carbon flux (Jz) is probably also a strong driver of the faunal differences between mid shelf G9 and G3, outer shelf G5, and upper bathyal G7, off the west coast. The driver for the faunal differences between the two west coast mid shelf subassociations may be related to mud percentage and bottom energy conditions, with a mean of just 2% mud off the exposed west coast of the northern North Island (G9) and a mean 49% mud in the quieter mid shelf bottom waters in the Wanganui Bight (G3). The

Table 18. Correlation coefficients between environmental proxies and relative abundance of common deep-sea benthic foraminifera of sample association F (Figs 28). Only correlation coefficients that have more than 95% confidence of statistical correlation (P test, Moore and McCabe 1993) are printed. Bolded values are the more significant. Bolded values are the more significant.

	Lat	Depth	Long	ngsed	% mud	% plank	FI	Chl-ann	Chl-spr	Chl-sum	Seas	Jz	SST	Btemp	Sal	O	P
Alabaminella weddellensis	-0.42				0.40		**0.58**	**0.51**		0.40				**0.50**	**0.50**		
Astrononion novozealandicum	0.45											**-0.50**	**-0.51**	-0.48	-0.43	**0.50**	**0.50**
Bulimina marginata f. *marginata*	-0.48							**0.79**	**0.68**	**0.63**				0.47	0.49		
Cassidulina carinata																	
Cibicides dispars s.l.																-0.44	
Discorbinella bertheloti	**-0.66**		**0.56**				**0.64**		0.39		-0.40		**0.70**	**0.75**	**0.79**	**-0.56**	**-0.66**
Evolvocassidulina orientalis	**-0.57**		0.44				0.40		0.43		**-0.61**		**0.60**	**0.60**	**0.59**	**-0.51**	**-0.61**
Gavelinopsis praegeri	0.43	-0.43		0.49				**-0.61**	**-0.56**	**-0.50**				-0.43	-0.48		
Globocassidulina canalisuturata			**-0.51**						-0.43								
Globocassidulina subglobosa	**-0.56**				**0.51**	0.44		**0.64**	**0.51**	**0.55**			0.42	**0.56**	**0.58**		
Nonionellina flemingi	-0.46				**0.56**			**0.68**	**0.57**	**0.55**				0.40	0.43		
Trifarina angulosa	0.43		-0.47								0.48		-0.42	**-0.58**	**-0.53**		0.42

Table 19. Correlation coefficients between environmental proxies and relative abundance of common deep-sea benthic foraminifera of sample association G (Fig. 30). Only correlation coefficients that have more than 95% confidence of statistical correlation (P test, Moore and McCabe 1993) are printed. Bolded values are the more significant.

	Lat	Depth	Long	ngsed	% mud	% plank	FI	Chl-ann	Chl-spr	Chl-sum	Seas	Jz	SST	Btemp	Sal	O	P
Alabaminella weddellensis		0.24				0.48		-0.24	-0.23	-0.31		-0.41					
Bolivina cacozela						-0.23						0.22					-0.30
Bolivina pseudolobata	0.31				0.36	0.31		-0.26	-0.36	-0.37	-0.27	-0.26	-0.26	-0.32		**-0.51**	-0.30
Bolivina robusta		**0.54**		0.37		**0.59**		-0.27	-0.31	-0.39		-0.40		-0.36	-0.32	-0.26	
Bolivina variabilis					0.22		-0.29										
Bulimina marginata f. *marginata*	0.26	-0.34		-0.33					0.35	0.40					0.24		
Cassidulina carinata		**0.54**	-0.26	0.30	0.31			-0.34	-0.48	-0.45	-0.42	-0.22		**-0.68**	**-0.65**	-0.41	
Cibicides dispars s.l.					-0.24		**0.59**										0.55
Discorbinella bertheloti				0.23													
Eilohedra vitrea					-0.22				0.27	0.36				0.28	0.23	0.25	
Evolvocassidulina orientalis	-0.39							0.24	0.24		0.35		0.37	0.26	0.22	0.25	0.29
Gaudryina convexa		-0.25			-0.28	-0.33	-0.23			0.23		0.27		0.29	0.23		
Gavelinopsis praegeri	-0.22	-0.29	0.27			-0.22	0.23	0.23	0.29	0.26			0.27	0.43	0.37	0.37	
Globocassidulina canalisuturata	**-0.68**			0.23	-0.38						0.25	-0.31	**0.64**	0.41	0.30	0.42	0.36
Miliolinella subrotundata		-0.38		-0.27	-0.24	-0.49	-0.35					**0.59**					
Neouvigerina proboscidea						0.22		-0.22	-0.30	-0.26		-0.26					
Nonionellina flemingi	0.28				0.43								-0.24	-0.27	-0.27		
Saidovina karreriana	0.23	-0.28			0.24	-0.39						0.27	-0.23				
Sphaeroidina bulloides					0.28												
Spiroplectinella proxispira		-0.43		-0.29	-0.26	**-0.58**	-0.31	0.24	0.29	0.36		**0.56**		0.29	0.24	0.25	
Trifarina angulosa		0.29				0.49		-0.29	-0.38	-0.39	-0.22			-0.30	-0.23		

amount of mud would also reflect the quantity of settling food and impact on the interstitial oxygen concentrations, both of which could influence the faunas. One of the main differences between these two is the far greater abundance of high-energy tolerant *Cibicides dispars* in G9 (mean 19%) compared with G3 (mean 1%). This is reflected in the high positive correlation between *C. dispars* and fragmentation index (r=0.59) in this data set, inferred to be caused by high wave or current energy breakage of shells.

There is also a difference in the geographic distributions (longitude) of the subassociations with some confined to the north-east and some to the west of New Zealand and several shared. The drivers for this east-west difference are not depth-related, but could be a combination of water temperature, bottom oxygen and surface phosphate (all vectors subparallel to longitude in Fig. 40). Surface phosphate values are only slightly lower off the west coast than the east (Fig. 11) and bottom oxygen concentrations are also lower out west. Neither of these is considered sufficiently different to produce the faunal differences. The largest differences are in the surface and bottom water temperatures at these shallow depths, largely as a result of the East Auckland Current carrying warm STW down the east coast of the North Island and only to a limited extent down the west coast. Thus water temperatures are on average 3°C cooler off the west of central New Zealand than the east of northern North Island (Fig. 9). Species that are significantly more common east than west within Assoc. G are *G. canalisuturata*, *E. orientalis* and *G. praegeri* (all with positive correlations with SST and negative with latitude (proxy for east-west divide here)).

The reason for the faunal distinctiveness of upper bathyal subassociation G8 is uncertain. It is restricted to a small region east of North Cape, beneath slightly warmer surface water than the other subassociations of G and it also has the lowest chlorophyll-a values (Fig. 10) and highest fragmentation index values. It is furthest from any source of terrigenous sediment input and upcurrent from any freshwater inflow from the land, all of which probably result in it being the most oligotrophic of the subassociations of G. At these upper bathyal depths, the high fragmentation is probably a result of strong bottom currents swinging around northern New Zealand and considerable downslope transport of foraminiferal tests possibly producing a mixed death assemblage.

Overall inferences from Canonical Correspondence Analyses

The above four analyses indicate that there are a number of environmental drivers that combine to produce the observed pattern of deep-sea benthic foraminiferal distribution around New Zealand. The strongest group of variables that produce most of the differences between associations and also some of the subassociation splits are depth-related. The most important of these are: 1. organic carbon flux to the seafloor (Jz), which decreases with increasing depth as it is consumed by mid-water biota on its downward journey; 2. carbonate corrosiveness of bottom waters, primarily deep in the lysocline at depths >3500 m in lower CPDW; 3. oxygen concentrations in the bottom and interstitial waters which are related to properties of the water masses (local oxygen minimum zone at lower bathyal depths in upper CPDW) and to high carbon flux which lowers interstitial oxygen.

The second strongest set of variables that appear to drive faunal association and subassociation distribution are latitude- and longitude-related. The most important of these are: 1. organic carbon flux (Jz) to the seafloor, which reflects phytoplankton productivity in the overlying surface waters (chlorophyll-a proxy) which itself is driven by variables such as dissolved nutrients (e.g., surface phosphate proxy); 2. the character, quantity and seasonality of the carbon flux, which reflects the overall composition and interacting blooms of the near surface plankton (e.g., seasonality index, SST partial proxy, chlorophyll-spring and chlorophyll-summer proxies); 3. bottom water temperature at shelf depths, which is strongly influenced by latitude-related SST. This is one of the major variables influencing the biogeographic distribution of global shallow-water biota, as reflected in the subdivision of New Zealand's mid shelf-upper bathyal faunas into a warm, northern association (G) and a cool, southern association (F). This is also responsible for some of the subdivision of G into warmer north-east-restricted subassociations (G1, G4) and cooler west-restricted subassociations (G3, G5).

Another environmental driver is bottom current strength (mud proxy and fragmentation index at shallow depths) which can winnow away most of the fines, leaving relatively clean, oxic sand and gravel substrates. Strong currents mostly occur at shallower (shelf) depths, but can impact deeper seafloor where submarine topography enhances current strength (E), particularly beneath deep-reaching fronts (B).

Discussion

Other workers have inferred that deep-sea benthic foraminiferal distribution patterns are strongly influenced by combinations of organic carbon flux, dissolved oxygen concentration, and biological interactions (van der Zwaan *et al.* 1999). The organic carbon flux is mostly derived from phytoplankton productivity, which when it sinks to the seafloor is the primary source of food for deep-sea benthic foraminifera and influences their abundance and composition (e.g., Altenbach & Sarnthein 1989, Hermelin & Shimmield 1995, Loubere & Fariduddin 1999, Gooday & Hughes 2002).

One group of thin-shelled, opportunistic, largely epifaunal taxa (e.g., *Alabaminella weddellensis, Epistominella exigua*) has been recognised to flourish where there is a relatively high, seasonally-pulsed, phytodetrital food supply (e.g., Gooday & Turley 1990, Gooday 1993, Smart *et al.* 1994, Nees 1997, Nees & Struck 1999; Table 16). Two of the three most abundant species in bathyal and abyssal depths around New Zealand (Tables 5, 16) belong to this group: *A. weddellensis*, and *E. exigua*.

These imply a strong seasonality in the phytodetrital food supply (Gooday 1993) over the Bounty Trough and west Bounty Plateau where their combined relative abundance exceeds 30% of the benthic fauna (Fig. 41). This is a region of known upwelling south of the STF and strong summer seasonal phytoplankton blooms (Bradford-Grieve *et al*. 1999, Nodder & Northcote 2001). Weaker seasonality (spring and autumn blooms) is indicated in deeper regions offshore of the east and west coasts of the North Island (20-30% relative abundance, Fig. 41). A region in which the benthic foraminiferal faunas indicate little influence of strongly seasonal food supply, lies beneath and to the south-east of the SAF (Associations A1 and B).

As it sinks, phytodetritus is consumed, resulting in decreasing food supply as water depth increases (Berger & Wefer 1990, Gooday 2003). As discussed earlier, this is a possible explanation for the observed depth-related distributional patterns of many deep-sea benthic foraminifera. The depth-related trend in abundance in this study, from *C. carinata*, to *A. weddellensis* and then to *E. exigua* (Fig. 19), correlates well with the reported decreasing carbon flux requirements of each species

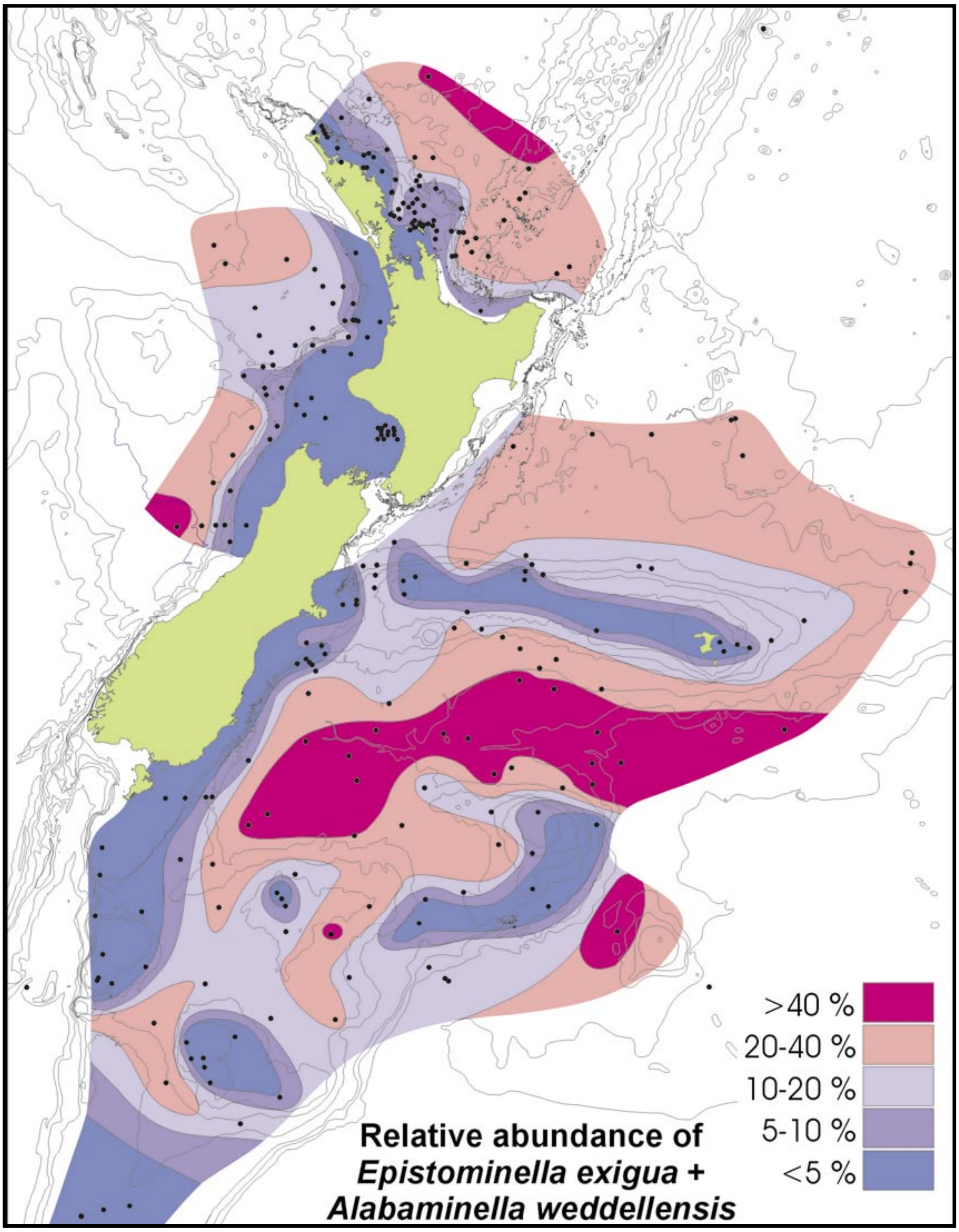


Figure 41. Contoured relative abundance of *Alabaminella weddellensis* plus *Epistominella exigua*, considered to be proxy indicators of the strength of seasonality in phytodetrital food supply (Gooday 1993).

for maximal productivity (e.g., Fariduddin & Loubere 1997, de Rijk *et al.* 2000). Subssociations of F and G that are dominated by epifaunal *C. carinata* (not G1, G2; Figs 28, 30) occur in almost all areas between 50 and 300 m around New Zealand, despite large differences in sea surface temperature, water mass (STW v. SAW), and phytoplankton productivity (as evidenced by chlorophyll-a and phosphate values). *Cassidulina carinata*, reportedly thrives in areas of sustained carbon flux, Jz (Mackensen *et al.* 1995), which is probably the over-riding factor here in shallow water, and is not transmitted to greater depths.

In some instances the composition of benthic foraminiferal assemblages appears to reflect the influence of low oxygen conditions in the bottom and interstitial waters (Schnitker 1994, Murray 1995, Kaiho 1999, Bernhard & Sen Gupta 1999, Gooday 2003). Low oxygen is often associated with high carbon flux, and thus the assemblages may also reflect a relationship with increased food supply (e.g., Pederson *et al.* 1988, Rathburn & Corliss 1994, Fontanier *et al.* 2002). Taxa identified as dominating oxygen-deficient substrates (Table 16) include *Bulimina* spp*.*, *Uvigerina* spp*.*, and some *Bolivina* spp. (Verhallen 1991, Hermelin 1992, Sen Gupta & Machain-Castillo 1993). In this study, the distributions of *Bulimina marginata* f. *aculeata*, *B. truncana*, *Gyroidina soldanii*, *Uvigerina peregrina*, *Melonis affinis*, *Osangularia bengalensis* and *Oridorsalis umbonatus* are positively correlated (eg., Table 4) with low bottom water oxygen concentrations. Either of these two *Bulimina* species co-dominate subassociations C3, C4, C6, D1, D5 and to a lesser extent C1 (Figs 24-25). These subassociations occupy the local oxygen minimum zone in the upper CPDW at lower bathyal-upper abyssal depths around New Zealand (~1300-2300 m), and their abundance here probably reflects the lower oxygen conditions. The oxygen concentrations in this zone are not particularly low (3.5-4.0 µmol kg^{-1} east and south of New Zealand) compared with some places in the world. The lowest oxygen values in the minimum zone around New Zealand occur off the west coast, where they range between 2.8 and 3.3 µmol kg^{-1} at depths between 1000 and 2300 m. Here to the west, both these species have their highest relative abundances (Fig. 42) and are the dominant species of subassociation C3 (*B. m.* f. *aculeata*) and D1 (*B. truncana*).

Initial quantitative assemblage studies on deep-sea benthic foraminifera interpreted the clearly recognisable depth-related distributional patterns to be a result of the difference in the thermohaline properties of the deep-water masses (e.g., Streeter 1973, Weston & Murray 1984 Murray *et al.* 1986, Schnitker 1994). For example, a *Nuttallides umbonifera* association was thought to be characteristic of Antarctic Bottom Water (Schnitker 1980, Weston & Murray 1984). In more recent times, the relationship between benthic foraminifera and deep-water masses has been largely discounted (e.g., van der Zwaan *et al.* 1999), although some workers argue that where productivity is uniform or low, epifaunal deep-sea foraminiferal faunas carry a strong imprint of the water masses that directly overlie them (e.g., Gooday 1994, Schnitker 1994, Murray 1995 Thomas & Gooday 1996, Mackensen *et al* 1995, Schmiedl *et al.* 1997). This view is supported in part by our observations around New Zealand, where the faunal associations match moderately well the documented bathymetric stratification of the overlying water masses (Fig. 8). Association A (>3500 m) is overlain by lower CPDW; C1, C3, C4, D1, D4, D6 (1300-3000 m) by the oxygen minimum zone of upper CPDW; D3, D5, D7, E1 mostly by AAIW; E2 and E3 by SAMW; F by SAW and G by STW (Table 5).

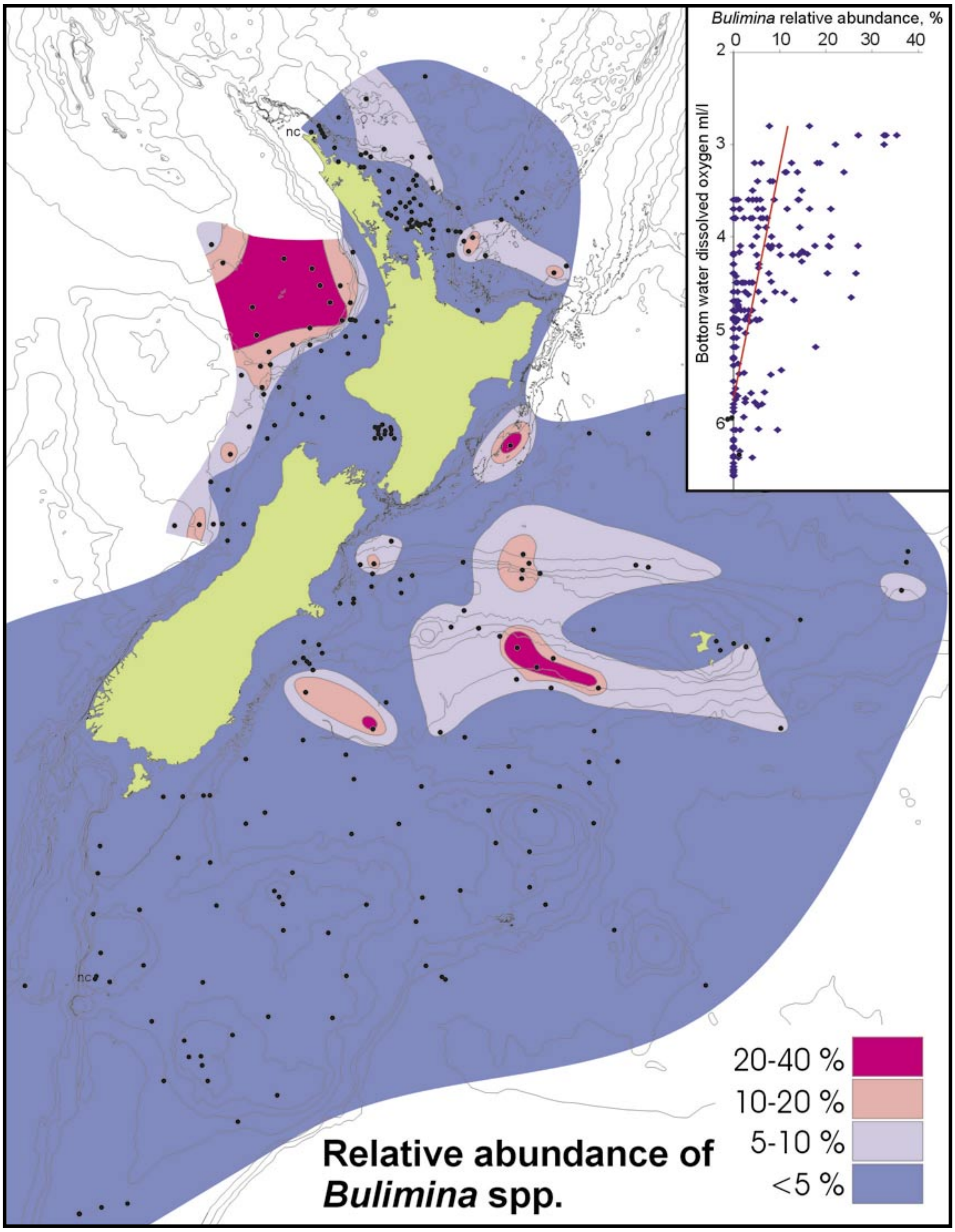


Figure 42. A. Contoured relative abundance around New Zealand of *Bulimina marginata* f. *aculeata* plus *Bulimina truncana*, considered to be proxy indicators of lower oxygen concentrations in bottom waters. B. Relative abundance of these two species combined plotted against bottom-water oxygen concentrations.

SPECIES DIVERSITY

FISHER ALPHA & SHANNON INDICES

The Fisher Alpha and Shannon species diversity indices have relatively strong negative correlation coefficients with latitude (Table 4, r = -0.54, -0.57), consistent with many other studies that indicate that species diversity decreases from warmer to colder areas. This trend is also clearly read from the trend lines on the depth plots (Figs 43-44) where faunas off the north-east region are generally more diverse at all depths from shelf down to mid abyssal depths (<3000 m). The trend lines appear to suggest that at shelf and upper bathyal depths (<600 m) species diversity decreases from north to south. At lower abyssal depths (>3000 m) faunas from all regions seem to have a similar range of species diversity (alpha and H). The contoured map of Fisher Alpha species diversity (Fig. 45) clearly shows the distribution of highest species diversity off the north-east coast and spreading southwards down the east coast of the North Island. Faunas with the very lowest species diversity (Alpha <5) occur off southern New Zealand at shelf depths on two of the subantarctic seamounts and in the very deepest sample (below the CCD).

Some workers have suggested that species diversity might be useful in estimating paleodepths of fossil assemblages. Buzas & Gibson (1969) and Gibson and Buzas (1973) in North Atlantic studies recorded increasing species diversity across the shelf to a maximum at upper bathyal depths before a gentle decline into the abyssal. In our study, alpha has a very weak significant positive correlation with depth (r = 0.12) and H has no significant correlation. The trend lines (Figs 43-44) suggest slight increasing mean species diversity across the shelf to an upper bathyal peak only in the west region. There is a slight overall decrease in mean species diversity across the shelf to mid-upper bathyal lows in both the north-east and east central regions. The southern region exhibits a slight consistent increase in species diversity from shelf depths all the way down to the mid abyssal (~3500 m) followed by a decline at greater depths, possibly related to dissolution of more fragile tests. In the east central region mean species diversity rises consistently from lower bathyal to lower abyssal depths (1000-4700 m). In the north-east species diversity rises slightly from mid bathyal to an upper abyssal peak

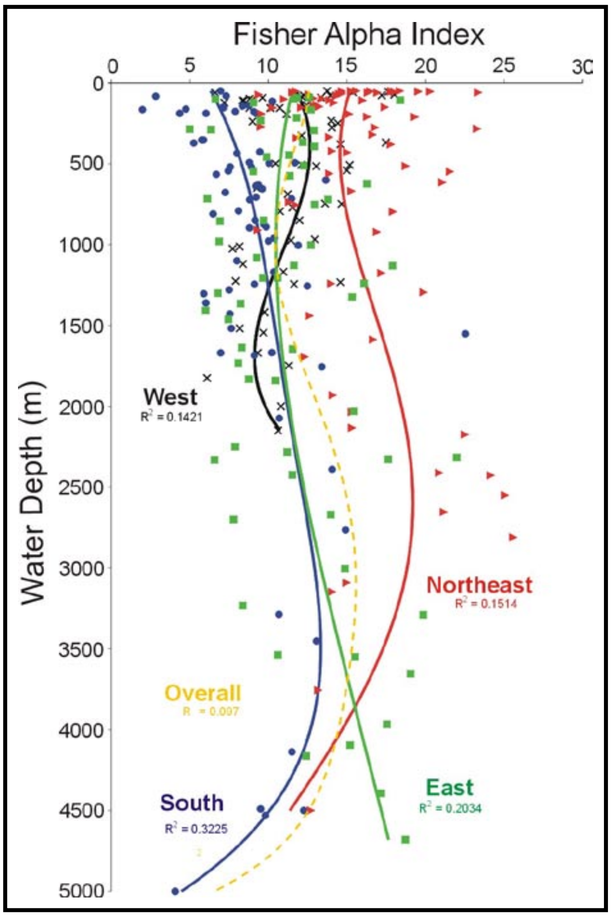


Figure 43. Fisher Alpha Index for benthic foraminiferal (>63 μm) species diversity plotted against depth in the four regions around New Zealand deeper than 50 m. Polynomial trend lines for each region and overall were generated using Excel and R^2 values gives a measure of goodness of fit.

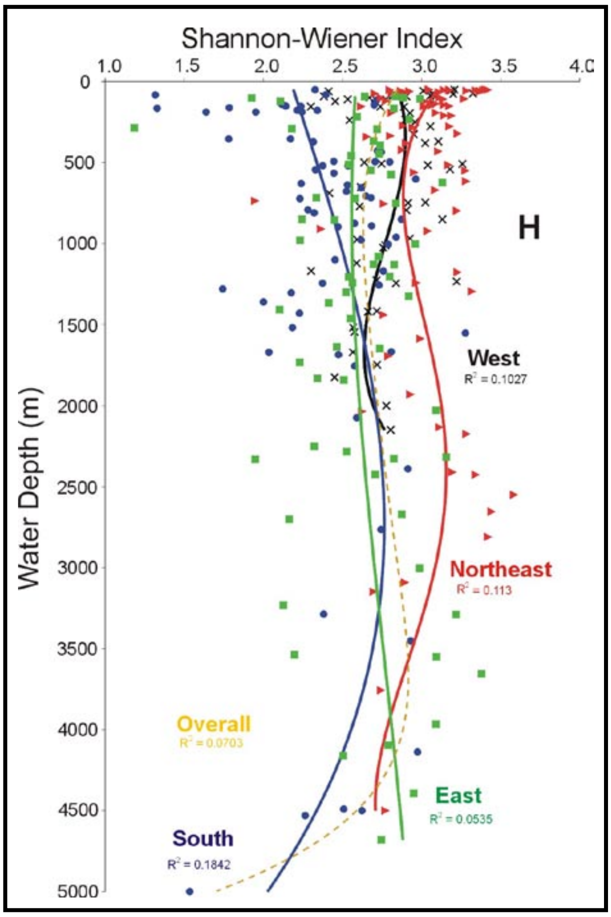


Figure 44. Shannon-Wiener Index, H, for benthic foraminiferal (>63 μm) species diversity plotted against depth in the four regions around New Zealand deeper than 50 m. Polynomial trend lines for each region and overall were generated using Excel and R^2 values gives a measure of goodness of fit.

(500-3000 m), before dropping again as depth increases (Figs 43-44). Unfortunately it seems that species diversity cannot be used with any confidence as a proxy for paleodepth around New Zealand.

The north-south decrease in species diversity is also evident in the mean values for Alpha and H for the two shelf-upper bathyal sample associations (Table 6). Southern-restricted Assoc. F has Alpha = 9±4 and H = 2.3±0.5, whereas northern-restricted G has Alpha = 14±4 and H = 3.0±0.3. Mid bathyal-abyssal association C, which doesn't occur in the southern region has similar high mean species diversity to G (Alpha = 13±5, H = 2.7±0.4). Associations A, B, D and E all have similar mean species diversity (Alpha = 11-13, H = 2.5-2.7). At subassociation level, the small northern-restricted, upper bathyal E2 has the highest mean species diversity (Alpha = 21, H = 3.3), closely followed by the northern, upper abyssal C4 (Alpha = 20±5, H = 3.2±0.3). The lowest species diversity occurs at outer shelf and upper bathyal depths on the subantarctic seamounts in subassociations F3 and E1 (Alpha = 7±2, 8±3; H = 2.1±0.4, 2.4±0.4).

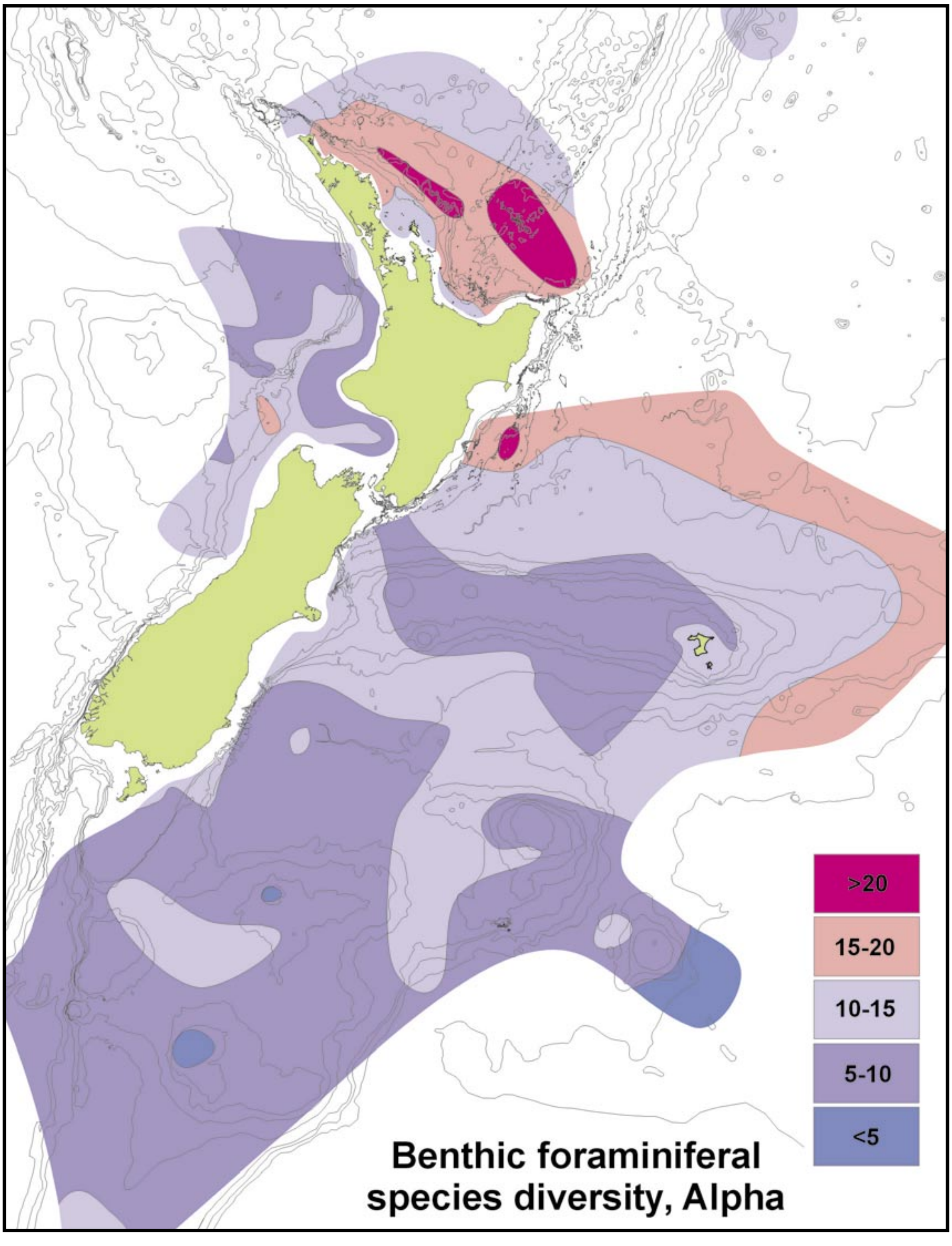


Figure 45. Contoured map for the New Zealand region showing the distribution of Fisher Alpha Index of benthic foraminiferal (>63 µm) species diversity at depths greater than 50 m.

Table 20 examines the relationship between the mean observed values of H and the mean theoretical values of H for a log series. The differences between the theoretical and observed values are given in the last column of Table 20. The observed values are always less than the theoretical log series values and an ANOVA on the differences indicates no significant difference among the associations. Therefore, based on the individual samples, no discrimination between associations is possible and no association is more similar to a log series than any other. In the upcoming section on SHE analysis we show how regions and depths can be categorized for their similarity to a log series using a community structure approach.

EVENNESS

This is solely a measure of evenness (E) of species counts within a fauna. Values range between 0 and 1, with the most evenly spread faunas having the highest values. In this study there is a moderately strong negative correlation between E and latitude (r = -0.44, Table 4) which implies that warmer water northern faunas are more even than southern ones. The E versus depth plot (Fig. 46) shows that at upper abyssal and shallower depths (<3000 m) faunas off north-east and west New Zealand generally have more even species distribution than those from the east central and southern regions. Evenness also has a moderate negative correlation with surface phosphate and

Table 20. Values of Fisher's alpha, ln(alpha), $H_{\text{log series}}$ = ln(alpha) + 0.577, mean of H_{observed} and delta ($H_{\text{log series}}$ - H_{observed}). Note values of delta are always positive indicating the theoretical log series is always greater than the observed. An ANOVA on delta values for the 6 associations is not significant.

Assoc	Alpha observed	ln(alpha)	H expected	H observed	Delta H	Distribution
A	13	2.565	3.142	2.75	0.39	
A1	10.1	2.313	2.890	2.5	0.39	S (N)
A2	17.3	2.851	3.428	3.13	0.30	E
B	11.2	2.416	2.993	2.5	0.49	S
C	13.2	2.580	3.157	2.7	0.46	
C1	13.7	2.617	3.194	2.74	0.45	E (N)
C2	19	2.944	3.521	3.13	0.39	N
C3	9.9	2.293	2.870	2.67	0.20	W
C4	22.1	3.096	3.673	3.27	0.40	N (E)
C5	12.6	2.534	3.111	2.36	0.75	E
C6	11.5	2.442	3.019	2.64	0.38	E,N,S (W)
C7	14.9	2.701	3.278	2.82	0.46	E (S)
D	10.7	2.370	2.947	2.6	0.35	
D1	9.9	2.293	2.870	2.77	0.10	W (E)
D2	12.2	2.501	3.078	2.93	0.15	E,W
D3	13.8	2.625	3.202	2.58	0.62	E
D4	15.5	2.741	3.318	2.97	0.35	N
D5	9.7	2.272	2.849	2.65	0.20	S
D6	9.2	2.219	2.796			
2.56	0.24	S				
D7	11.6	2.451	3.028	2.78	0.25	E,W
D8	9.3	2.230	2.807	2.52	0.29	E (N,W)
E	10.7	2.370	2.947	2.8	0.15	
E1	21.3	3.059	3.636	3.28	0.36	N
E2	7.9	2.067	2.644	2.42	0.22	S
E3	11.3	2.425	3.002	2.66	0.34	E
F	8.8	2.175	2.752	2.3	0.45	
F1	12.3	2.510	3.087	2.74	0.35	E
F2	6.8	1.917	2.494	2.08	0.41	S
F3	10.2	2.322	2.899	2.17	0.73	E
G	13.8	2.625	3.202	2.96	0.24	
G1	16.7	2.815	3.392	3.18	0.21	N
G2	12.3	2.510	3.087	3	0.09	N,W
G3	12.8	2.549	3.126	2.95	0.18	W
G4	11.6	2.451	3.028	2.83	0.20	N
G5	10.6	2.361	2.938	2.72	0.22	W
G6	13.3	2.588	3.165	3.01	0.15	N (W)
G7	14.4	2.667	3.244	2.98	0.26	N (W)
G8	17.9	2.885	3.462	2.74	0.72	N
G9	9.6	2.262	2.839	2.54	0.30	W (E)

chlorophyll-a (r = -0.41, -0.34) which could be entirely an artifact of the latitudinal trend or could be the reason for the latitudinal trend with more dominance of opportunistic species (r-strategists) in the south where nutrients and food supply are higher.

In this study, E ranges between 0.16 and 0.69 (mean 0.46). There are no obvious trends with increasing water depth (Fig. 46), although there is a very weak, significant negative correlation between E and depth (r = -0.17, Table 4). As with Alpha and H, the main difference between the sample associations for the mean value of E is seen in the two shallower associations, with northern-restricted G being more even (E = 0.51±0.08) than shallow-restricted F (E = 0.38±0.10). The other low evenness association is the southern-restricted, lower bathyal B (E = 0.37±0.09). The remaining associations have E values between 0.39 and 0.47.

At subassociation level, the northern-restricted, mid shelf G1 and the small central New Zealand outer shelf G2 (Fig. 29) have the most even species distributions (E = 0.56±0.08, 0.59±0.15). The east-restricted, upper bathyal D5 and F3, in Canterbury Bight and on Chatham Rise, have the least even faunas (E = 0.34±0.04, 0.31±0.11).

SHE ANALYSIS

SHE analysis for biofacies identification (SHEBI)

The data for the four large regional areas consisting to the north-east, west, east and south were analysed using SHE analysis to identify communities (Buzas *et al*, 2007). Rather than analysing individual stations to look for patterns, SHE analysis for biofacies identification (SHEBI) groups stations into communities and then examines the accumulation of S, H and E for patterns. In the north-east 238 species were analysed from 56 stations. Of these 56 stations, 51 or 91% could be designated into four communities or biofacies. In the west 149 species at 32 stations were analysed. These were grouped into 3 biofacies with 24 stations or 75% belonging to these biofacies. In the east 251 species at 61 stations were analysed. Only 32 stations or 52% could be grouped into 5 biofacies. In the south 214 species from 68 stations were examined. About half (44%) of these stations could be grouped into four biofacies. We have then a pattern of fewer stations forming statistically recognisable communities from north to south.

SHE analysis for community structure identification (SHECSI)

Buzas *et al*. (2007) published the regression equations and biodiversitygram (BDG) plots for the deep-sea New Zealand data. Here we will use those analyses (shown here in Tables 21-24) along with the calculation of the null model (Log Series) suggested by Buzas & Hayek (2005) to compare community structure in the four regional areas and show how each is unique in terms of their community structure.

Figure 47 is a BDG plot of the observed values from regression equations for lnS, H and lnE at N = 200, 400, 1000 and 1300. Values for a theoretical log series are plotted on the same graph. For the log series the value of S at N = 1300 is used to estimate α, the parameter of the log series. Values of S at the other values of N are estimated from S = αln(1 + N/α). As already noted, the estimate for the information function of a log series is H = lnα + 0.577 and lnE = H –lnS. In the north-east stations range from 50 – 561 m in depth. The community consists of 33 stations and is the largest accumulated number we have observed in SHE analysis. The average depth is 223 m or upper bathyal, but the community covers middle-outer shelf as well as upper bathyal depths. At N = 1300 the estimate for S is 75 (Table 21, biofacies 1) so that Fisher's α = 17.314 and the estimate for the log series H is 3.43. We have then for the log series $\ln S_{LS} = 3.43 - 1.00 \ln E_{LS}$ and for the observed $\ln S_0 = 2.92 - 1.39 \ln E_o$. As

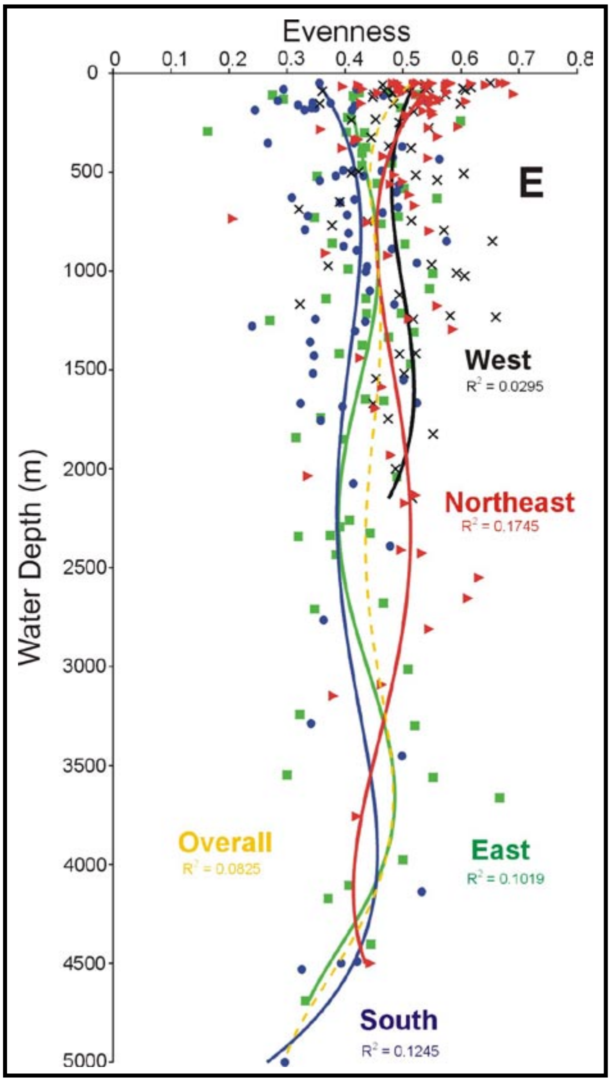


Figure 46. Evenness index, E, for benthic foraminiferal faunas (>63 μm) plotted against depth in the four regions around New Zealand deeper than 50 m. Polynomial trend lines for each region and overall were generated using Excel and R^2 values gives a measure of goodness of fit.

Table 21. Results of SHE analysis for north-east of New Zealand.

Biofacies	Stations depth	n	N	S	H	E	β_1	β_1 confidence limits
1	N56 - N24		200	36	3.09	0.61		
	Outer shelf-	33	400	47	3.18	0.50	- 1.39	- 1.44 < β < - 1.34
	Upper bathyal		1000	68	3.28	0.39		
	50-561m		1300	75	3.30	0.36		
	μ = 223m							
Regression equations:								
	lnS = 1.52 + 0.39ln N, p = 0.00, R^2 = 0.98				H = 2.51 +0.11lnN, p = 0.00, R^2 = 0.94			
	lnE = 0.99 - 0.28lnN, p = 0.00, R^2 = -.98				lnS = 2.92 - 1.39lnE, p = 0.00, R^2 = 0.99			
2	N20 - N15		200	33	2.78	0.46		
	Mid bathyal	6	400	46	2.95	0.42	- 2.28	- 3.39 < β < - 1.16
	754-1242m		1000	69	3.19	0.35		
	μ = 967m		1300	77	3.28	0.32		
Regression equations:								
	lnS = 1.12 + 0.45lnN, p = 0.00, R^2 = 0.99				H = 1.35 + 0.27lnN, p = 0.01, R^2 = 0.93			
	lnE = 0.23 - 0.19lnN, p = 0.00, R^2 = 0.98				lnS = 1.84 - 2.28lnE, p = 0.00, R^2 = 0.94			
3	N14 - N9		200	43	3.28	0.62		
	Lower bathyal	6	400	54	3.29	0.48	- 1.04	- 1.20 < β < - 0.89
	1295-2036m		1000	77	3.30	0.35		
	μ = 1664m		1300	87	3.31	0.32		
Regression equations:								
	lnS = 1.74 + 0.38lnN, p = 0.00, R^2 = 0.99				H = 3.17 + 0.02lnN, p = 0.47, R^2 = 0.37			
	lnE = 1.43 - 0.36lnN, p = 0.00, R^2 = 0.99				lnS = 3.23 - 1.04lnE, p = 0.00, R^2 = 0.99			
4	N6 - N1		200	54	3.66	0.69		
	Abyssal	6	400	68	3.65	0.55	- 0.86	- 1.31 < β < - 0.40
	2550-3757m		1000	90	3.63	0.40		
	μ = 3002m		1300	96	3.63	0.36		
Regression equations:								
	lnS = 2.34 + 0.31lnN, p = 0.00, R^2 = 0.99				H = 3.77 - 0.02lnN, p = 0.71, R^2 = 0.20			
	lnE = 1.43 - 0.34lnN, p = 0.00, R^2 = 0.97				lnS = 3.72 - o.86lnE, p = 0.01, R^2 = 0.93			

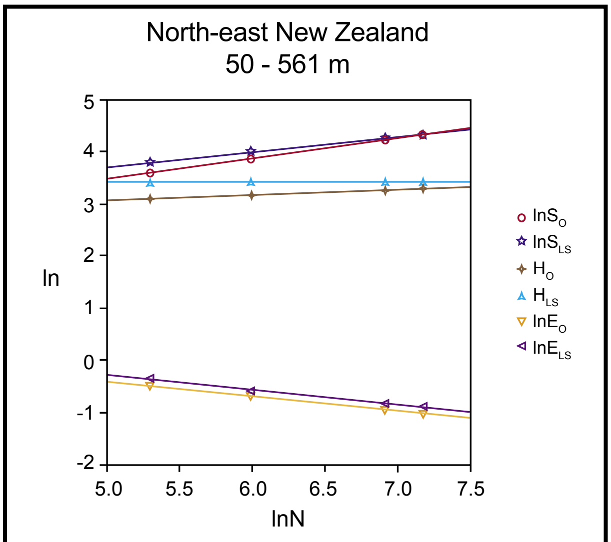
n is the number of stations in the community. N is the number of individuals used in the regression equations to calculate S, H and E. β_1 is from the regression equation $\ln S = \beta_0 + \beta_1 \ln E$.

shown on Fig. 47 the differences between the β's are for $\beta_0 = 0.51$ and for $\beta_1 = 0.39$. Visually, the observations are quite close to a log series null model.

Figure 48 is a BDG plot of the observed regression values and a log series in the north-east from stations at depths of 754–1242 m in depth. The average depth is 967 m or middle bathyal. The community consists of 6 stations. At N = 1300 the estimate for S =77 (Table 21, biofacies 2) and for Fisher's $\alpha = 17.914$ giving an estimate for the log series H = 3.46. The difference between β_0 values is 1.62 and β_1 values 1.28 (Fig. 48). Even though the values for lnS, H and lnE are close to the previous biofacies, the community structure is quite different. The BDG shows H increasing sharply as lnN increases. This positive slope for the regression H versus lnN is typical of a log normal distribution (Buzas & Hayek, 2005).

Figure 49 is a BDG plot of the observed regression values and a log series in the north-east from stations at 1295–2036 m in depth. The average depth is 1664 m or lower bathyal. The community consists of 6 stations. At N = 1300 S = 87 (Table 21, biofacies 3) so that Fisher's $\alpha = 21.008$ and the estimate for the log series H = 3.62. The difference between β_0 values is 0.30 and β_1 values 0.04 (Fig. 49). The very low difference for β_1 values indicates as Fig. 49 shows that the observed and log series values of H are constant and parallel to the x-axis (lnN). The difference between β_0 is shown not only by the H's but also lnE's. Visually, the observations are close to a log series null model.

Figure 50 is a BDG plot of the observed regression values and a log series in the north-east from stations at 2550–3757 m in depth. The average depth is 3002



n = 33

$\ln S_{LS} = 3.43 - 1.00 \ln E_{LS}$

$\ln S_O = 2.92 - 1.39 \ln E_O$

$\Delta = 0.51 \quad 0.39$

at N = 200

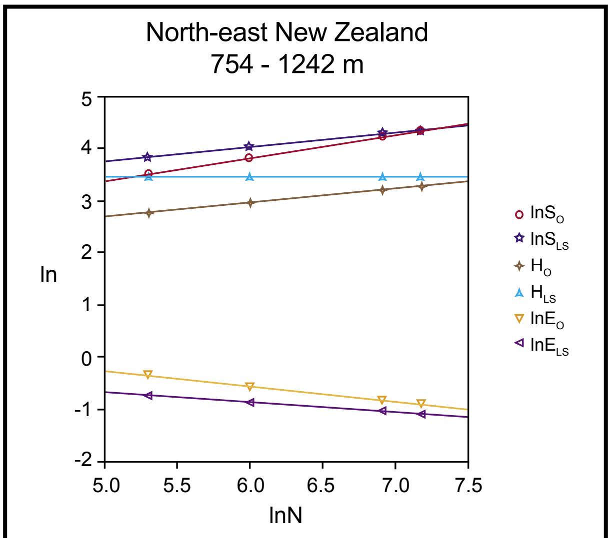
$H_{LS} - H_O$

3.43 - 3.09 = 0.34

$\ln S_{LS} - \ln S_O$

3.78 - 3.59 = 0.19

Figure 47. Biodiversitygram (BDG) of community structure, north-east New Zealand, average depth 223 m. Δ is difference in regression coefficients between log series null model and observations.



n = 6

$\ln S_{LS} = 3.46 - 1.00 \ln E_{LS}$

$\ln S_O = 1.84 - 2.28 \ln E_O$

$\Delta = 1.62 \quad 1.28$

at N = 200

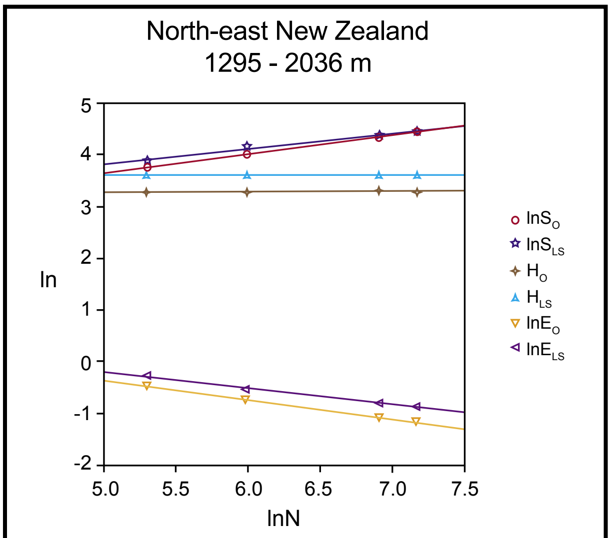
$H_{LS} - H_O$

3.46 - 2.78 = 0.68

$\ln S_{LS} - \ln S_O$

3.80 - 3.50 = 0.30

Figure 48. BDG of community structure, north-east New Zealand, average depth 967 m. Δ as in Fig. 47.



n = 6

$\ln S_{LS} = 3.62 - 1.00 \ln E_{LS}$

$\ln S_O = 3.23 - 1.04 \ln E_O$

$\Delta = 0.30 \quad 0.04$

at N = 200

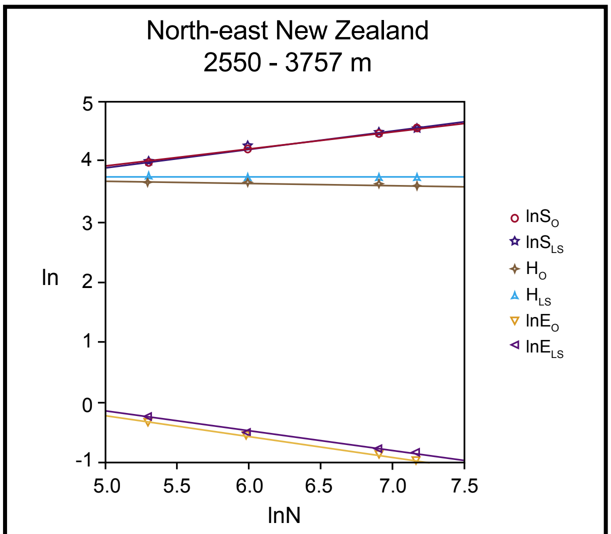
$H_{LS} - H_O$

3.62 - 3.28 = 0.34

$\ln S_{LS} - \ln S_O$

3.90 - 3.75 = 0.15

Figure 49. BDG of community structure, north-east New Zealand, average depth 1664 m. Δ as in Fig. 47.



n = 6

$\ln S_{LS} = 3.75 - 1.00 \ln E_{LS}$

$\ln S_O = 3.72 - 0.86 \ln E_O$

$\Delta = 0.03 \quad -0.14$

at N = 200

$H_{LS} - H_O$

3.75 - 3.66 = 0.09

$\ln S_{LS} - \ln S_O$

3.98 - 3.98 = 0.00

Figure 50. BDG of community structure, north-east New Zealand, average depth 3002 m. Δ as in Fig. 47.

m or abyssal. The community consists of 6 stations. At N = 1300 the regression estimate for S = 96 (Table 21, biofacies 4) so that Fisher's α = 23.918 and the estimate for the log series H = 3.75. The difference between the β_0 values is 0.03 and β_1 values -0.14 (Fig. 50). The estimate for the observed and log series values of lnS are nearly identical and the small difference between the H's is due to small differences in the values of lnE. Visually, the observations are very close to a log series null model.

As noted earlier in the north-east 91% of the stations could be placed in the 4 recognisable communities.

Figure 51 is a BDG plot of the observed regression values and a log series in the west from stations at depths of 60–154 m. The average depth is 112 m or outer shelf. The community consists of 6 stations. At N = 1300 the regression estimate for S = 78 (Table 22, biofacies 1) so that Fisher's α = 18.217 and the estimate for the log series H = 3.48. The difference between the β_0 values is 1.82 and β_1 values 0.91. Fig. 51 shows the slopes for the observed lnS and H are much larger than for the null model. The difference in evenness does not change appreciably as ln N increases (Fig. 51). Visually, the observations are far from the log series null model and are best interpreted as log normal.

Figure 52 is a BDG plot of the observed regression values and a log series in the west from stations at depths of 541–1120 m in depth. The average depth is 883 m or middle bathyal. The community consists of 8 stations. At N = 1300 the regression estimate for S = 72 (Table 22, biofacies 2) so that Fisher's α = 16.424 and the estimate for the log series H = 3.38. The difference between the β_0 values is 0.34 and the β_1 values 0.35. Visually, the observations are very close to a log series null model.

Figure 53 is a BDG plot of the observed regression values and a log series in the west from stations at depths of 1233–2000 m in depth. The average depth is 1562 m or lower bathyal. The community consists of 10 stations. At N = 1300 the regression estimate for S = 72 (Table 22, biofacies 3) so that Fisher's α = 16.424 and the estimate for the log series H = 3.38. We note in passing that these estimates are identical to the ones for the previous biofacies. The difference between the β_0 values is 0.08 and the β_1 values -0.11. Visually, the observations are very close to a log series model. The BDG shown in Figure 53 is similar to the BDG in the west at middle bathyal (Fig. 52) and in the north-east from abyssal depths (Fig. 50).

As noted earlier, in the west 75% of the stations could be grouped into 3 communities.

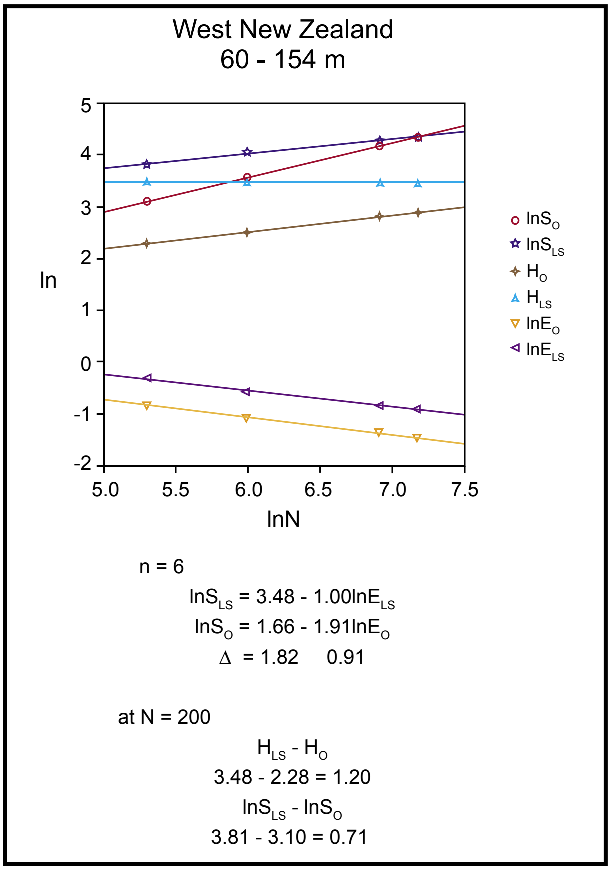


Figure 51. BDG of community structure, west New Zealand, average depth 112 m. Δ as in Fig. 47.

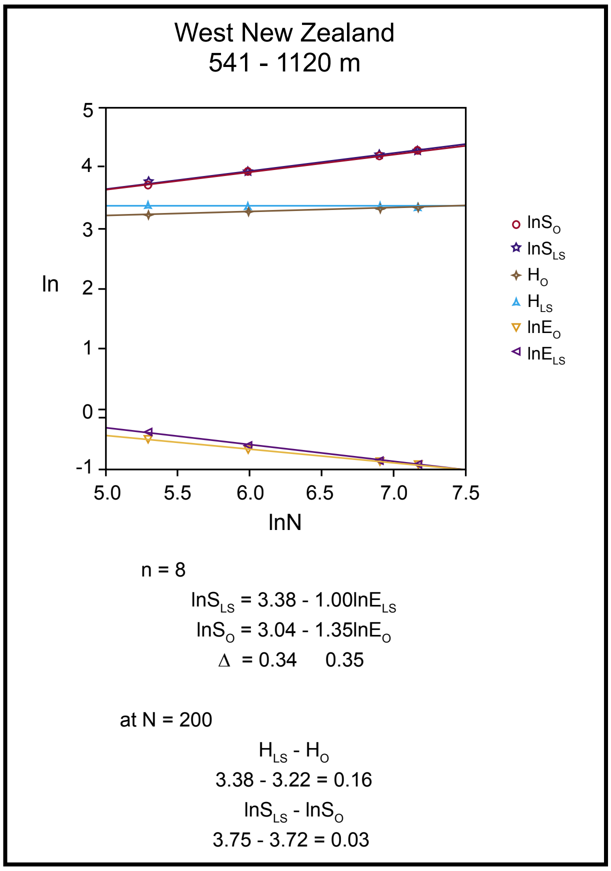


Figure 52. BDG of community structure, west New Zealand, average depth 883 m. Δ as in Fig. 47.

Figure 54 is a BDG plot of the observed regression values and a log series in the east from stations at 289–511 m in depth. The average depth is 394 m or upper bathyal. The community consists of 7 stations. At N = 1300 the regression estimate for S =84 (Table 23, biofacies 1) so that Fisher's α = 20.065 and the log series estimate for H = 3.58. The difference between the β_0 values is 3.09 and the β_1 values 2.06. The slopes for the observed lnS and H are much larger than for the log series null model. The difference in evenness remains relatively constant as lnN increases. Visually, there is little resemblance to a log series null model, the strong positive slope (0.53) for H versus lnN (Table 23) indicates a log normal distribution.

Figure 55 is a BDG plot for the observed regression values and a log series in the east from stations at 547–980 m in depth. The average depth is 735 m or middle bathyal. The community consists of 9 stations. At N = 1300 the regression estimate for S = 78 (Table 23, biofacies 2) so that Fisher's α = 18.217 and the log series estimate for H = 3.48. The difference between β_0 values is 0.90 and β_1 values 0.50. The slopes for the observed lnS and H are not as positive as in the previous biofacies, but nevertheless, the visual configuration does not resemble a log series null model and is best considered as log normal.

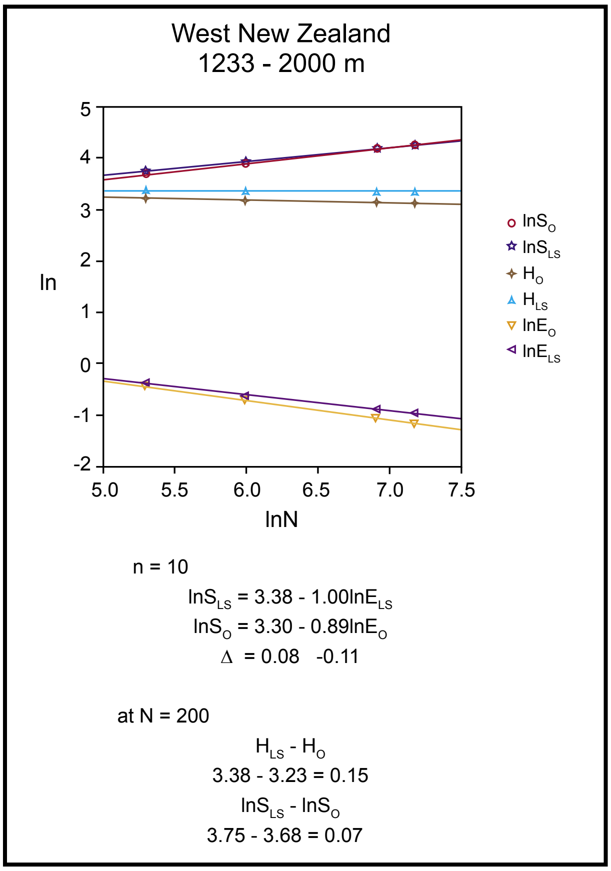


Figure 53. BDG of community structure, west New Zealand, average depth 1562 m. Δ as in Fig. 47.

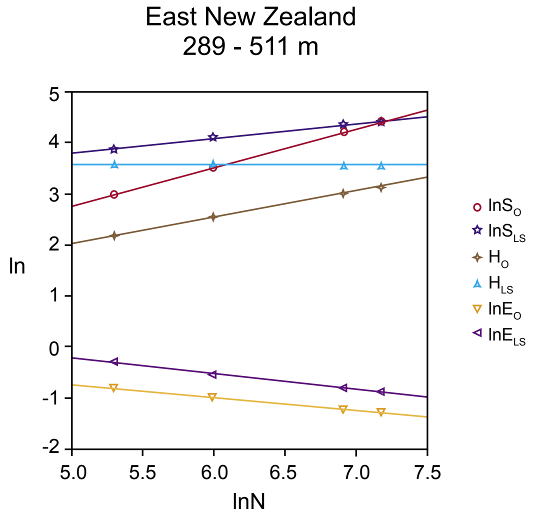
Figure 56 is a BDG plot for the observed regression values and a log series in the east from stations at 1003–1204 m in depth. The average depth is 1109 m or lower bathyal. This community consists of 5 stations. At N = 1300 the regression estimate for S = 91 (Table 23, biofacies 3) so that Fisher's α = 22.287 and the log series estimate for H = 3.68. The difference between β_0 values is 0.85 and β_1 values 0.29. The BDG resembles that of the previous biofacies in the east (Fig. 55) and visually resembles a log normal.

Figure 57 is a BDG plot for the observed regression values and a log series in the east from stations at 1462–1841 m in depth. The average depth is 1692 m or lower bathyal. This community consists of 5 stations. At N = 1300 the regression estimate for S = 66 (Table 23, biofacies 4) so that Fisher's α = 14.684 and the estimate for the log series H = 3.26. The difference between β_0 values is 1.18 and β_1 values 0.55. Visually the BDG closely resembles that of the previous two in the east (Figs 55-56) and does not resemble a log series null model. Although the diversity values for this community are considerably smaller than for the previous two, the community structure (log normal) is essentially the same.

Figure 58 is a BDG plot for the observed regression values and a log series in the east from stations at 2030–2322 m in depth. The average depth is 2245 m or upper abyssal. This community consists of 5 stations. At N = 1300 the regression estimate for S = 82 (Table 23, biofacies 5) so that Fisher's α = 19.443 and the log series estimate for H = 3.54. The difference between the β_0 values is 0.49 and the β_1 values -0.01. The slope of lnS versus lnN is steeper than for a log series but, because both the log series and observed H values are constant, this difference shows up in lnE values as it must from consideration of the decomposition equation. While the slope of the observed lnS versus lnE is nearly -1.00, the difference in the slopes of lnS distinguishes this deep community from those in the north-east (Figs 49-50) and the west (Fig. 53).

In contrast to the high number of stations grouped into communities in the north-east and west only 52% could be grouped in the east. The community structure is also different. The first biofacies in the east is the most radical departure from a log series observed in these data sets. The middle three biofacies also exhibit a community structure most consistent with a log normal rather than a log series and only the community structure from abyssal depths resembles that of other areas.

Figure 59 is a BDG plot for the observed regression values and a log series in the south from stations ranging from 143–188 m in depth. The average depth is 169 m or outer shelf. This community consists of 10 stations. At N = 1300 the regression estimate for S = 58 (Table 24, biofacies 1) so that Fisher's α = 12.452 and the log series estimate of H = 3.10. The difference between values for β_0 is 0.21 and the β_1 values -0.28. Note the striking contrast in community structure exhibited by this outer shelf community and those of the shallower depths in



n = 7

$\ln S_{LS} = 3.58 - 1.00 \ln E_{LS}$

$\ln S_{O} = 0.49 - 3.06 \ln E_{O}$

Δ = 3.09   2.06

at N = 200

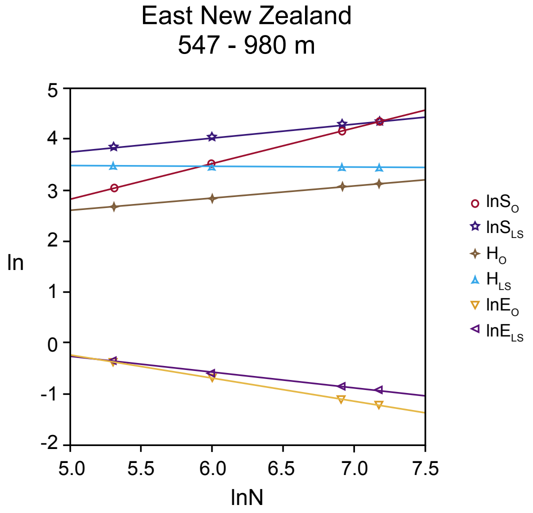
$H_{LS} - H_{O}$

3.58 - 2.19 = 1.39

$\ln S_{LS} - \ln S_{O}$

3.87 - 2.99 = 0.88

Figure 54. BDG of community structure, east New Zealand, average depth 394 m. Δ as in Fig. 47.



n = 9

$\ln S_{LS} = 3.48 - 1.00 \ln E_{LS}$

$\ln S_{O} = 2.58 - 1.50 \ln E_{O}$

Δ = 0.90   0.50

at N = 200

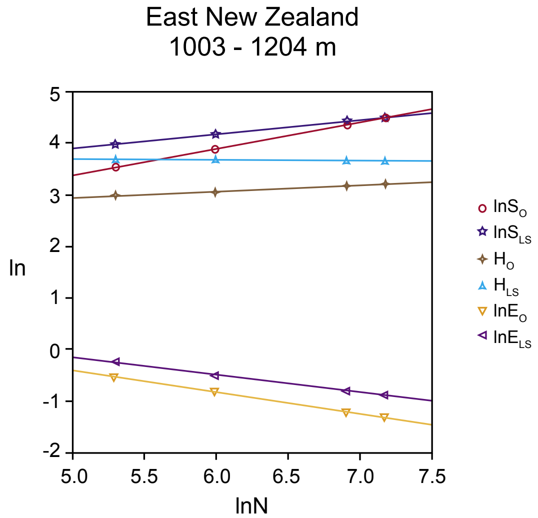
$H_{LS} - H_{O}$

3.48 - 2.69 = 0.79

$\ln S_{LS} - \ln S_{O}$

3.81 - 3.05 = 0.76

Figure 55. BDG of community structure, east New Zealand, average depth 735 m. Δ as in Fig. 47.



n = 5

$\ln S_{LS} = 3.68 - 1.00 \ln E_{LS}$

$\ln S_{O} = 2.83 - 1.29 \ln E_{O}$

Δ = 0.85   0.29

at N = 200

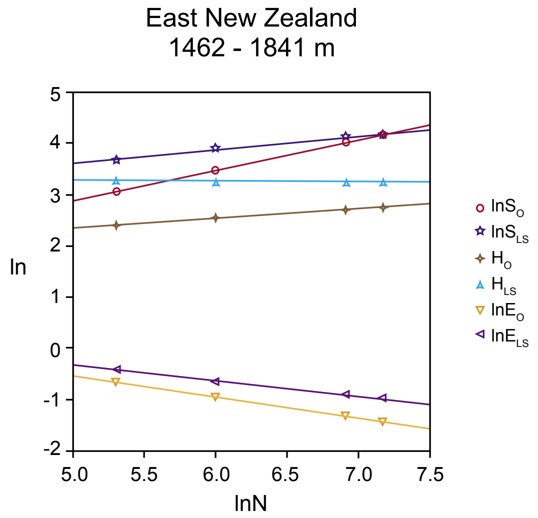
$H_{LS} - H_{O}$

3.68 - 2.97 = 0.71

$\ln S_{LS} - \ln S_{O}$

3.94 - 3.52 = 0.42

Figure 56. BDG of community structure, east New Zealand, average depth 1109 m. Δ as in Fig. 47.



n = 5

$\ln S_{LS} = 3.26 - 1.00 \ln E_{LS}$

$\ln S_{O} = 2.08 - 1.55 \ln E_{O}$

Δ = 1.18   0.55

at N = 200

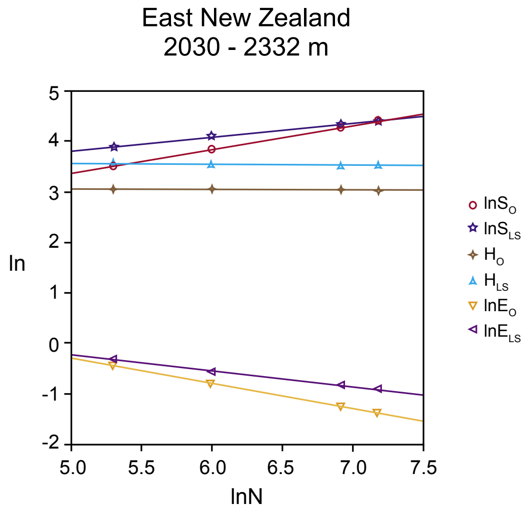
$H_{LS} - H_{O}$

3.26 - 3.06 = 0.20

$\ln S_{LS} - \ln S_{O}$

3.67 - 3.06 = 0.61

Figure 57. BDG of community structure, east New Zealand, average depth 1692 m. Δ as in Fig. 47.



n = 5

$\ln S_{LS} = 3.54 - 1.00 \ln E_{LS}$

$\ln S_O = 3.05 - 0.99 \ln E_O$

Δ = 0.49 -0.01

at N = 200

$H_{LS} - H_O$

3.54 - 3.05 = 0.49

$\ln S_{LS} - \ln S_O$

3.85 - 3.50 = 0.35

Figure 58. BDG of community structure, east New Zealand, average depth 2245 m. Δ as in Fig. 47.

Table 22. Results of SHE analysis for west of New Zealand.

Biofacies	Stations depth	n	N	S	H	E	β_1	β_1 confidence limits
1	T11, T18, T27,							
	T23, T19, T28		200	22	2.28	0.46		
	Outer shelf	6	400	35	2.52	0.37	- 1.91	$-2.62 < \beta < -1.19$
	60-154m		1000	65	2.83	0.28		
	μ = 112m		1300	78	2.92	0.26		
Regression equations:								
	$\ln S = -0.45 + 0.67 \ln N$, p = 0.00, $R^2 = 0.99$				$H = 0.48 + 0.34 \ln N$, p =0.00, $R^2 = 0.97$			
	$\ln E = 0.93 - 0.32 \ln N$, p = 0.00, $R^2 = 0.95$				$\ln S = 1.66 - 1.91 \ln E$, p = 0.00, $R^2 = 0.93$			
2	T32, T33, T14,							
	T34, T15, T2,							
	T35, T36		200	41	3.22	0.62		
	Mid bathyal	8	400	51	3.28	0.53	- 1.35	$-1.54 < \beta < -1.16$
	541-1120m		1000	67	3.35	0.43		
	μ = 883m		1300	72	3.37	0.41		
Regression equations:								
	$\ln S = 2.13 + 0.30 \ln N$, p = 0.00, $R^2 = 0.99$				$H = 2.80 + 0.08 \ln N$, p = 0.00, $R^2 = 0.88$			
	$\ln E = 0.68 - 0.22 \ln N$, p = 0.00, $R^2 = 0.99$				$\ln S = 3.04 - 1.35 \ln E$, p = 0.00, $R^2 = 0.99$			
3	T37, T26, T16,							
	T4, T38, T5,							
	T6, T39, T7,							
	T8		200	39	3.23	0.65		
	Lower bathyal	10	400	49	3.20	0.50	- 0.89	$-1.00 < \beta < -0.77$
	1233-2000m		1000	66	3.16	0.36		
	μ = 1562m		1300	72	3.15	0.33		
Regression equations:								
	$\ln S = 1.98 + 0.32 \ln N$, p = 0.00, $R^2 = 0.99$				$H = 3.44 - 0.04 \ln N$, p = 0.00, $R^2 = 0.57$			
	$\ln E = 1.47 - 0.36 \ln N$, p = 0.00, $R^2 = 0.99$				$\ln S = 3.30 - 0.89 \ln E$, p = 0.00, $R^2 = 0.99$			

n is the number of stations in the community. N is the number of individuals used in the regression equations to calculate S, H and E. β_1 is from the regression equation $\ln S = \beta_0 + \beta_1 \ln E$.

Table 23. Results of SHE analysis for east of New Zealand.

Biofacies	Stations depth	n	N	S	H	E	β_1	β_1 confidence limits
1	E32, E45, E3,							
	E46, E63, E34,							
	E47		200	20	2.19	0.42		
	Upper bathyal	7	400	34	2.56	0.36	-3.06	$-3.70 < \beta < -2.42$
	289-511m		1000	71	3.03	0.29		
	$\mu = 394$m		1300	84	3.18	0.27		
Regression equations:								
	$\ln S = -1.09 + 0.77\ln N, p = 0.00, R^2 = 0.99$				$H = -0.62 + 0.53\ln N, p = 0.00, R^2 = 0.98$			
	$\ln E = 0.47 - 0.25\ln N, p = 0.00, R^2 = 0.97$				$\ln S = 0.49 - 3.06\ln E, p = 0.00, R^2 = 0.98$			
2	E33, E4, E26,							
	E35, E48, E27,							
	E12, E5, E13		200	21	2.69	0.70		
	Mid bathyal	9	400	34	2.87	0.51	-1.50	$-1.99 < \beta < -1.00$
	547-980m		1000	67	3.12	0.34		
	$\mu = 735$m		1300	78	3.17	0.31		
Regression equations:								
	$\ln S = -0.66 + 0.70\ln N, p = 0.00, R^2 = 0.98$				$H = 1.31 + 0.26\ln N, p = 0.01, R^2 = 0.78$			
	$\ln E = 1.97 - 0.44\ln N, p = 0.00, R^2 = 0.98$				$\ln S = 2.58 + -1.50\ln E, p = 0.00, R^2 = 0.94$			
3	E62, E36, E28,							
	E49, E52		200	34	2.97	0.58		
	Lower bathyal	5	400	49	3.07	0.36	-1.29	$-1.74 < \beta < -0.84$
	1003-1204m		1000	79	3.19	0.31		
	$\mu = 1109$m		1300	91	3.23	0.28		
Regression equations:								
	$\ln S = 0.71 + 0.53\ln N, p = 0.00, R^2 = 0.99$				$H = 2.23 + 0.14\ln N, p = 0.04, R^2 = 0.90$			
	$\ln E = 1.52 - 0.39\ln N, p = 0.01, R^2 = 0.96$				$\ln S = 2.83 - 1.29\ln E, p = 0.00, R^2 = 0.98$			
4	E51, E14, E7,							
	E53, E39, E38		200	21	2.40	0.52		
	Lower bathyal	6	400	32	2.56	0.36	-1.55	$-1.94 < \beta < -1.16$
	1462-1841m		1000	56	2.77	0.28		
	$\mu = 1692$m		1300	66	2.80	0.25		
Regression equations:								
	$\ln S = -0.12 + 0.60\ln N, p = 0.00, R^2 = 0.98$				$H = 1.29 + 0.21\ln N, p = 0.02, R^2 = 0.89$			
	$\ln E = 1.42 - 0.39\ln N, p = 0.00, R^2 = 0.99$				$\ln S = 2.08 - 1.55\ln E, p = 0.00, R^2 = 0.98$			
5	E29, E54, E65,							
	E61, E8,		200	33	3.05	0.66		
	Abyssal	5	400	46	3.05	0.47	-0.99	$-1.40 < \beta < -0.59$
	2030-2332m		1000	72	3.04	0.29		
	$\mu = 2245$m		1300	82	3.04	0.27		
Regression equations:								
	$\ln S = 0.96 + 0.48\ln N, p = 0.01, R^2 = 0.96$				$H = 3.08 - 0.005\ln N, p = 0.94, R^2 = 0.05$			
	$\ln E = 2.12 - 0.48\ln N, p = 0.00, R^2 = 0.99$				$\ln S = 3.05 - 0.99\ln E, p = 0.00, R^2 = 0.98$			

n is the number of stations in the community. N is the number of individuals used in the regression equations to calculate S, H and E. β_1 is from the regression equation $\ln S = \beta_0 + \beta_1 \ln E$.

Table 24. Results of SHE analysis for south of New Zealand.

Biofacies	Stations depth	n	N	S	H	E	β_1	β_1 confidence limits
1	S6-S15		200	28	2.72	0.55		
	Outer Shelf	10	400	36	2.62	0.37	-0.72	$-0.84 < \beta < -0.60$
	143-188m		1000	52	2.49	0.23		
	μ = 169m		1300	58	2.44	0.20		
Regression equations:								
	$lnS =1.27 + 0.39lnN, p = 0.00, R^2 = 0.97$				$H = 3.52 - 0.15lnN, p = 0.00, R^2 = 0.89$			
	$lnE = 2.25 - 0.54lnN, p = 0.00, R^2 = 0.99$				$lnS = 2.89 - 0.72lnE, p = 0.00, R^2 = 0.98$			
2	S20-S27		200	27	2.78	0.58		
	Upper Bathyal	8	400	35	2.81	0.46	-1.12	$-1.31 < \beta < -0.92$
	435-565m		1000	52	2.83	0.33		
	μ = 519m		1300	56	2.88	0.31		
Regression equations:								
	$lnS = 1.23 + 0.39lnN, p = 0.00, R^2 = 0.98$				$H = 2.57 + 0.04lnN, p = 0.22, R^2 = 0.48$			
	$lnE = 1.33 - 0.35lnN, p = 0.00, R^2 = 0.99$				$lnS = 2.70 - 1.12lnE, p = 0.00, R^2 = 0.98$			
3	S42-S47		200	31	2.91	0.57		
	Lower Bathyal	6	400	41	2.98	0.46	-1.26	$-1.64 < \beta < -0.89$
	960-1244m		1000	58	3.04	0.35		
	μ = 1076m		1300	65	3.10	0.32		
Regression equations:								
	$lnS = 1.31 + 0.40lnN, p = 0.00, R^2 = 0.99$				$H = 2.38 + 0.10lnN, p = 0.05, R^2 = 0.82$			
	$lnE = 1.07 - 0.31lnN, p = 0.00, R^2 = 0.98$				$lnS = 2.76 - 1.26lnE, p = 0.00, R^2 = 0.98$			
4	S63-S68		200	35	3.00	0.58		
	Abyssal	6	400	48	3.05	0.44	-1.06	$-1.57 < \beta < -0.55$
	3452-5000m		1000	73	3.10	0.30		
	μ = 4352m		1300	82	3.13	0.28		
Regression equations:								
	$lnS = 1.11 + 0.46lnN, p = 0.00, R^2 = 0.99$				$H = 2.63 + 0.07lnN, p = 0.38, R^2 = 0.44$			
	$lnE = 1.52 - 0.39lnN, p = 0.00, R^2 = 0.95$				$lnS = 3.01 - 1.06lnE, p = 0.00, R^2 = 0.94$			

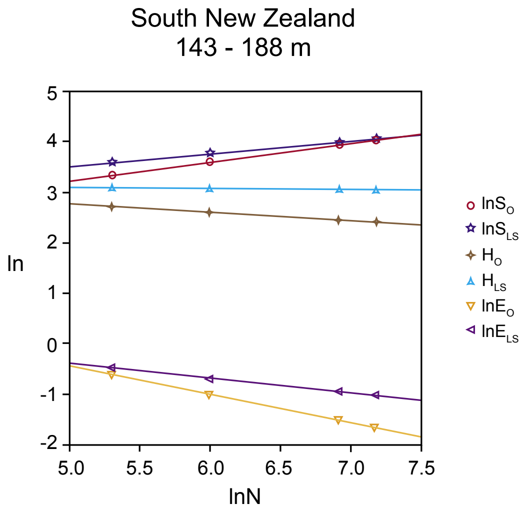
n is the number of stations in the community. N is the number of individuals used in the regression equations to calculate S, H and E. β_1 is from the regression equation $lnS = \beta_0 + \beta_1 lnE$.

other areas: Figure 59 versus Figures 47, 51 and 54. The negative value of β_1 for the observations in this biofacies is only observed elsewhere at depths of greater than 1500 m. Visually, the BDG does not closely resemble a log series.

Figure 60 is a BDG for the observed regression values and a log series in the south from stations at 435–565 m in depth. The average depth is 519 m or upper bathyal. The community consists of 8 stations. At N = 1300 the regression estimate for S = 56 (Table 24, biofacies 2) so that Fisher's α = 11.910 and the log series estimate of H = 3.05. The difference between the β_0 values is 0.35 and the β_1 values 0.12. Visually, the BDG does resemble a log series.

Figure 61 is a BDG for the observed regression values and a log series in the south from stations at 960–1240 m in depth. The average depth is 1076 m or lower bathyal. The community consists of 6 stations. At N = 1300 the regression estimate for S = 65 (Table 24, biofacies 3) so that Fisher's α = 14.400 and the log series estimate of H = 3.24. The difference between the β_0 values is 0.43 and the β_1 values 0.26. Visually as well as with the regression equations, this biofacies resembles the previous one (Fig. 60).

Figure 62 is a BDG for the observed regression values and a log series in the south from stations at 3452–5000 m in depth. The average depth is 4352 m or lower abyssal. The community consists of 6 stations. At N = 1300 the regression estimate for S = 82 (Table 24, biofacies 4) so that Fisher's α = 19.443 and the log series estimate for H = 3.54. The difference between the β_0 values is 0.53 and the $\beta_1$values 0.06. Similar to other lower bathyal and abyssal areas the value of β_1 is close to -1.00. However, the high value of the difference between β_0 makes the community structure more similar to the abyssal area in the east than in the north-east.



n = 10

$\ln S_{LS} = 3.10 - 1.00 \ln E_{LS}$

$\ln S_O = 2.89 - 0.72 \ln E_O$

$\Delta = 0.21 \quad -0.28$

at N = 200

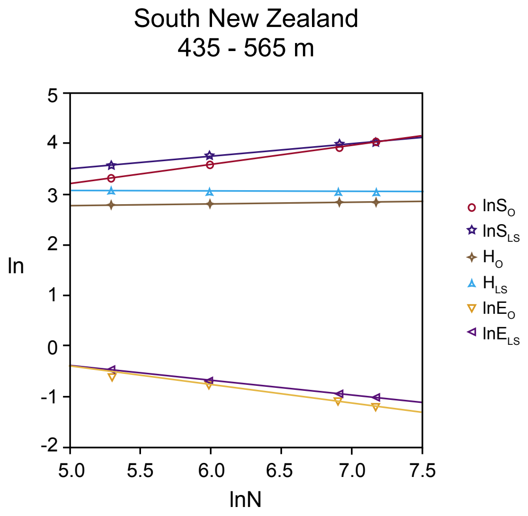
$H_{LS} - H_O$

$3.10 - 2.72 = 0.38$

$\ln S_{LS} - \ln S_O$

$3.56 - 3.34 = 0.22$

Figure 59. BDG of community structure, south New Zealand, average depth 169 m. Δ as in Fig. 47.



n = 8

$\ln S_{LS} = 3.05 - 1.00 \ln E_{LS}$

$\ln S_O = 2.70 - 1.12 \ln E_O$

$\Delta = 0.35 \quad 0.12$

at N = 200

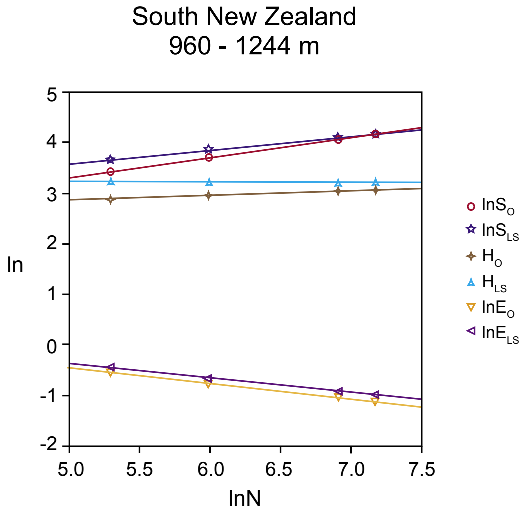
$H_{LS} - H_O$

$3.05 - 2.78 = 0.27$

$\ln S_{LS} - \ln S_O$

$3.54 - 3.30 = 0.24$

Figure 60. BDG of community structure, south New Zealand, average depth 519 m. Δ as in Fig. 47.



n = 6

$\ln S_{LS} = 3.24 - 1.00 \ln E_{LS}$

$\ln S_O = 2.76 - 1.26 \ln E_O$

$\Delta = 0.43 \quad 0.26$

at N = 200

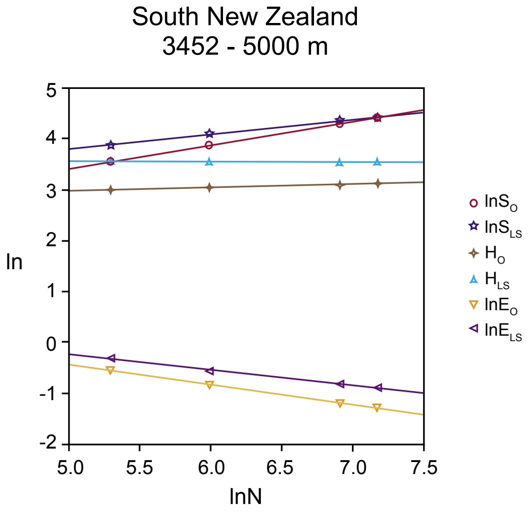
$H_{LS} - H_O$

$3.24 - 2.91 = 0.33$

$\ln S_{LS} - \ln S_O$

$3.66 - 3.43 = 0.23$

Figure 61. BDG of community structure, south New Zealand, average depth 1076 m. Δ as in Fig. 47.



n = 6

$\ln S_{LS} = 3.54 - 1.00 \ln E_{LS}$

$\ln S_O = 3.01 - 1.06 \ln E_O$

$\Delta = 0.53 \quad 0.06$

at N = 200

$H_{LS} - H_O$

$3.54 - 3.00 = 0.54$

$\ln S_{LS} - \ln S_O$

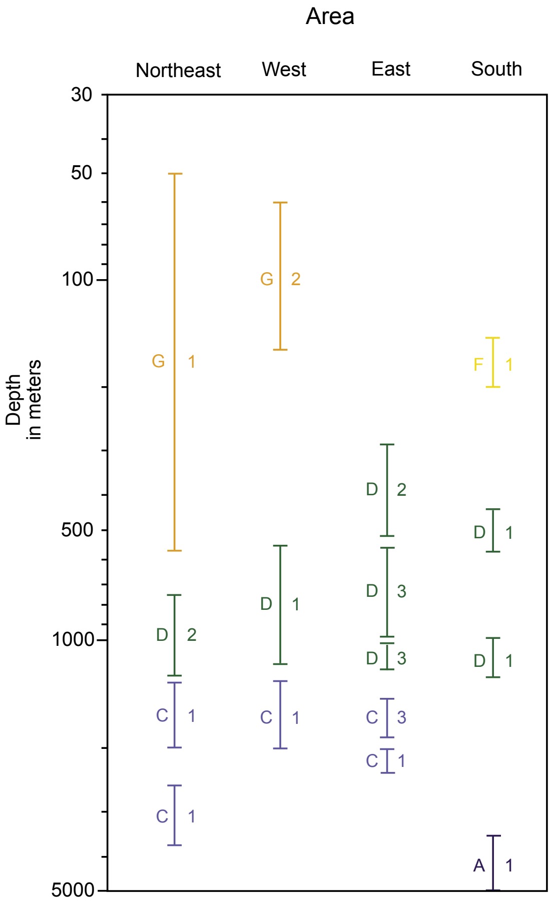
$3.85 - 3.55 = 0.30$

Figure 62. BDG of community structure, south New Zealand, average depth 4352 m. Δ as in Fig. 47.

In the south, only 44% of the stations could be grouped into biofacies or communities. Even though all of the deeper biofacies resemble a log series, the very close fit observed in the north-east and west is never achieved.

This brief review indicates that each of the four regions examined for community structure is unique in that regard (Fig. 63). In the north-east, we observed a huge biofacies or community consisting of 33 stations extending from the middle shelf to upper bathyal depths. This community resembles a log series. At mid-bathyal depths there is a substantial departure from a log series pattern with a relatively large positive slope for H. At lower bathyal and abyssal depths the observations are close to the log series null model. Nearly all, 91%, of the stations could be grouped into communities. In the West the outer shelf community shows a sharp departure from a log series with a strong positive slope for H. This stands in contrast to the north-east's and south's most shallow biofacies. The two deeper biofacies in the west closely resemble the log series null model.

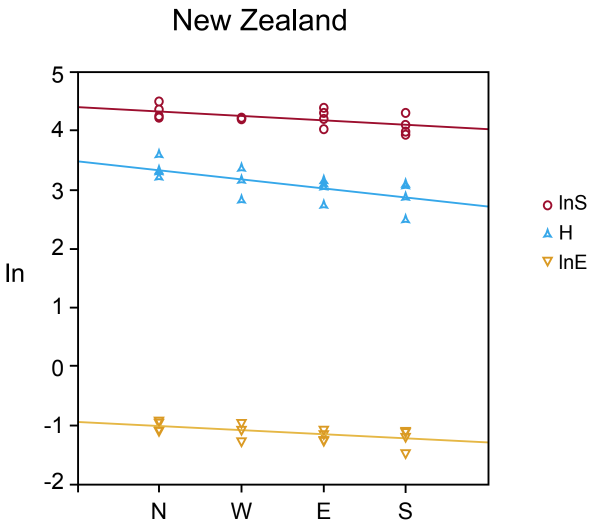
In all, 75% of the stations were grouped into communities. The east stands in sharp contrast to all the other areas (Fig. 63). Only 52% of the stations could be grouped into communities and except for the community at abyssal depths all have a strong positive slope for H. In the south only 44% of the stations grouped into communities and the shallowest at outer shelf depths is the only relatively shallow community exhibiting a negative slope for H. The remaining communities in the south are more similar to a log series null model, but none are as similar as the deepest communities in the north and west. All abyssal communities resemble a log series and 5 of 6 communities deeper than 1300 m resemble a log series. The communities in the east have the largest departure from the null model followed by the south. The log series is characterised by a constant H and is interpreted as representing community stability.



1. Δ B_o and B_1 < 0.60
2. Δ B_o and B_1 > 0.60
3. Δ B_o > 0.60, B_1 < 0.60

Letters refer to dendrogram in figure B1 and plot in Figure B3.

Figure 63. Distribution of community structure types with depth and geography.



lnS = 4.39 - 0.08Area, p = 0.02, R^2 = 0.34

H = 3.49 - 0.16Area, p = 0.01, R^2 = 0.43

lnE = -0.93 - 0.08Area, p = 0.03, R^2 = 0.30

Figure 64. Distribution of lnS, H and lnE with latitude at N = 1000. H, lnS and lnE decrease significantly to the south.

Biodiversity based on SHE communities

As already stated, analysis of individual samples indicates a latitudinal diversity gradient is present in the New Zealand area. Using the 16 communities identified by SHE analysis for biofacies identification, we examined latitudinal biodiversity by plotting plotting lnS, H and lnE by area. Figure 64 shows the results along with the regressions. Although the R^2 values are not particularly high, nevertheless, all three regressions are statistically significant. We conclude that in the deep-sea around New Zealand, as in many other parts of the world, a latitudinal species gradient exists.

The change in diversity with depth is not as clear. Buzas *et al.* (2007) showed an overall significant regression with depth when not differentiating between areas. However, examination of individual samples as well as the communities already examined here indicate that a division into north-east with south and east with west is warranted. Figure 65 shows regression for the north-east and south data grouped together. The regressions are significant for lnS and H, both increasing with depth. Figure 66 shows a regression for east and west grouped together. None of the regressions are significant and the slopes are barely discernable from zero. On the eastern continental margin of North America as well as in the Gulf of Mexico an increase in diversity is observed with depth (Gibson & Buzas 1973). Here it is puzzling that we observed it in the north and south but not in the east and west.

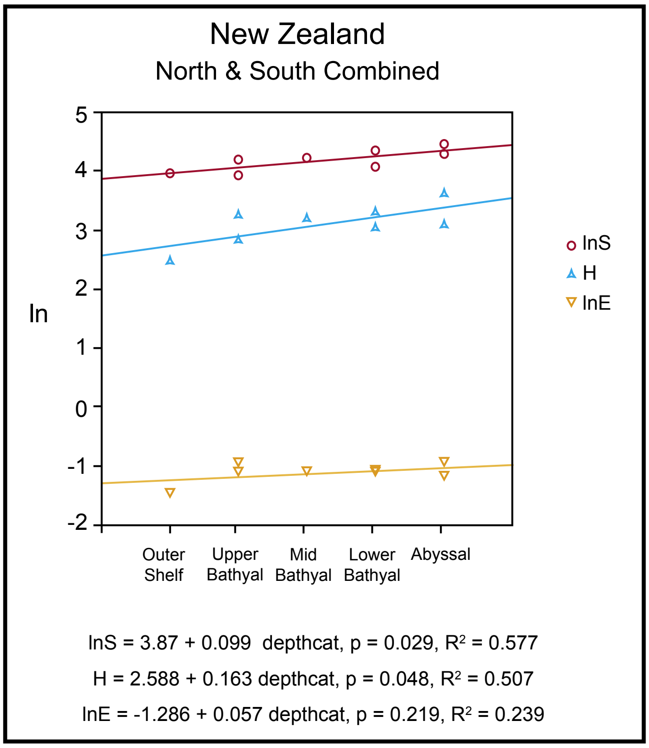


Figure 65. Distribution of lnS, H and lnE with depth at N = 1000 in the north-east and south areas combined. lnS and H increase significantly with depth.

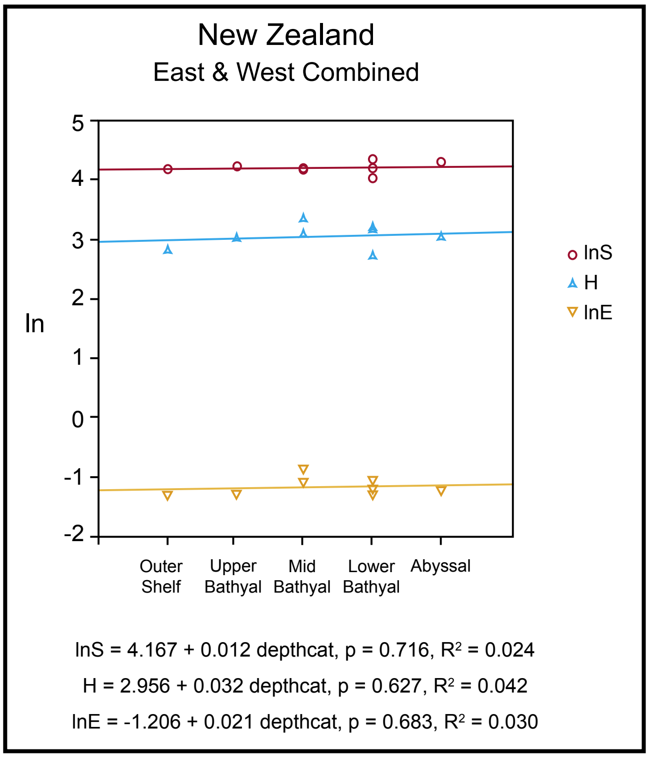


Figure 66. Distribution of lnS, H and lnE with depth at N = 1000 in the east and west areas combined. There is no significant relationship with depth.

SPECIES FREQUENCY, DURATION AND BIOGEOGRAPHY OF ALL NEW ZEALAND BENTHIC FORAMINIFERA (DEEP PLUS SHALLOW)

COMPILATION OF DISTRIBUTIONAL DATA

Data used in these analyses of the frequency, species duration and biogeographic distribution of the total benthic foraminiferal fauna from around New Zealand is drawn from several sources.

Deep-water (> 50 m) data sources

a. The complete lists of the identified fauna in the quantitative counts from the ecologic distribution studies utilised in the preceding chapter (Appendix III).

b. Partial lists of additional species obtained from additional qualitative picks of a selection of the samples used in the quantitative study above.

c. Additional lists of the identified fauna in quantitative counts of faunas >150 µm undertaken for ecologic distribution studies off the west coast of central New Zealand (W1-16, W18-19, W23-39; Hayward *et al.* 2003), but not used in the ecologic studies above.

d. Full species lists produced by us during this study from new and existing foraminiferal faunal slides held in the collections of the Institute of Geological and Nuclear Sciences, Auckland War Memorial Museum and University of Auckland, Geology Store (Appendix II). These slides were selected for their diverse faunas and to provide maximum geographic spread around the coasts of New Zealand and its outlying islands at depths deeper than 50 m.

Because we wished to investigate distribution patterns around the whole of New Zealand, we combined the species lists from closely positioned stations (a-d above) within similar bathymetric zones (mid shelf, outer shelf, uppermost bathyal, upper bathyal, mid bathyal, lower bathyal, upper abyssal, mid abyssal, lower abyssal) into 130 composite localities, each comprising data from 1-20 samples (Appendix IV). This resulted in more comprehensive listings of species that occur in the different depth zones within each region. This data set lists 498 species (Appendix V), from which we selected all the most common and frequently occurring species plus a smaller number of additional easily recognised or biogeographically significant rarer species to include in our detailed taxonomic section with illustrations - a total of 341 species.

Shallow water (0-50 m) data sources

These data comprised full species lists from 32 composite localities from brackish and inner shelf environments (0-50 m) from around New Zealand (Appendix IV). These lists were formerly compiled and used in similar analyses just on the shallow-water (0-100 m) faunas (Hayward *et al.* 1999). Data from mid-shelf (50-100 m) samples that were already included in the deep-water data set (a-d above) were deleted from these composite localities, to remove duplication.

Combined data set

The species records (498 species) from our 130 deep-water composite localities were combined with the species records (353 species) from our 32 shallow-water composite localities. This resulted in a data set of 641 benthic foraminiferal species in 162 composite localities from depths between 0 and 5000 m from all around New Zealand (Fig. 67; Appendix IV). This data was used as the basis for most of our subsequent analyses on species frequency, duration and biogeography. For some of these analyses we grouped the species into those that had their dominant occurrence in shallow-water depths (<100 m) and those that dominantly occurred in deep-water (>100 m). This subdivision was based on the proportion of the shallow- and deep-water composite localities in which each species occurred.

The known world biogeographic distribution of each of the species identified in the dataset from the 162 composite localities was recorded in one of six large biogeographic categories. Information on species distributions was obtained from the type localities of species, our records from around New Zealand and major taxonomic works from various parts of the world (e.g., Culver & Buzas 1980, 1981, 1982, 1984, 1986, Boltovskoy 1987, Loeblich & Tappan 1994, Jones 1994, Yassini & Jones 1995).

SPECIES FREQUENCY

A comprehensive species list of foraminifera in a region, such as New Zealand, is accomplished by sampling a number of localities within it. From this we can then sum all the species recorded at all the localities to get an estimate of the total number of species occurring in that region. It is recognised, however, that some species occur at only one locality, others at two, etc. The number of localities at which a species occurs is often termed the frequency of species occurrence. Buzas *et al.* (1982) found that the number of species occurring at 1, 2, ..., n localities conforms to Fisher's log series (Fisher *et al.* 1943) and as a consequence the vast majority of species occur rarely.

In this analysis we have used the combined data set from 162 composite localities from around New Zealand (Appendix IV, Fig. 67). We calculated the frequency of species occurrence for all localities, for those shallower than 100 m and those deeper than 100 m (Fig. 68). The plot of each quite closely approximates a typical log series plot. Approximately 20% of all species have been recorded from just 1 composite locality in this study (Table 25). For the full data set, fewer than 1% of species occur in more than 75% of localities, and 4% occur in more than half of the localities. Frequency of occurrence of these common species is only slightly higher in the deep water localities, but considerably higher in the shallow water (<100 m)

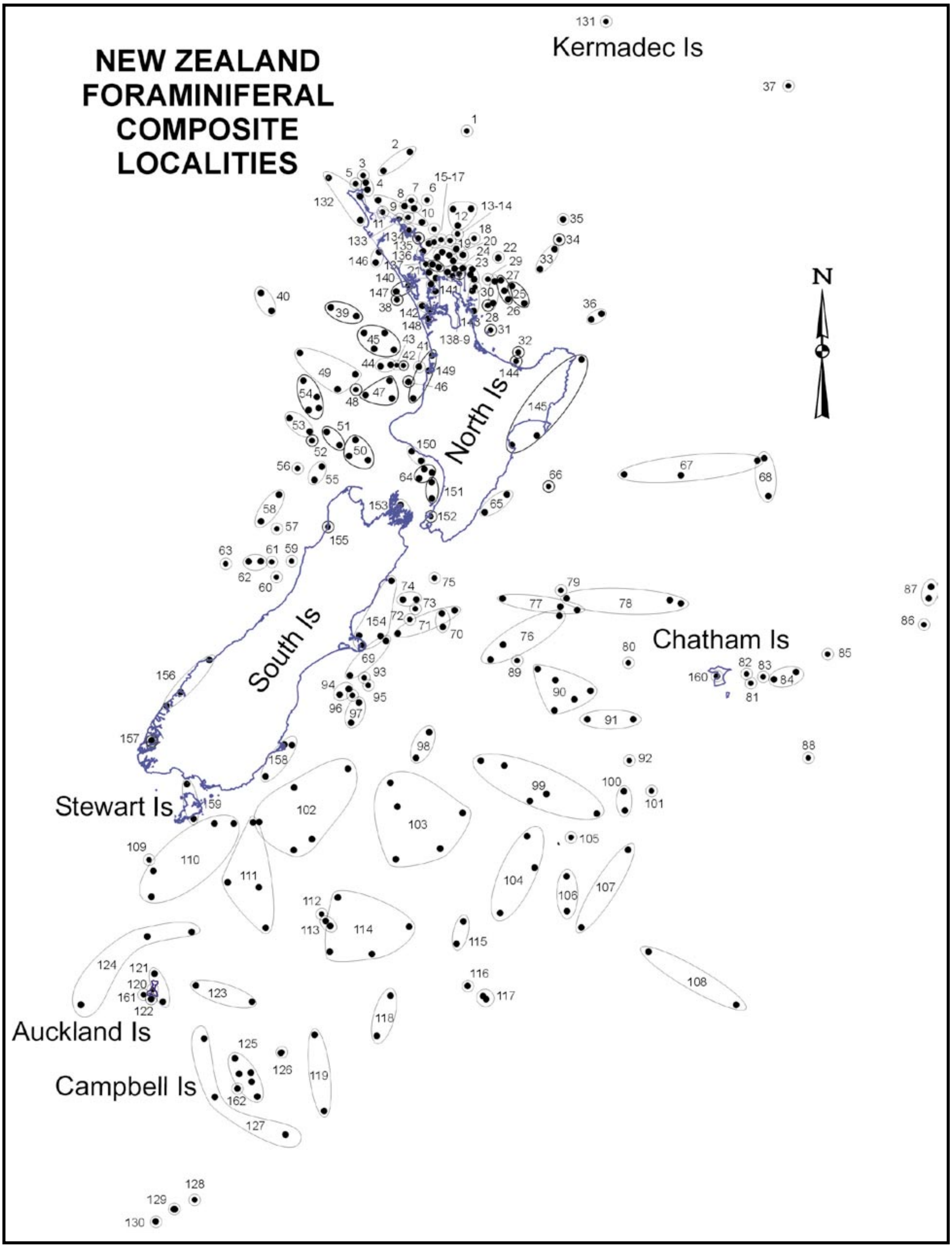


Figure 67. Location of 162 composite localities (Appendix IV) used for analysis of frequency of occurrence and biogeography.

Table 25. Frequency of occurrence data for benthic foraminiferal species in the composite localities (Appendix IV, Fig. 67) from around New Zealand.

	All localities	Shallow localities	Deep localities
Depth range	0-5000 m	0-100 m	100-5000 m
No of localities	162	46	116
No of species	641	405	495
No of occurrence records	10168	4063	6082
Fisher Alpha	152	112	127
% of species with 1 record	19%	22%	22%
% of species with <2% frequency	37%	22%	26%
% of species with 2-25% frequency	52%	45%	61%
% of species with >25% frequency	11%	33%	13%
% of species with >50% frequency	4%	15%	6%
% of species with >75% frequency	0.6%	4%	1.4%

localities, where 15% of species occur in more than 75% of localities and 33% of species occur in over half of the localities.

To simplify the discussion on the frequency of species occurrence, species were lumped into three arbitrarily defined occurrence classes: rare species occur in <2% of localities (32% of all species); most species are frequent and occur in 2-25% of localities (57%); whereas common species occur in >25% of localities (11%). Examination of species occurrence by order (Fig. 69) shows that species in the two least common orders, Carterinida and Robertinida, are mostly rare. Four of the other orders (three agglutinated), Astrorhizida, Litiolida, Trochamminida, Spirillinida, have no common species and a high proportion (30-60%) of rare species. Three orders, Textulariida, Miliolida, Lagenida, have similar species frequency distributions with 5-8% common and 22-30% rare. Two calcareous orders have the highest species frequencies, with the Rotaliida having 14% common and 22% rare, surpassed by the Buliminida with 26% common and just 12% rare.

Buzas & Culver (1991) observed, from their studies around North America, that species that were endemic to one of their five biogeographic provinces were usually rare species with low frequencies of occurrence. They also concluded that species that occurred in all five provinces consisted of a high percentage of abundantly occurring species. Our data (Fig. 70) do not confirm this result, however. We find that species endemic to New Zealand have the lowest numbers of rare taxa (17%) of our six biogeographic categories. Species that occur more widely

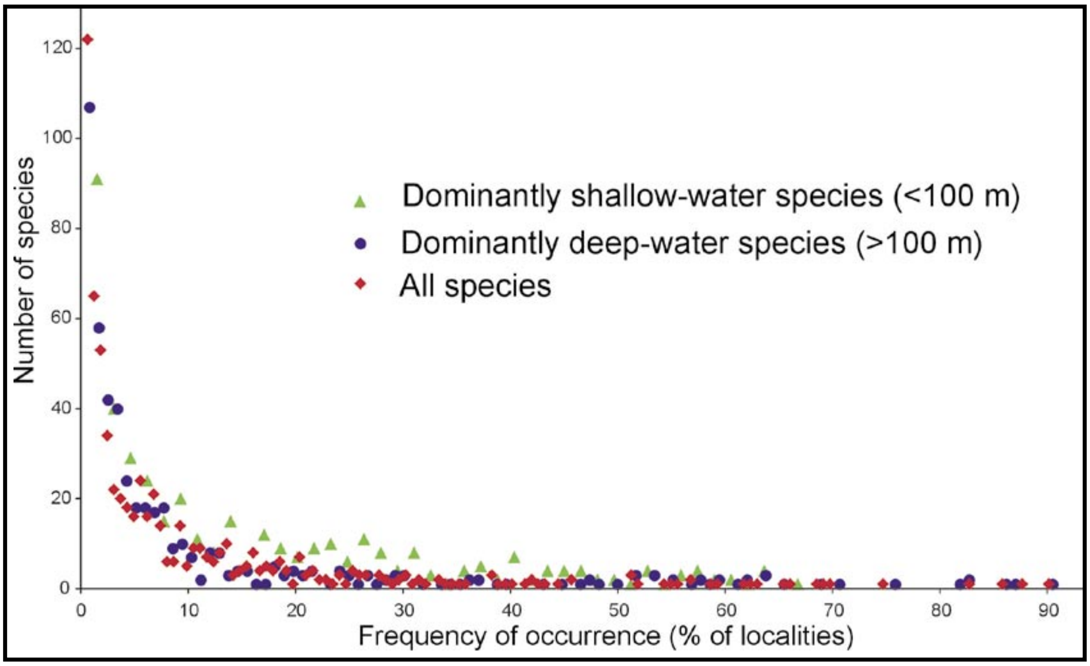


Figure 68. Observed frequency of species occurrence of dominantly shallow-water (<100 m), dominantly deep-water (>100 m) benthic foraminifera and all species combined as percentage occurrence in the 162 composite localities (Fig. 67) around New Zealand.

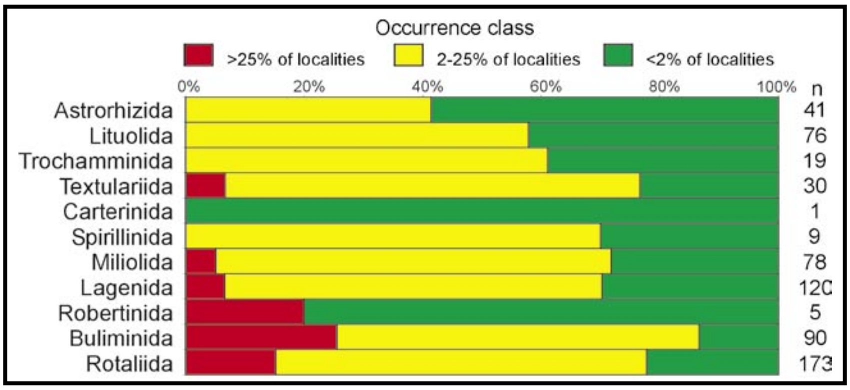


Figure 69. Percentage of species from our total New Zealand benthic foraminiferal composite locality data base in the 11 orders that are present in three occurrence classes.

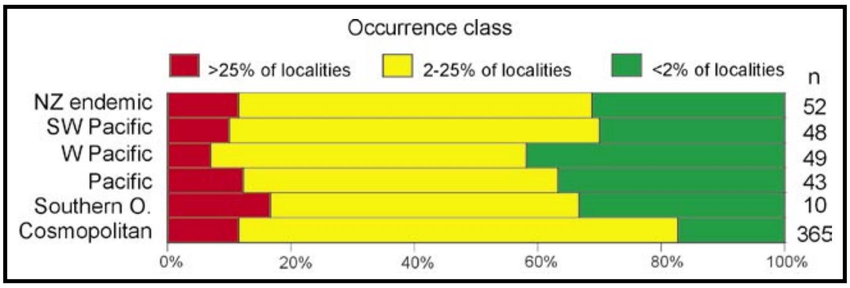


Figure 70. Percentage of species from our total New Zealand benthic foraminiferal composite locality data base in six major biogeographic regions that are present in three occurrence classes.

in the West Pacific and Pacific have the largest numbers of rare taxa (37-42%). Common species (occur in >25% of localities) are more abundant among species that are endemic to the South-west Pacific (17%), followed by endemic to New Zealand (12%), the West Pacific (12%) or cosmopolitan (12%). We have no explanation for this difference between North American and South-west Pacific patterns.

SPECIES DURATION (Fig. 71)

The recorded New Zealand stratigraphic ranges (in terms of New Zealand stages, Fig. 72) of each of the 642 species in our total New Zealand species list have been obtained from the most recent summary (Hayward *et al.* in press) and are given for each of the common species in the taxonomic section. We recognise that whilst these ranges can never be regarded as absolute, they are good approximations for most of the more common and useful taxa. Our data indicate that species in two orders (Carterinida, Trochamminida) have no recorded New Zealand fossil record (Table 26). Two of the three other orders of agglutinated foraminifera (Lituolida, Astrorhizida) have just 5% and 10% of their extant species with a New Zealand fossil record. The fourth agglutinated order (Textulariida) has 30% with a fossil record. Of the calcareous foraminifera, two of the smaller orders (Spirillinida, Robertinida) have just 20% of their species recorded from the New Zealand fossil record, with the others in order of increasing fossil record (Table 26) being Miliolida (36%), Lagenida (45%), Rotaliida (53%) and Buliminida (59%). Clearly the agglutinated and aragonitic tests appear to suffer more taphonomic loss than calcareous tests.

Foraminifera that live dominantly in normal salinity shallow (< 100 m) and deep (> 100 m) water have a similar proportion of species recorded fossil from New Zealand (38-42 %), with a much lower proportion from brackish environments (11%).

There are a number of possible explanations for the lack of fossil records for species in our data set:

a. preferential post-mortem disaggregation of many agglutinated tests as a result of bacterial decay of the cement between grains (e.g., Astrorhizida, Lituolida, Trochamminida, Carterinida; Hayward *et al.* 2001);

b. preferential taphonomic dissolution of aragonitic or porcellaneous tests (e.g., Robertinida, Miliolida);

c. species evolved in the Holocene (unlikely);

d. species migrated to New Zealand in the late Quaternary (e.g., *Saidovina* spp.);

e. species so rare or geographically limited that it has yet to be found fossil in New Zealand;

f. species live in environments that have poor or undersampled fossil records (e.g., brackish and intertidal species);

g. perceived lack of stratigraphic usefulness of species (e.g., Lagenida, Spirillinida, Miliolida) has meant that it has not been identified to specific level in New Zealand fossil samples;

h. taxonomic difficulties with a group mean that some species have not been identified in New Zealand fossil samples so far (e.g., *Quinqueloculina* spp.).

If we discount the species for which we have no fossil data, there are 249 modern species with recorded fossil ranges in New Zealand. Since all these are still living their ranges are only partial species durations. The New Zealand stage in which a species has been first recorded fossil in New Zealand has been tabulated, totalled (Table 27) and standardised as number of first appearances per million years (Fig. 71).

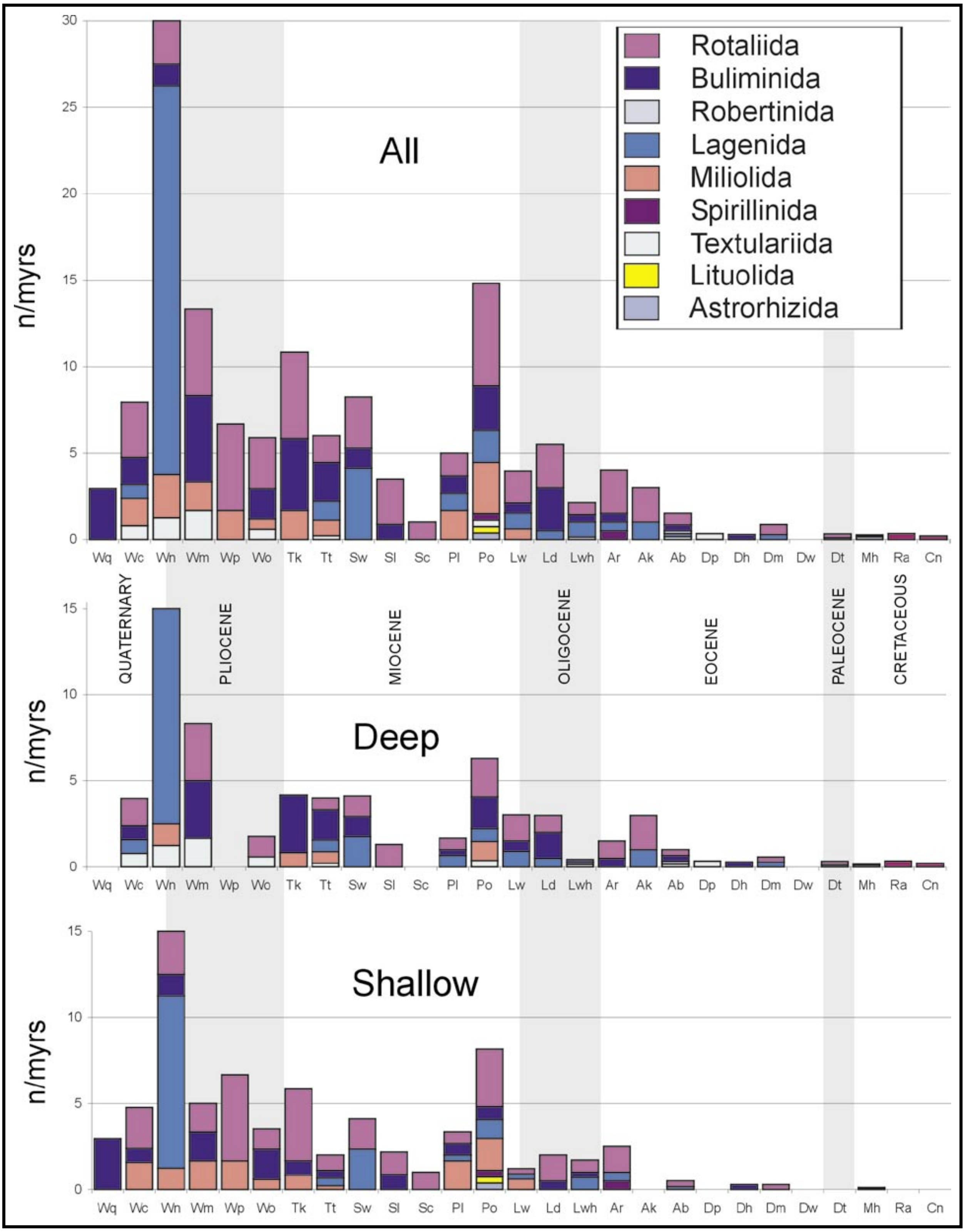


Figure 71. Partial species duration histograms for the 246 extant New Zealand benthic foraminifera (shallow and deep water) that have a recorded New Zealand fossil stratigraphic range. They have been standardised as number of originations per million years (n/myrs) in New Zealand stage subdivisions, see Fig. 72, in each suborder. The total species list for shallow and deep-water around New Zealand was used.

Top: Subdivided by Order.

Middle: Dominantly deep-water species only (>100 m).

Bottom: Dominantly shallow-water species only (<100 m).

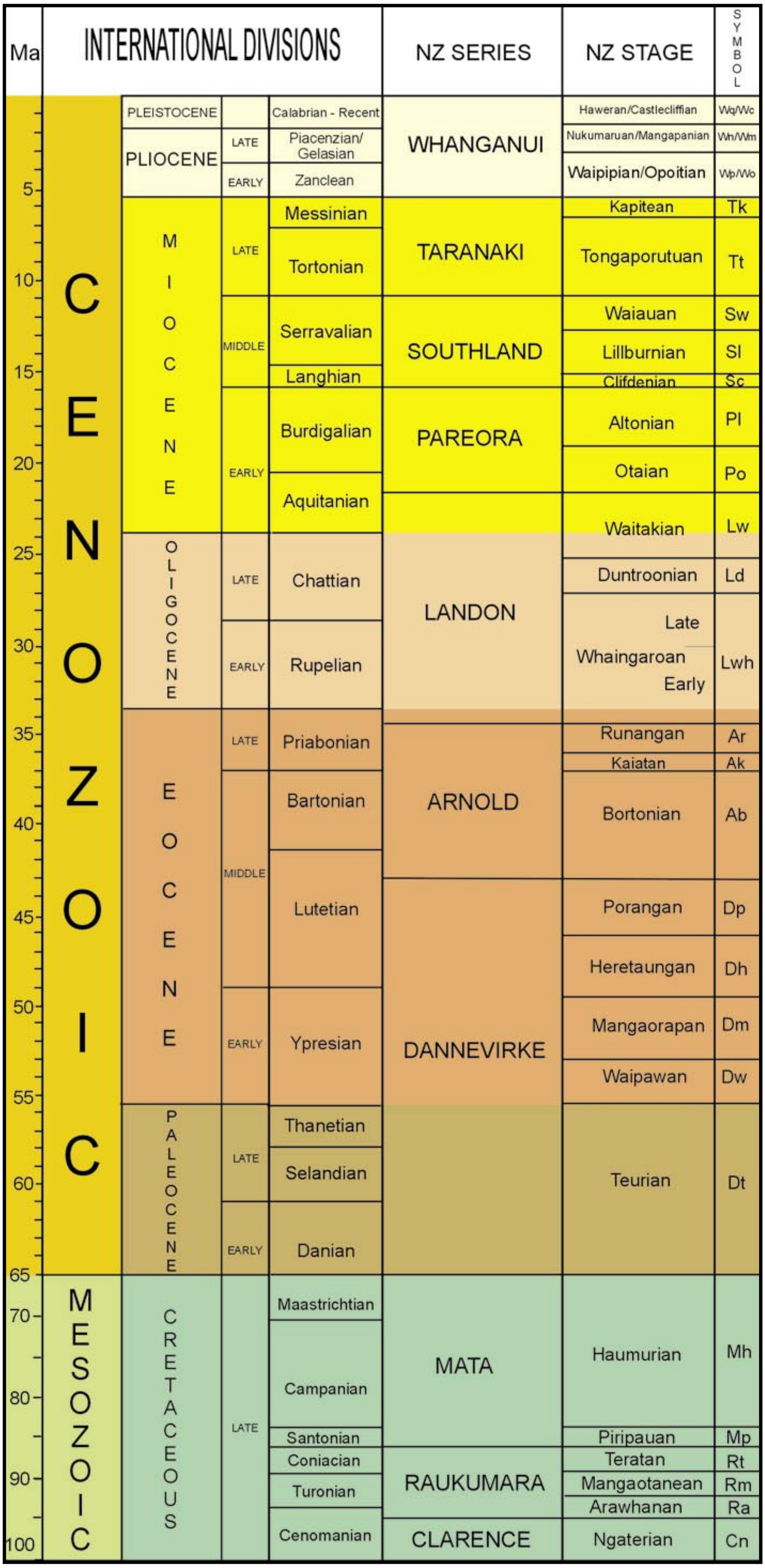


Figure 72. Geological time scale for the Cenozoic and Late Cretaceous, showing correlation of New Zealand stages with international subdivisions. After Cooper (2004).

Table 26. Number of foraminiferal species in brackish, shallow-water, and deep-water around New Zealand and their partial species durations.

	Total number species	Number brackish	Number shallow water (<100 m)	Number deep water (>100 m)	Number this study (>50 m)	% with NZ fossil record	Mean spp duration all myrs	Mean spp duration shallow myrs	Mean spp duration deep myrs
Order:									
Astrorhizida	41	2	10	26	34	10	68	53	84
Lituolida	76	10	15	58	63	5	75	22	93
Trochamminida	19	5	3	11	13	0	.	.	.
Textulariida	30	2	7	18	27	30	19	.	19
Sprillinida	9	0	9	1	7	22	29	29	
Carterinida	1	0	1	0	0	0	.	.	.
Miliolida	78	0	52	20	61	36	14	14	15
Lagenida	120	0	51	64	105	45	18	22	15
Robertinida	5	0	2	2	3	20	43	.	43
Buliminida	90	0	32	57	86	59	17	16	18
Rotaliida	173	8	87	65	138	53	20	19	23
Total	642	27	269	322	537	39	20	18	21
Biogeographic affinity:									
NZ endemic	52	0	43	8		60	13	13	10
SW Pacific	48	1	27	30		42	18	19	17
W Pacific	49	0	26	23		39	13	15	10
Pacific	43	1	16	27		30	10	9	12
Southern O.	10	0	7	3		40	9	9	.
Cosmopolitan	365	24	144	199		43	24	22	25
Unclassified	75	1	6	68					
% with NZ fossil record		12	46	37					

The first major influx of new arrivals from overseas or newly evolved species was in the late Eocene (Kaiatan-Runangan stages), with a more significant pulse during the warm early Miocene (Otaian stage). In deep water there were two other influxes in the late Miocene (Waiauan-Kapitean stages) and late Pliocene (Mangapanian-Nukumaruan stages). The large peak in the Nukumaruan (Fig. 71) may be partly overestimated by the additional study that deep-water uniserial lagenids have received for this interval (Hayward, 2002). In shallow water there was a broader peak period of influx (Fig. 71) in the latest Miocene to Pleistocene (Kapitean-Castlecliffian stages) which may reflect the lower proportion of shallow-water strata preserved from earlier periods. Seven species (3%; dominantly agglutinated and deep water) first appeared in the Cretaceous, with the remaining first appearances in the Cenozoic: three species (1%; all deep water) appeared in the Paleocene, 25 (10%) in the Eocene, 39 (16%) in the Oligocene, 118 (47%) in the Miocene, 34 (14%) in the Pliocene and 23 (9%) in the Pleistocene. There is no major difference in the timings of first appearances between deep and shallow water-dwelling species (Table 28).

If the time ranges of species with fossil records (using New Zealand stages) are converted to millions of years, our data set indicates a mean species duration for these 249 species of 20 million years (Table 28). This value is comparable with the mean of 19 million years obtained for all extant species of *Elphidium* in New Zealand (Hayward *et al.* 1997c) and the mean of 21 myrs for 267 benthic foraminiferal species from the NW Atlantic margin with a fossil record anywhere in the world (Buzas and Culver, 1989). The 108 dominantly shallow water-dwelling New Zealand species (<100 m) with a fossil record have a mean species duration of 19 myrs, only slightly shorter than that of the 138 dominantly deep water-dwelling New Zealand species (>100 m) which have a mean of 21 myrs (Table 28). This slight difference in species duration between shallow and deep-dwelling species is more marked along the Atlantic margin of North America, where species from shallower than 200 m have a mean species duration of 16 myrs and those from deeper water 26 myrs (Buzas & Culver 1984).

We find, like Buzas & Culver (1991), that commonly occurring species (in >25% of localities) have a far greater percentage with a fossil record (81%) than frequent (44%) or rarely occurring species (14%). Buzas & Culver (1989) found that species with a fossil record in both their rare and abundant frequency of occurrence classes on the Atlantic margin of North America had the same mean partial species durations (21 myrs). Our New Zealand data

Table 27. Number of species first appearances by New Zealand stage and order. Stage abbreviations and age ranges are given in Fig. 72.

	Wq	Wc	Wn	Wm	Wp	Wo	Tk	Tt	Sw	Sl	Sc	Pl	Po	Lw	Ld	Lwh	Ar	Ak	Ab	Dp	Dh	Dm	Dw	Dt	Mh	Ra	Cn
Astrorhizida	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Lituolida	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Trochamminida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Textulariida	0	1	1	1	0	1	0	1	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	0	0	0
Spirillinida	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Miliolida	0	2	2	1	1	1	2	4	0	0	0	5	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Lagenida	0	1	18	0	0	0	0	5	7	0	0	3	5	3	1	6	1	1	1	0	0	1	0	1	1	0	0
Robertinida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Buliminida	1	2	1	3	0	3	5	10	2	2	0	3	7	2	5	3	1	0	2	0	1	0	0	0	0	0	0
Rotaliida	0	4	2	3	3	5	6	7	5	6	1	4	16	6	5	5	5	2	4	0	0	2	0	2	0	0	0
Total	1	10	24	8	4	10	13	27	14	8	1	15	40	13	11	15	8	3	9	1	1	3	0	3	5	1	1

Table 28. Stratigraphic distribution of the first appearances in New Zealand strata of deep- and shallow-water, common and rarely occurring benthic foraminifera, as a percentage of those with a fossil record. Comparison with similar data from the Atlantic continental margin of North America (Buzas and Culver, 1989) and global lower bathyal-lower abyssal depths (Boltovskoy, 1987).

Age	NZ All species	NZ Shallow species (<100 m)	NZ Deep-water species (>100 m)	NZ Common species >25 % of locs	NZ Frequent species 2-25% of locs	NZ Rare species <2% of locs	Atlantic All species	Atlantic Common species	Atlantic Rare species 1300-4500 m	World Deep-water species
Pleistocene	9	10	9	3	9	19	13	13	13	3
Pliocene	14	17	11	9	15	12	12	14	11	4
Miocene	47	47	47	48	49	38	46	41	48	22
Oligocene	16	17	15	21	15	8	15	16	14	28
Eocene	10	7	12	13	9	8	8	11	7	16
Paleocene	1	0	2	4	0	4	2	2	2	27
Cretaceous	3	2	4	0	2	12	4	2	5	
Number of fossil species	249	108	138	52	171	26	267	87	180	148
Percent fossil species	39	42	38	81	44	14	33	64	27	
Mean duration (myrs)	20	19	21	21	19	24	21	21	21	24

however shows that commonly occurring species with a fossil record have a slightly longer mean species duration (21 myrs) than the intermediate species class (19 myrs), but both have a shorter mean species duration than the rarely occurring (<2% of localities) class (24 myrs). These latter results are difficult to explain, except that species durations have only been calculated for those species with a New Zealand fossil record and those with no fossil record have not been included when calculating mean species durations.

In our total data set, there are far more endemic species (60%) with a New Zealand fossil record than any of the other biogeographic categories (Table 26). This could imply that there have been a large number of relatively recent arrivals in New Zealand. Species with a Southern Ocean, South-west Pacific, West Pacific or cosmopolitan distribution have 39-43% of species with a New Zealand fossil record, whereas Pacific species have a significantly lower percentage (30%). From their North American Atlantic coast studies, Buzas & Culver (1991) obtained the reverse result with 11% (18) of the endemic species having a fossil record, compared with 53% of their "ubiquitous species" (those occurring right around the North American continent). There are several possible reasons for the great difference between the New Zealand and north-east American values for percentage of endemic species with a fossil record. One contributing factor may be the excellent New Zealand fossil record throughout the Cenozoic from shallow through to deep bathyal, even in the Pliocene and early Pleistocene. Another possible reason may be the isolation of New Zealand from other shallow-water regions and the greater difficulty of dispersal across the ocean than exists around the North American continent.

Although Buzas & Culver (1991) expected that endemic species would have shorter species durations than "ubiquitous" they found no significant difference between the two. Our data on the other hand (Table 26) provide some support for the theory that endemic species (mean species duration 13 myrs) have a shorter species duration than cosmopolitan species (24 myrs). There is a wide scatter in the mean species duration values for species of different biogeographic affinity. The small number of Southern Ocean species have the shortest durations (9 myrs), which may reflect speciation in the Southern Ocean since the onset of cooler temperatures in the Pliocene and Quaternary. Endemic, West Pacific and Pacific species all have mean durations of 10-13 myrs whereas cosmopolitan and South-west Pacific species have the second longest mean durations of 18 myrs. Deep-water species (dominantly >100 m) with cosmopolitan and Pacific biogeographic affinities have longer species durations than their shallow water counterparts (Table 26), whereas the reverse is true for species with endemic, South-west Pacific, West Pacific and Southern Ocean biogeographic affinities. Thus in deeper water more widespread species have longer species durations, but in shallower water, species with more restricted biogeographic distribution have longer species duration.

BIOGEOGRAPHY

World biogeography

Sixty-four percent of the benthic foraminifera in our total New Zealand species data set have a cosmopolitan distribution (Table 28). Nine percent are endemic to New Zealand and a further 8% to each of the South-west Pacific (including Australia), West Pacific and Pacific. A greater proportion of deep-water species (69%) have a cosmopolitan distribution than do shallower-water (<100 m) species (55%). The reverse is true for endemic species with just 3% of deep-water species only known from New Zealand waters, but 16% of shallow-water species. Otherwise deep- and shallow-water species have similar percentages of taxa with South-west Pacific, West Pacific, Pacific and Southern Ocean biogeographic affinities. In contrast, 92% of the 26 species that are dominantly brackish in their distribution have a cosmopolitan distribution and none are endemic to New Zealand.

There is a wide spread of the suborders through all six biogeographic categories (Table 29). The clearest deviation from even spreads are in the cosmopolitan and New Zealand endemic categories. A high proportion (69-84%) of the species in Lagenida and agglutinated orders (Allorhizida, Lituolida, Trochamminida, Textulariida) are cosmopolitan. Just over 50% of the three most common orders are cosmopolitan – Miliolida (55%), Buliminida (58%), Rotaliida (53%). The Rotaliida (18%) and Miliolida (17%) have the greatest proportion of endemic species, with low numbers in the agglutinated orders (0-8%), Lagenida (3%) and Buliminida (5%).

Endemic taxa

In this study of Recent New Zealand benthic foraminifera, we record one endemic genus (*Zeaflorilus*) and 50 endemic species or forms (Table 30). The accuracy of these figures depends on the rigour of our taxonomic discrimination and upon the extent of our searches through the quagmire of overseas literature in an effort to discover overseas records of these species (usually under other names). Our literature and faunal searches, although extensive, could not be exhaustive and thus we would expect that further overseas work will reduce this list, most likely in the miliolids.

With this proviso, our work indicates that the majority of endemic species are from the Order Rotaliida (28 species), with fewer from the Miliolida (11), Buliminida (4), Lagenida (2), Textulariida (2), Astrorhizida, Lituolida and Spirillinida (1 each) and none from the Allogrominida, Trochamminida, Carterinida nor Robertinida (Table 30). Nearly 30% of the endemic species belong to just three genera - *Notorotalia* (6 species), *Pileolina* (5) and *Quinqueloculina* (3). *Notorotalia* is a southern hemisphere-restricted genus, which is one of New Zealand's most common, shallow-water genera in the Recent and the Neogene (Vella 1957, Hornibrook 1961, 1996), but is relatively uncommon and of low diversity (1-2 species) elsewhere. New Zealand is accepted as the centre of diversity and origin for the family Notorotaliidae and may

Table 29. Percentage of benthic foraminiferal species (total data set) in each order that belong to each of the six major biogeographic categories.

	NZ endemic	SW Pacific	W Pacific	Pacific	Southern O.	Cosmopolitan	No of spp.
Allogromiida	0	0	0	0	0	100	1
Astrorhizida	3	5	3	3	3	84	37
Lituolida	1	8	6	11	0	73	71
Trochamminida	0	11	6	6	6	72	18
Textulariida	8	8	12	4	0	69	26
Spirillinida	10	10	10	10	0	60	10
Miliolida	17	9	12	7	0	55	69
Carterinida	0	0	0	0	0	100	1
Lagenida	3	9	11	4	1	73	102
Robertinida	0	50	25	0	0	25	4
Buliminida	5	13	7	15	2	58	86
Rotaliida	18	11	8	6	3	53	155
Total							580

also be the centre of greatest diversity of the glabratellid genus *Pileolina*. Species of this latter genus, particularly the endemics *P. radiata* and *P. zealandica*, are abundant in shallow water throughout New Zealand and the genus appears to have its greatest relative abundance and number of species in New Zealand waters, with a much lower frequency of occurrence and only 1-2 species elsewhere.

Quinqueloculina, on the other hand, has a similarly high abundance and diversity elsewhere to that found in New Zealand. We suspect that some or all of the three reportedly endemic species (*Q. cooki*, *Q. delicatula*, *Q. rebeccae*) here in New Zealand are yet to be identified overseas, or may be recorded under other names, however we have not found them illustrated in the recently published atlases of Australian, Indonesian or Papua New Guinea Recent foraminifera (Yassini & Jones 1995, Loeblich & Tappan 1994, Haig 1988).

In our data set, no endemics live dominantly in brackish conditions. In normal salinity conditions, more endemic species are found in shallow water than deep water (Table 30) – 90% occur at inner-mid shelf depths, 76% at upper bathyal depths, 36% at lower bathyal and 20% at abyssal depths. Some of these deeper occurrences might be explained as resulting from downslope post-mortem transport. In terms of mean frequency of occurrence there is a similar decrease from inner-mid shelf (24%) to abyssal (2%). Eighteen percent (9 spp.) of endemics are restricted in their occurrence to shelf depths (0-200 m) and 52% (26 spp.) to shelf-upper bathyal depths (<600 m) (Table 30). Just 5 endemic species (10%) are restricted in their occurrence to water deeper than 100 m and none belong to the common calcareous orders – Lagenida, Buliminida, Rotaliida (Table 30). These deep-water-restricted endemic species are: *Sigmoilopsis finlayi* (outer shelf-upper bathyal), *Siphonaperta crassa* (outer shelf to lower bathyal), *Spiroloculina novozelandica* (upper-mid bathyal), *Ruakituria pseudorobusta* (bathyal), and *Jullienella zealandica* (lower bathyal).

Nine endemic taxa have rather restricted recorded geographic ranges. Most of these are dominantly shallow-water taxa with one of them restricted to the Kermadec Islands (*Glabratellina kermadecensis*), three to north-east New Zealand (*Elphidium excavatum* f. *oirgi*, *Pileolina calcarata* and *P. harmeri*), and two to the southern region of New Zealand (*Astacolus neolatus, Notorotalia aucklandica*). Three species of dominantly deep-water endemics have restricted distributions recorded by us, with *Cornuloculina margaritifera* only recorded from the north region and *Julienella zelandica* and *Ruakituria pseudorobusta* only in the west region.

Intra-New Zealand biogeography based on composite locality data set

Jaccard coefficients were calculated between all 162 composite localities in the data set containing presence/absence records for 641 species and these localities were grouped using unweighted pair Q-mode cluster analysis (Sokal & Sneath 1968). Fifteen clusters (with 6 unclustered localities) were selected by inspection of the resulting dendrogram (Fig. 73) and when plotted around New Zealand they were found to mostly occur in mappable geographic regions (Fig. 74). These regions often overlap and the complex pattern is hard to interpret. As we found in the deep quantitative study, the distribution pattern is driven by a number of variables many of which are related to water depth and some to latitude and longitude. To tease out the biogeographic distribution patterns we attempted to remove much of the influence of depth-related variables by dividing the localities into five bathymetric groups and analysing them separately. For each group we generated a detrended correspondence analysis ordination of the constituent composite localities based solely on the presence/absence of species.

1. ABYSSAL (Fig. 75): The DECORANA ordination shows that the 27 abyssal (>2000 m depth) composite localities around New Zealand can be grouped and mapped into four large geographic provinces on the basis

Table 30. Benthic foraminiferal taxa that are endemic to New Zealand region and their frequency of occurrence in different bathymetric zones, as measured by their % occurrence in the composite localities within each zone (Appendix IV, Fig. 67).

	Inner shelf 0-100 m	Outer shelf 100-200 m	Upper bathyal 200-600 m	Mid bathyal 600-1000 m	Lower bathyal 1000-2000 m	Abyssal >2000 m	All 0-5000 m
Astrorhizida							
Jullienella zealandica	.	.	.	.	5.3	.	0.6
Lituolida							
Ruakituria pseudorobusta	.	.	2.3	.	5.3	.	1.2
Textulariida							
Siphotextularia blacki	31.9	6.7	2.3	.	1.5	3.7	12.3
Spiroplectinella proxispira	8.9	6.0	10.0	1.0	5.3	.	33.3
Spirillinida							
Spirillina denticulogranulata	1.6	6.7	2.3	.	.	.	4.3
Miliolida							
Miliolinella vigilax	36.2	2.0	6.8	1.0	5.3	7.5	17.3
Cornuloculina margaritifera	2.1	.	.	5.0	.	.	1.2
Pyrgo n.sp.	19.1	.	.	.	.	.	5.6
Quinqueloculina cooki	44.7	.	2.3	.	.	.	13.6
Quinqueloculina delicatula	59.6	2.0	4.5	.	.	.	2.4
Quinqueloculina rebeccae	17.2	.	2.3	.	.	.	5.6
Sigmoilopsis finlayi	.	1.0	2.3	.	.	.	0.6
Sigmoilopsis wanganuiensis	27.7	4.0	36.4	35.0	31.6	.	29.6
Siphonaperta crassa	.	6.7	6.8	5.0	5.3	.	3.7
Siphonaperta macbeathi	19.1	.	.	.	.	.	5.6
Spiroloculina novozelandica	.	.	4.5	15.0	.	.	3.9
Triloculina chrysostoma	12.8	6.7	4.5	.	.	.	5.6
Lagenida							
Astacolus neolatus	8.5	.	.	.	.	.	2.5
Astacolus vellai	2.1	.	.	.	.	.	0.6
Lenticulina erratica	1.6	.	2.3	.	.	.	3.7
Buliminida							
Bolivina cacozela	72.3	73.3	47.7	65.0	21.5	22.2	54.9
Ehrenbergina mestayeri	25.5	33.3	2.3	.	.	.	11.1
Globocassidulina canalisuturata	63.8	6.0	45.5	55.0	42.2	22.2	51.9
Virgulopsis turris	55.3	2.0	16.0	1.0	1.5	3.7	25.4
Rotaliida							
Anomaliniodes sphericus	25.5	4.0	13.6	5.0	26.3	3.7	19.1
Cibicides temperatus	8.5	2.0	11.4	5.0	1.5	.	9.3
Discorbinella deflata	6.4	6.7	4.5	.	5.3	.	4.3
Discorbinella vitrevoluta	38.3	13.3	.	.	5.3	.	13.0
Elphidium excavatum f. *oirgi*	23.4	.	.	.	.	.	6.8
Elphidium novozelandicum	63.8	6.7	4.5	.	.	.	2.4
Elphidium vellai	6.4	.	.	.	.	.	1.9
Epistominella cf. *cassidulinoides*	4.3	.	.	.	.	.	1.2
Gavelinopsis hamatus	51.6	2.0	2.3	.	.	3.7	17.9
Glabratellina kermadecensis	2.1	.	.	.	.	.	0.6
Karreria maoria	14.9	.	2.3	5.0	.	.	5.6
Nonionella magnalingua	23.4	26.7	16.0	15.0	1.5	3.7	17.3
Nonionellina flemingi	14.9	46.7	31.8	25.0	1.5	11.1	23.5
Notorotalia aucklandica	8.5	2.0	2.3	5.0	.	.	5.6
Notorotalia depressa	68.9	53.3	25.0	15.0	1.5	3.7	35.2
Notorotalia finlayi	42.6	6.7	2.3	.	.	.	13.6
Notorotalia inornata	17.2	.	.	.	.	.	4.9
Notorotalia olsoni	29.8	.	2.3			.	9.3
Notorotalia zelandica	29.8	6.7	4.5	.	.	.	1.5
Pileolina calcarata	19.1	6.7	.	.	.	.	6.2
Pileolina gracei	6.4	.	.	.	.	.	1.9
Pileolina harmeri	17.2	6.7	2.3	1.0	.	.	7.5
Pileolina radiata	55.3	4.0	6.8	5.0	.	.	22.2
Pileolina zealandica	59.6	2.0	2.3	5.0	.	.	2.4
Planulinoides norcotti	4.3	6.7	2.3	.	.	.	2.5
Rosalina paupereques	4.4	6.7	4.5	.	.	.	13.6
Rosalina vitrizea	12.8	2.0	2.3	.	1.5	.	7.5
Zeaflorilus parri	55.3	13.3	4.5	.	.	.	18.5
Mean frequency	23.6	7.3	6.7	5.2	3.3	1.6	11.0
Number of species	47	33	38	19	18	10	52
% of endemic species	90	63	73	37	35	19	100

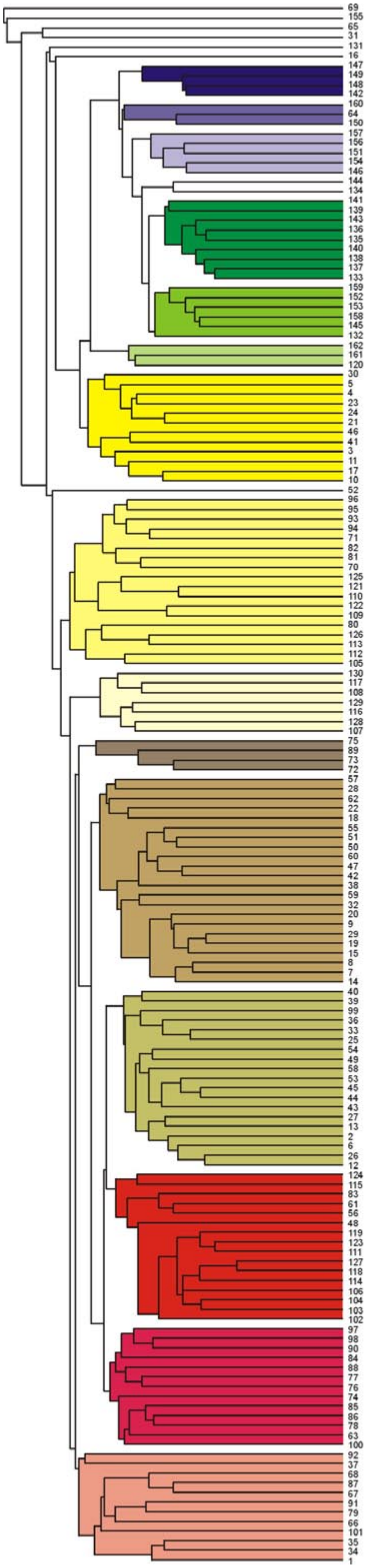


Figure 73. Cluster analysis dendrogram (Jaccard Coefficient) based on presence/absence data of 641 benthic foraminiferal species in all 162 composite localities, 0-5000 m, in the New Zealand region.

of their benthic foraminiferal species composition. The northern province includes localities off both the eastern and western coasts. The Far Southern province groups all abyssal localities south and east of the Campbell Plateau. Localities east of New Zealand can be divided into a northern Hikurangi Plateau group and a southern Bounty Trough group, with one locality from the south (101) being more similar to the northern group. The single sample (37) from the Kermadec Trench in the far north is compositionally most similar to the Bounty Trough group. Just 32% of the 260 species in abyssal localities are common to at least three of these provinces (Table 31). Some of the differences between provinces reflect the north to south decrease in number of species (except the one locality from Kermadec T) with 156 species in the northern and 91 in the far southern provinces (Fig. 75). Other differences between provinces relate to the more limited distribution of some species, with the northern and Hikurangi Plateau provinces having the greatest number of species restricted in occurrence to their provinces (15% each). In the south, the Bounty Trough and Far Southern have just 5% and 7% respectively of the abyssal species restricted in occurrence to their provinces.

2. MID-LOWER BATHYAL (Fig. 76): The DECORANA ordination shows that the 39 mid-lower bathyal (600-2000 m deep) composite localities can be readily grouped and mapped into three geographic provinces. The north-western province encompasses all localities west of New Zealand and east of the northern North Island, whereas localities east and south of the South Island are divided into two distinct provinces separated along the line of the Bounty Trough. As with the abyssal foraminifera, some of the provincial differences reflect the latitudinal decrease in species diversity from 231 species in the north-west to 141 in the south (Fig. 76). This species diversity reduction results in the high percentage (30%) of the mid-lower bathyal species that are restricted in occurrence to the north-western province. Nevertheless there are also some species that are restricted to the southern (9% of species) and the eastern (14%) provinces and also contribute to the distinctiveness of the different provincial faunas. Only 22% of the species occur in all three provinces.

3. UPPER BATHYAL (Fig. 77): The DECORANA ordination shows that 31 of the 35 upper bathyal (200-600 m) composite localities can be divided into two geographically separate provinces – a north-western and a south-eastern. Two of the western localities (48, 61) plot among the south-eastern localities and show that the subdivision isn't absolute. Two further localities (65, 122) plot separately from all others and have been accorded minor provincial status here, but the Wairarapa locality has an artificially low number of species records (Table 32) and probably is not distinct from one of the two main provinces. The Auckland Island Seamount locality is compositionally more similar to the north-western province than the adjacent south-eastern, but it is distinctive in its own right with 5% of the 311

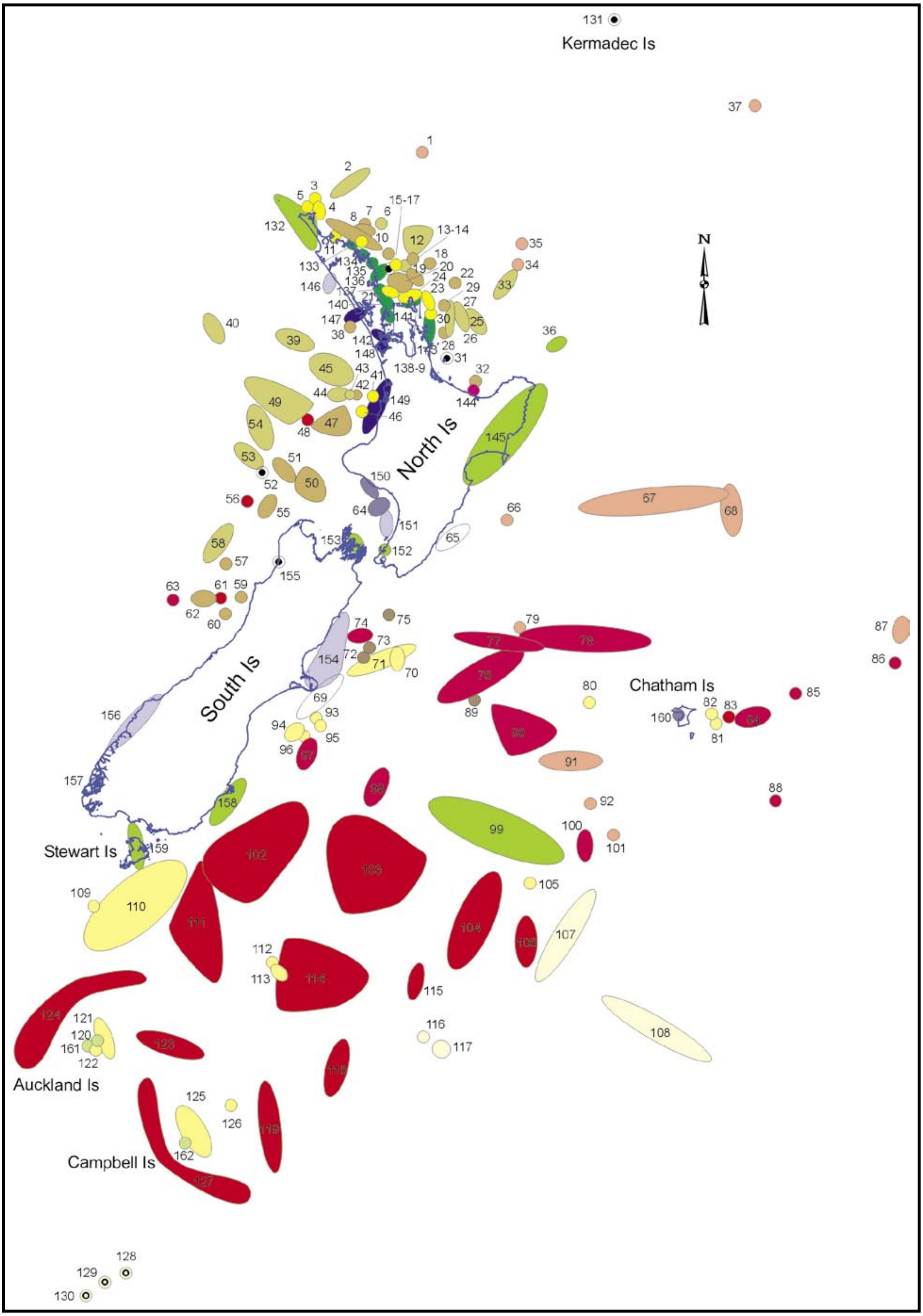


Figure 74. Distribution of the presence/absence clusters in the 162 composite localities around New Zealand.

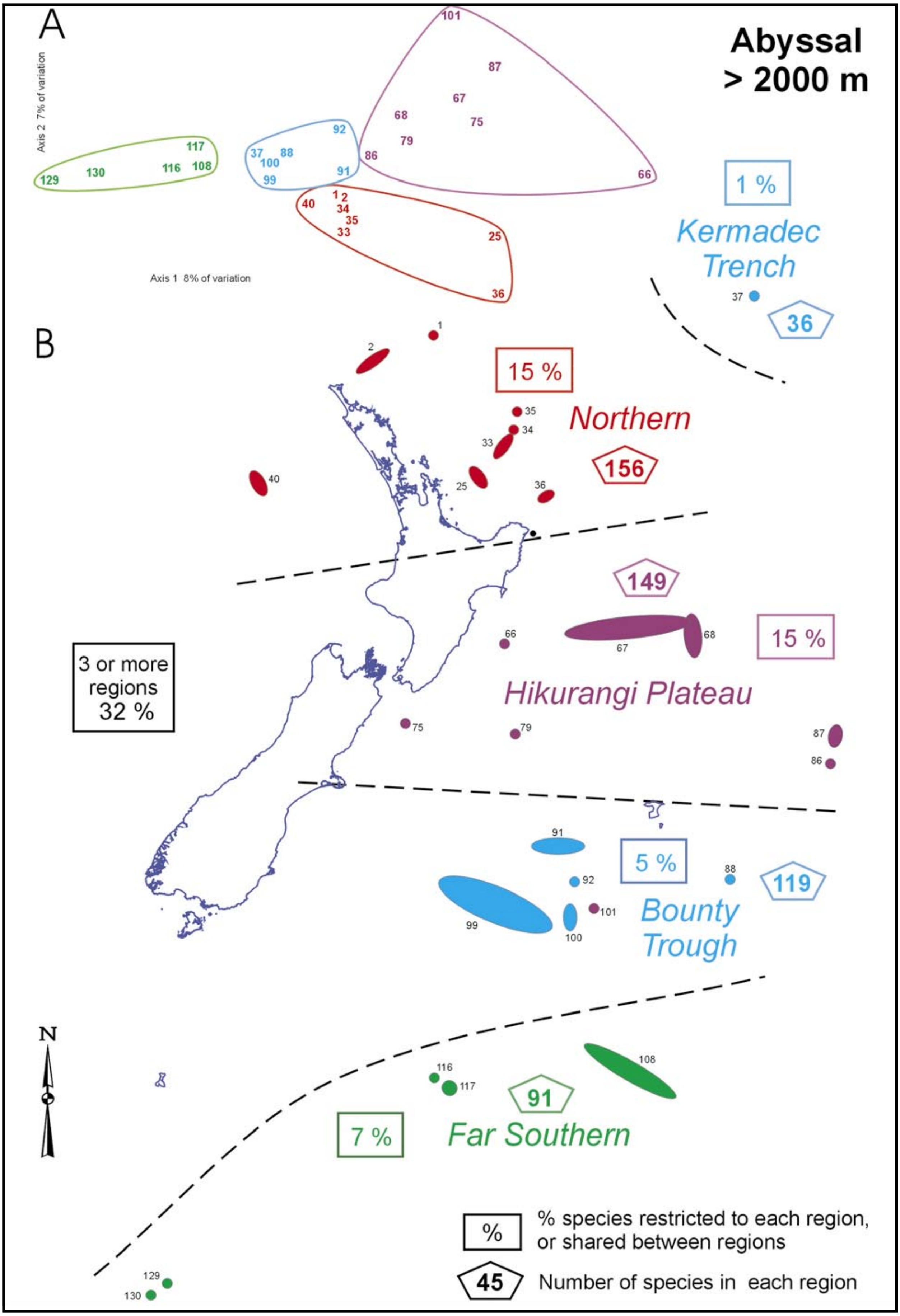


Figure 75. A. Detrended correspondence analysis ordination of 27 abyssal (2000-5000 m) composite localities (260 species) and B. their mapped biogeographic subdivision.

Table 31. Percentage of the 260 abyssal species that occur in each of the abyssal biogeographic provinces (identified in Fig. 75) or combinations of these provinces.

	Kermadec Trough	**North**	**Hikurangi Plateau**	**Bounty Trough**	**Far South**
No. of composite locs	1	8	6	7	5
No. of species	36	156	149	119	91
1 region only	0.8	15	15	4.6	6.9
2 regions:					
North	0.4				
Hikurangi Plateau	0.8	8.8			
Bounty Trough	0	3.5	4.2		
Far South	0	3.5	1.9	3.1	
3 regions	15				
4 regions	10.4				
5 regions	6.2				

upper bathyal species only occurring within it. As at greater depths, there is a reduction in diversity from 260 species in the north-west to 144 in the south-east, resulting in 40% of the upper bathyal species from around New Zealand not being recorded from outside the north-western province. Nevertheless, the south-eastern province has 10% of the species restricted to it. Just 36% of the total species co-occur in the large north-western and south-eastern provinces.

4. MID-OUTER SHELF (Fig. 78): The DECORANA ordination clearly divides the 28 mid-outer shelf (50-200 m) composite localities into two geographically separate provinces – north-western and south-eastern. The north-western province is far more diverse with 311 species and 57% of the total mid-outer shelf species only present in that province. Thirty-five percent of species occur in both provinces with 8% restricted to the south-eastern province, which has a total diversity of 147 species.

5. INNER-MID SHELF (Fig. 79): The DECORANA ordination shows that the 32 inner-mid shelf (0-100 m) composite localities can be divided into five biogeographic provinces based on their species composition. These provinces correspond well with the shallow marine biogeographic provinces defined on the basis of molluscs by Powell (1955) and his names are used, except that the New Zealandian is used for the combination of Powell's Cookian and Forsterian provinces (Hayward *et al.* 1999). The only lack of clear subdivision between our shallow-water provinces is a slight overlap along the gradational boundary between the Aupourian and New Zealandian provinces. The ordination suggests that the Kermadecian is compositionally most similar to its nearest neighbour, the Aupourian and that the Antipodean is closer in composition to the Moriorian than the New Zealandian. If the Kermadec and Chatham Island localities are ignored, we can once again see a north to south diversity decrease with 261 species in the Aupourian, 226 in the New Zealandian, and 131 in the Antipodean. The low shallow-water species diversity in the Kermadecian and Moriorian provinces, and to some extent in the Antipodean, reflects the low diversity of marine habitats around these small island groups, the young age of the islands (Kermadec), the harsh conditions in the Last Glaciation (Subantarctic islands) and the large separation across open ocean for new immigrants to cross. Each of these five provinces has at least three species, and often many more, that are restricted to them. Of the 320 species recorded in this study from inner-mid shelf depths, 15%

Table 32. Percentage of the 311 species that occur in each of the 4 upper bathyal biogeographic provinces (identified in Fig. 77) or combinations of these provinces.

	North-west	**South-east**	**Wairarapa**	**Auckland Islands**
No of composite locs.	20	13	1	1
No. of species	260	144	17	62
1 region only	39.9	10	0.6	4.8
2 regions:				
South-east	24.8			
Wairarapa	3.9	0		
Auckland Islands	4.5	1	0	
3 regions	10.6			
4 regions	0			

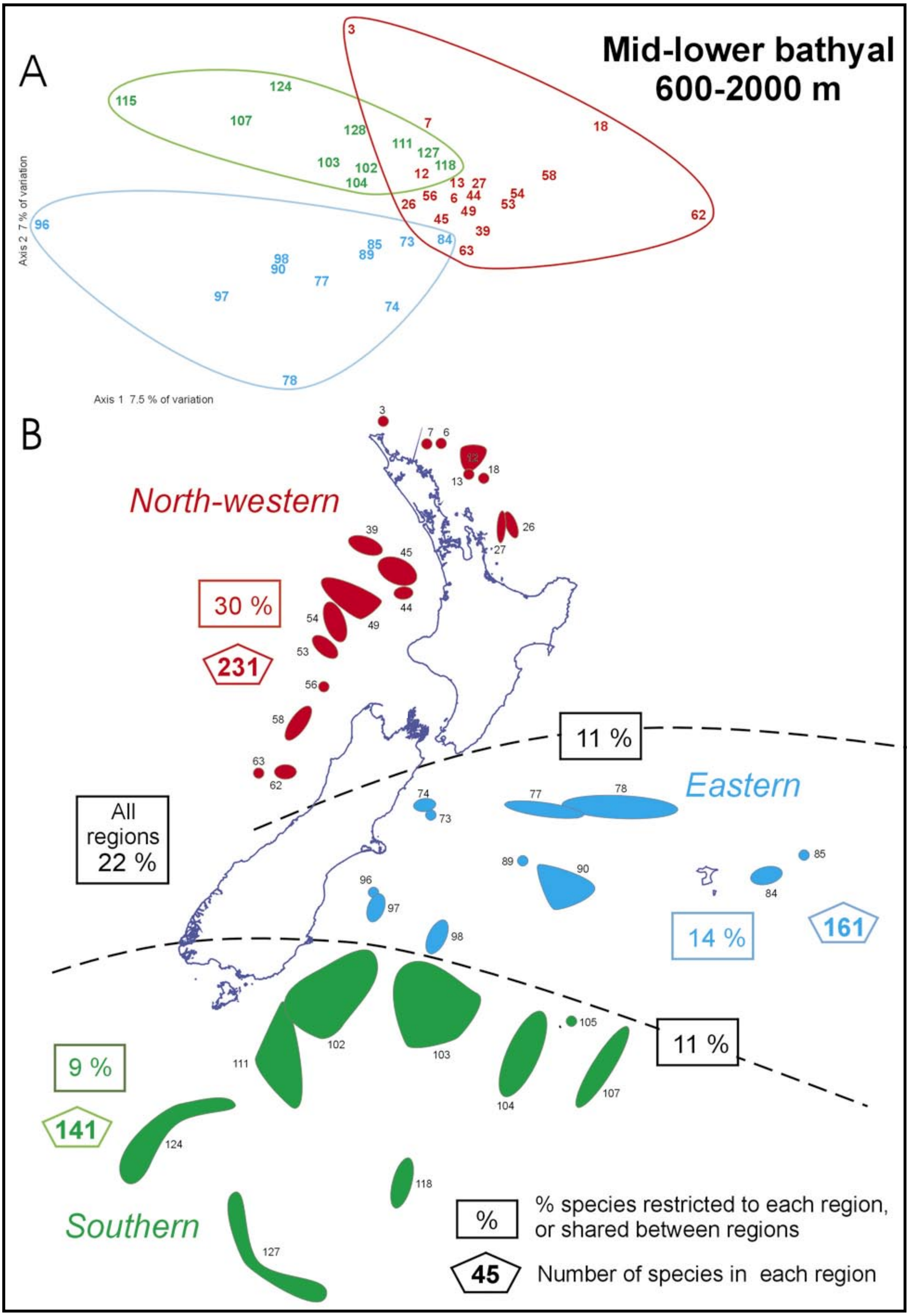


Figure 76. A. Detrended correspondence analysis ordination of 39 mid-lower bathyal (600-2000 m) composite localities (315 species) and B. their mapped biogeographic subdivision.

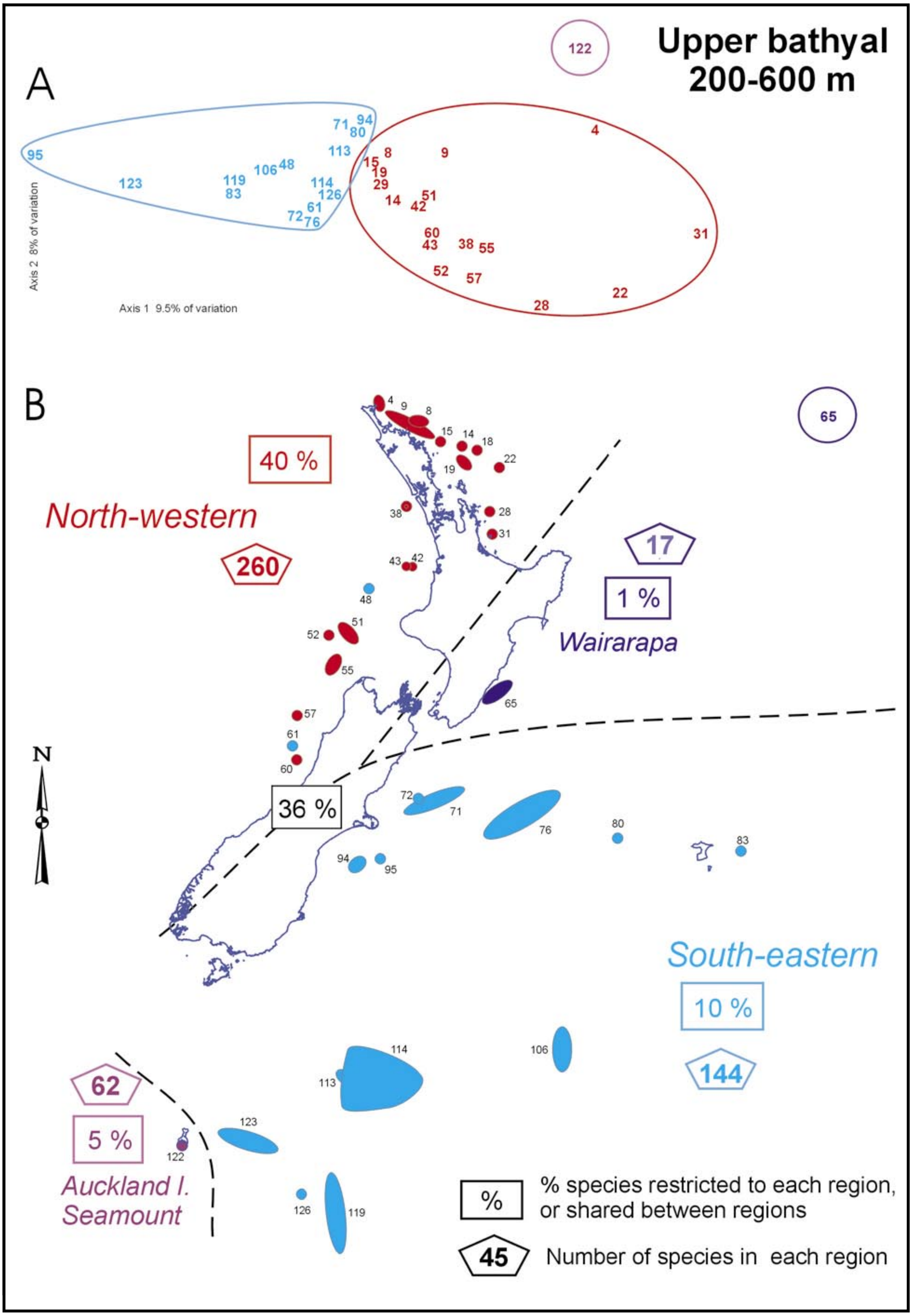


Figure 77. A. Detrended correspondence analysis ordination of 35 upper bathyal (200-600 m) composite localities (311 species) and B. their mapped biogeographic subdivision.

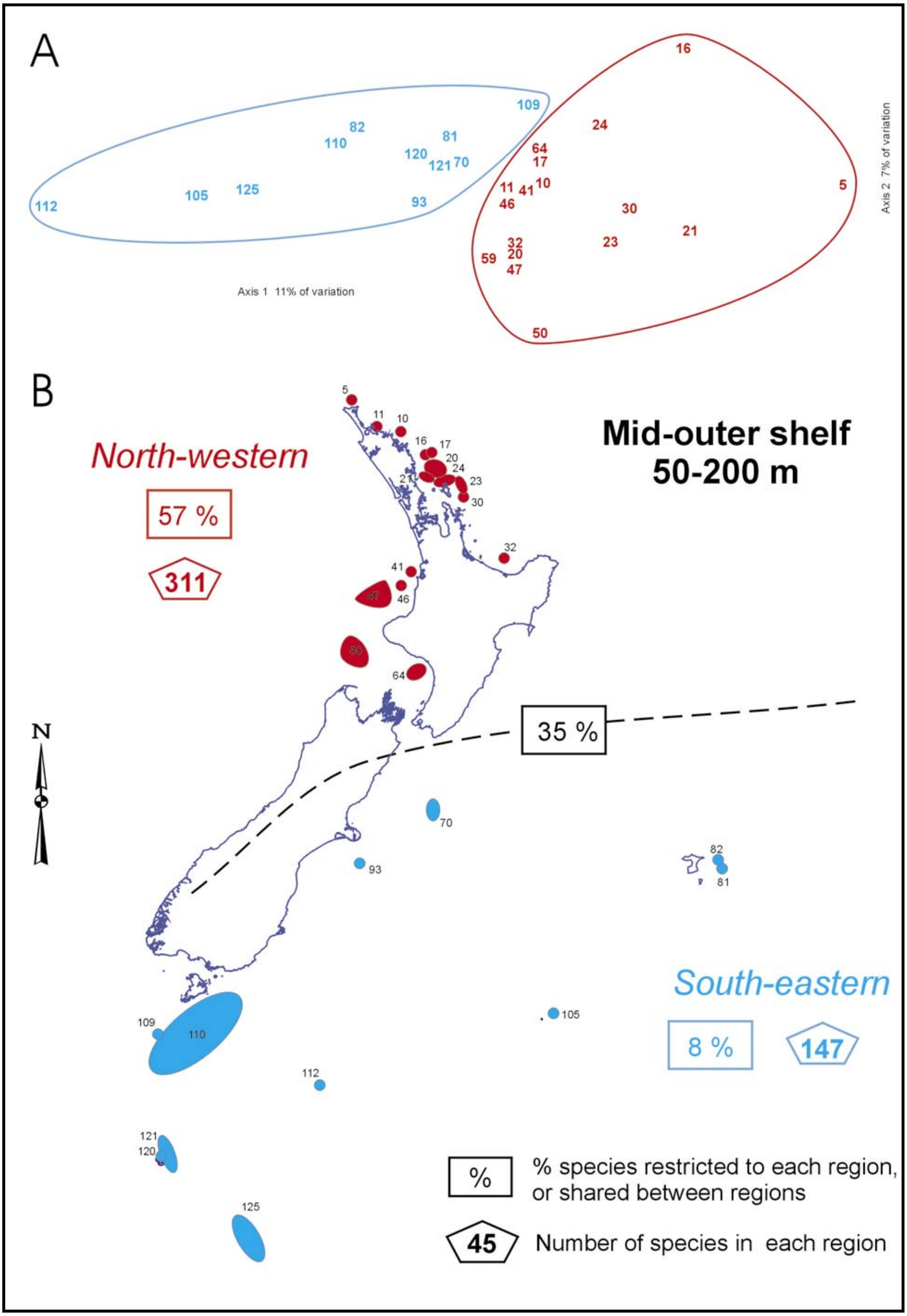


Figure 78. A. Detrended correspondence analysis ordination of 28 mid to outer shelf (50-200 m) composite localities (320 species) and B. their mapped biogeographic subdivision.

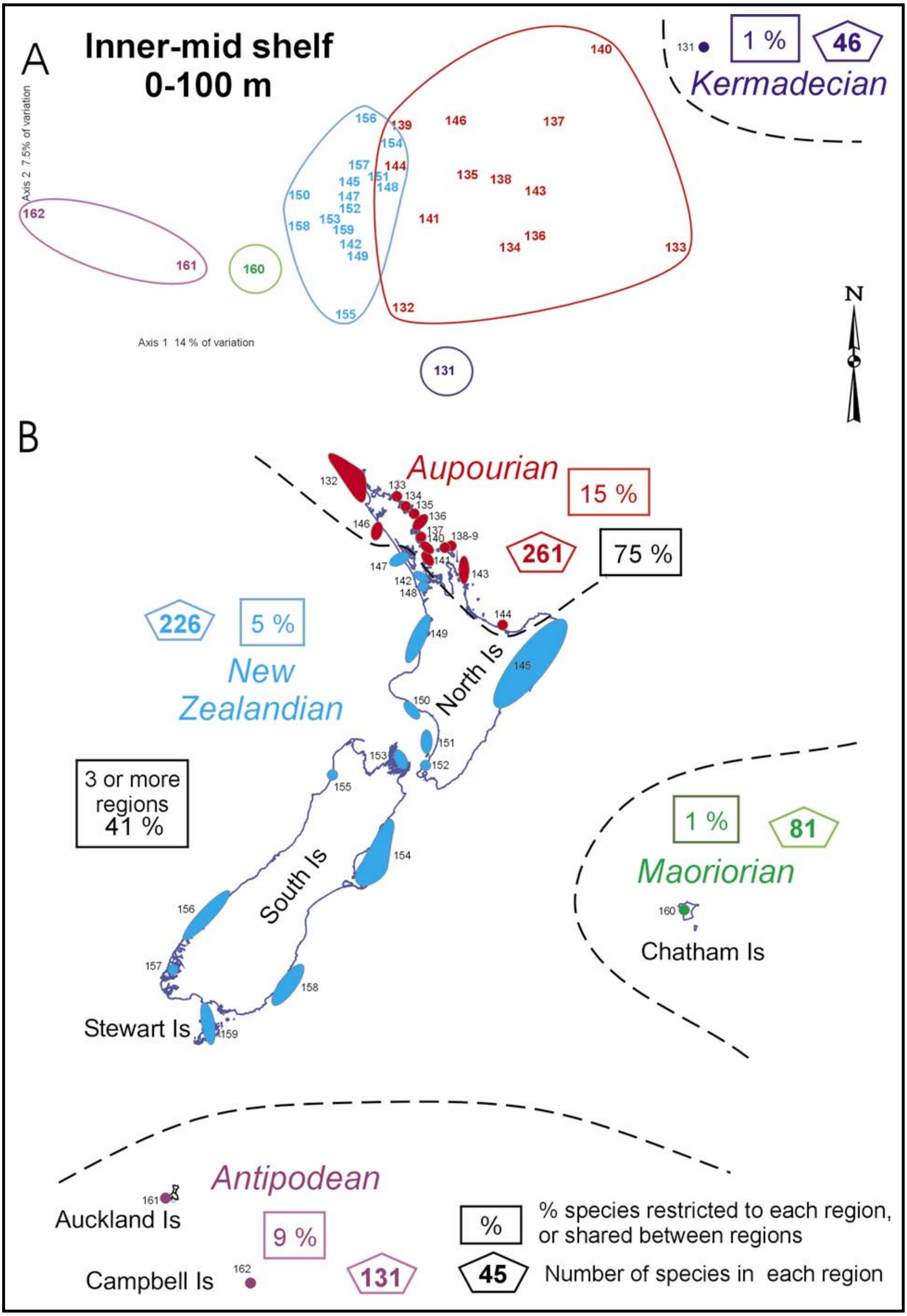


Figure 79. A. Detrended correspondence analysis ordination of 32 inner to mid shelf (0-100 m) composite localities (338 species) and B. their mapped biogeographic subdivision.

Table 33. Percentage of the 320 species that occur in each of the 5 inner-mid shelf biogeographic provinces (identified in Fig. 79) or combinations of these provinces.

	Kermadecian	Aupourian	New Zealandian	Moriorian	Antipodean
No. of composite locs.	1	13	15	1	2
No. of species	46	261	226	81	131
1 region only	1.3	14.9	5.4	1	8.9
2 regions:					
Aupourian	0				
New Zealandian	0.3	24.8			
Moriorian	0	0.3	0.6		
Antipodean	0	0.6	0.6	0.3	
3 regions	21.9				
4 regions	14.3				
5 regions	4.8				

are restricted to the warm Aupourian province, 9% to the cool Antipodean, 5% to the large New Zealandian, and 1% each to the Kermadecian and Moriorian (Table 33). Forty-five percent of species that occur around mainland New Zealand have not been recorded from any of the three outlying island provinces. Hayward *et al.* (1999, Table 8; 2007) listed species that are restricted to these various shallow-water provinces.

Discussion

Our analyses suggest that the benthic foraminiferal biogeography around New Zealand differs at different depths and in different water masses. Five provinces can be recognised in our shallowest faunas (inner-mid shelf) and these correspond almost exactly with those identified from molluscs (Powell 1955), except that his Cookian and Forsterian provinces around central and southern mainland New Zealand cannot be separated based on foraminiferal data. At mid-outer shelf and upper bathyal depths, only two provinces can be identified – one with greater species diversity in the north and west and one in the south and east. With increasing depth greater subdivision is again possible, with three provinces recognisable at mid-lower bathyal depths and four (possibly five) at abyssal depths.

Our ecologic distribution studies suggest that the drivers of these biogeographic subdivisions are likely to be a combination of water temperature (shallow provinces), variations in surface water nutrient availability and phytoplankton productivity (food supply), and carbonate corrosiveness of bottom waters (abyssal provinces).

Intra-New Zealand species distribution based on quantitative deep-water data set

Clearly the composite locality data set has some inconsistencies in the data collection effort between localities and regions that could have influenced the biogeographic analysis above. Thus a subset of this, the quantitative data collected for the deep-water ecologic distribution analysis (Appendix III) was analysed separately. Here the number of specimens counted from each sample was similar and thus comparison of the species composition (quantitative data converted to presence/absence) might be more consistent. Unfortunately the number of samples studied at different depths differs between the four regions (north, south, east, west of New Zealand, Table 34) and this means there is still some inconsistency within our analysed data. We undertook three analyses, comparing the species composition between the four regions across all depths, at mid and outer shelf depths (50-200 m) and at bathyal-abyssal depths (200-5000 m).

When all the data is considered together (Fig. 80) we find that 24% of all 424 species occur in all four regions, 17% occur only in the north, 16% only in the east, 8% only in the south and just 4% are restricted to the west (Table 35). These relative abundances are similar to those for the bathyal-abyssal subset (Fig. 80) where a slightly lower percentage of the 372 species occur in all regions (22%), in the north (13%) and west (3%) and the same percentage in the east (16%) and south (8%). The relative abundances are considerably different in the shallow subset (250 species, Fig. 80) with just 13% present in all four regions, and considerably more restricted to the north region (20%) than the west (9%), east (7%) or south (7%).

Using the total number of species in each region (Table 34), we find that greatest diversity occurs in the north (69%), followed by east (61%) then west and south (50-51% each). At bathyal and abyssal depths, north and east have the same diversity (65% each) and the south (48%) has more species than west (43%). At shelf depths, north is again by far the most diverse (70% of species), followed by west (56%), east (40%) and south (37%). Unfortunately these relative abundances reflect the number of stations studied at the different depths in each region, with the north and west having far more shallow stations than the east and south regions, and the north and west having fewer bathyal and abyssal stations with the deepest station in the west being just 2150 m.

Not surprisingly the 44 common species (occurring in >25% of stations) are more widespread among the regions than the 208 rare species (in <2% of stations). Ninety-five percent of the common species occur in all four regions in the full depth range, whereas none of the rare species do (Fig. 80). There are more rare species restricted to the north and east regions (26%, 25%) than the west (11%) and south (14%). This shows that the main faunal differences between the three regions is in the numerous rarely occurring species – a conclusion similar to that of Buzas & Culver (1991), who found that species with more restricted biogeographic distributions were more commonly those with low frequency of occurrence.

Species restricted to different regions around New Zealand

From our total data set we can recognise species that appear to have distribution patterns that are restricted to one part of the New Zealand region (Table 35). The pattern in shelf-depth waters (<200 m) is quite different from that in bathyal and abyssal depths (>200 m).

BATHYAL AND ABYSSAL DEPTHS: For species dominantly occurring in water depths >200 m the number of regionally-restricted species is more even, with 39-40 species restricted to each of the north and east regions, 14 to the west and 12 to the south. Many of these species have rare occurrence and thus their apparent restricted distribution within part of the New Zealand region may be a result of this rarity. Thirty of the species restricted to the east are agglutinated abyssal species that are most common at and below the CCD. We believe that this distribution pattern is largely a result of more deep abyssal samples examined from the east than in the other three regions, with particularly rich agglutinated faunas at lower abyssal depths on the Hikurangi Plateau (Subassociation C1).

SHELF DEPTHS: We believe that the shallow-water pattern is more robust than the deep-water pattern and clearly reflects the biogeographic pattern of decreasing diversity with increasing latitude and decreasing temperature. Thus at shelf depths within the New Zealand region there are 5 species known to be restricted to the Kermadec Islands (Kermadecian Province) in the far north, 50 to the north (Aupourian), 5 to the west, 1 to the east, and 15 to the south (mostly Antipodean Province).

Table 34. Percentage of the benthic foraminiferal species in our quantitative deep-sea data set with occurrences in various combinations of the north, east, west and south study regions.

a. Deeper than 200 m

	ALL	N	W	E	S
No. Stns	187	40	39	55	53
No. spp.	372	242	161	241	180
Species		65.1	43.3	64.8	48.4
1 Region		12.6	3.2	15.6	8.3
2 Regions:					
W		3.8			
E		6.7	1.9		
S		4.0	0.5	4.0	
3 Regions:					
NEW	7.8				
NWS	2.7				
NES	5.4				
EWS	1.3				
4 Regions	22.0				

b. Shallower than 200 m

	ALL	N	W	E	S
No. Stns	78	36	20	7	15
No. spp.	250	176	140	99	93
Species		70.4	56.0	39.6	37.2
1 Region		20.0	8.8	6.8	7.2
2 Regions:					
W		14.0			
E		2.4	3.6		
S		2.4	2.8	1.6	
3 Regions:					
NEW	7.2				
NWS	7.6				
NES	3.6				
EWS	1.2				
4 Regions	13.2				

c. All depths, 50-5000 m

	ALL	N	W	E	S
No. Stns	265	76	59	62	68
No. spp.	424	293	210	260	217
Species		69.1	49.5	61.3	51.2
1 Region		16.5	4.0	16.3	7.8
2 Regions:					
W		5.2	0.0	0.0	
E		4.5	1.9	0.0	
S		3.3	0.9	3.5	
3 Regions:					
NEW	8.3				
NWS	4.2				
NES	6.4				
EWS	0.9				
4 Regions	24.1				

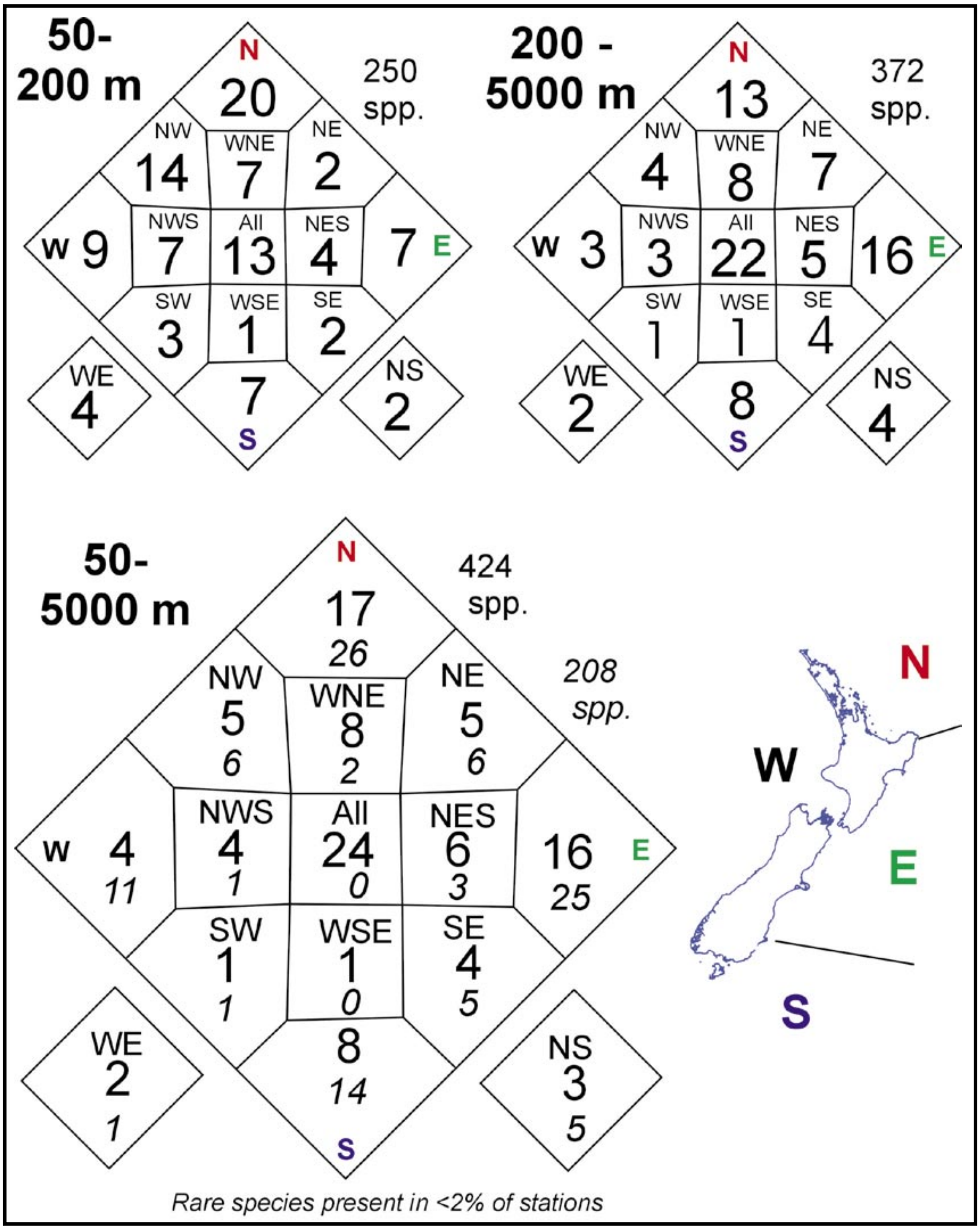


Figure 80. Percentage of the benthic foraminiferal species in our quantitative deep-sea data set with occurrences in various combinations of the north, east, west and south study regions. The lower diagram also includes the percentages of rare species (in italics) in each regional category.

Table 35. List of species that are restricted in their deep-water occurrence (>100 m) to one of the four main geographic regions around New Zealand.

North	East	South	West
Cylindroclavulina bradyi	*Adercotryma glomeratum*	*Ammodiscus mestayeri*	*Hyperammina elongata*
Dorothia rotundata	*Ammobaculites filiformis*	*Cyclammina cancellata*	*Pseudoclavulina serventyi*
Duquepsammia bulbosa	*Ammobaculites microformis*	*Karreriella bradyi*	*Tritaxis challengeri*
Gaudryina quadrangularis	*Ammobaculites paradoxus*	*Lagenammina spiculata*	*Quinqueloculina bicornis*
Hormosina pilulifera	*Ammodiscus gullmarensis*	*Rhizammina algaeformis*	*Grigelis neopyrula*
Nouria polymorphinoides	*Ammodiscus profundissimus*	*Textularia lythostrota*	*Laevidentalina sidebottomi*
Rhabdammina antarctica	*Cribrostomoides crassimargo*	*Patellinoides conica*	*Laryngosigma* cf. *compacta*
Rhabdammina scabra	*Cyclammina pusilla*	*Spirillina denticulogranulata*	*Marginulina striata*
Spirotextularia fistulosa	*Cystammina pauciloculata*	*Spirillina novaezealandiae*	*Pyramidulina pauciloculata*
Textularia candeiana	*Eggerelloides scaber*	*Spirillina vivipara*	*Vaginulina* cf. *inflata*
Textulariella barretti	*Eratidus foliaceus*	*Astacolus crepidulus*	*Bolivina neocompacta*
Massilina granulocostata	*Hormosina globulifera*	*Globulina minuta*	*Bulimina m.* f. *acaenapeza*
Pseudoflintina triquetra	*Hormosinella guttifera*	*Guttulina bartschi*	*Notorotalia hornibrooki*
Pyrgo n.sp.	*Hyperammina cylindrica*	*Guttulina irregularis*	*Planulina aff. subinflata*
Pyrgo clypeata	*Polystomammina nitida*	*Laculatina quadrilatera*	
Quinqueloculina cooki	*Psammophax consociata*	*Laevidentalina guttifera*	
Quinqueloculina boueana	*Psammosphaera fusca*	*Lenticulina orbicularis*	
Quinqueloculina rebeccae	*Recurvoidatus parcus*	*Lenticulina tasmanica*	
Sigmoilopsis finlayi	*Reophax dentaliniformis*	*Vaginulina* cf. *jarvisi*	
Spiroloculina novozelandica	*Reophax nodulosus*	*Vaginulinopsis sublegumen*	
Astacolus neolatus	*Rotaliammina sigmoidea*	*Ehrenbergina aff. crassitrigona*	
Dentalina cuvieri	*Saccammina sphaerica*	*Globocassidulina crassa*	
Grigelis semirugosa	*Spiroplectammina carteri*	*Islandiella* sp.	
Guttulina regina	*Storthosphaera albida*	*Paracassidulina sagamiensis*	
Hemirobulina angistoma	*Trochamminopsis xishaensis*	*Trifarina gracilis*	
Laevidentalina ariena	*Usbekistania charoides*	*Cibicides fumeus*	
Pseudonodosaria brevis	*Nummulopyrgo globulosus*	*Colonimilesia coronata*	
Pseudopolymorphina cf. *australis*	*Amphicoryna separans*	*Notorotalia aucklandica*	
Pyramidulina cf. *doliolaris*	*Dentalina mutsui*	*Planorbulina acervalis*	
Pyrulina fusiformis	*Glandulina sp.*	*Planulina ariminensis*	
Bolivina arta	*Guttulina ovata*		
Bolivina striatula	*Pyrulina gutta*		
Ehrenbergina hystrix	*Vaginulina spinigera*		
Favocassidulina australis	*Bolivina alata*		
Globocassidulina decorata	*Alexanderina viejoensis*		
Globocassidulina elegans	*Baggina* sp.		
Praeglobobulimina spinescens	*Chilostomella oolina*		
Sigmavirgulina tortuosa	*Cibicides deliquatus*		
Trifarina pacifica	*Discorbitina pustulata*		
Ammonia aoteana	*Eoeponidella pulchella*		
Cymbaloporetta bradyi	*Karreria maoria*		
Eponides repandus	*Notorotalia zelandica*		
Glabratella margaritacea	*Subanomalina guadalupensis*		
Hyalinea asiana	*Robertinoides oceanicus*		
Neoconorbina terquemi			
Nonionoides turgida			
Notorotalia olsoni			
Pileolina calcarata			
Pileolina harmeri			
Planulinoides biconcava			
Planulinoides norcotti			
Svartkina australiensis			
Trochulina dimidiatus			
Valvulineria minuta			

PALEOENVIRONMENTAL ASSESSMENTS USING NEW ZEALAND CENOZOIC FORAMINIFERA

Over the last seventy years fossil foraminifera have been widely used in New Zealand for dating sedimentary rock sequences. As foraminifera have become better known and age determinations more refined (Hoskins 1982, Hornibrook *et al.* 1989, Cooper 2004), there have been increasing requests for paleoenvironmental data obtainable from foraminiferal faunas. This data is useful in studies on sedimentology, lithostratigraphy, sequence stratigraphy, paleogeographic reconstructions and tectonic histories of sedimentary basins, paleoclimatology, and paleoceanography. It also assists dating procedures, as the presence/absence of stratigraphically significant taxa in a sample may be due to a favourable/unfavourable paleoenvironment rather than a different age.

One of the main reasons for the present research into New Zealand's deep-sea benthic foraminifera has been to supply information that summarises their present-day environmental distributions, particularly depth ranges, and to identify the main environmental variables that produce these patterns, to assist with paleoenvironmental assessments based on fossil New Zealand faunas, mainly from the Neogene. In this chapter we have attempted to build on Hayward's (1986a) and Hayward *et al*'s (1999) guides, with the addition of more precise data on modern deep-sea distribution patterns around New Zealand.

Variables influencing the environmental distribution of deep-sea foraminifera

A wide variety of interrelated variables influence the activities of foraminifera and their geographic distribution. Previous workers have noted that these include temperature, salinity, substrate type, light intensity, hydrostatic pressure, length of exposure during tidal cycles, current strength, nutrients, carbon flux, biological competition, predation, turbidity, pH and the concentration of O_2, $CaCO_3$ and trace elements (Boltovskoy and Wright 1976). The effects of most of these variables are poorly understood. Fortunately the solutions to most geological problems do not require paleoenvironmental assessments for each of these variables individually.

Our quantitative ecologic studies indicate that at depths exceeding 50 m around New Zealand the main environmental drivers influencing foraminiferal distribution are: character, quantity and seasonality of organic carbon flux to the seafloor (Jz), oxygen concentrations in the bottom and interstitial waters, carbonate corrosiveness of bottom waters, bottom water temperature (at shelf depths), and bottom current strength.

Some of the earlier quantitative studies on deep-sea benthic foraminiferal assemblages interpreted their distribution to be most strongly influenced by the temperature-salinity characteristics of the different deep sea water masses (Schnitker 1994, Murray 1995). In more recent decades this idea has largely been rejected and replaced by the quantity and quality of organic carbon flux to the seafloor as the major driver of deep-sea benthic foraminiferal patterns (Gooday 1993, Thomas & Gooday 1996, van der Zwaan *et al*. 1999). In regions of lower carbon flux (oligotrophic) the degree of oxygenation of the sea floor sediments and bottom water is also recognised as being a strong influence (Rathburn & Corliss 1994, Kaiho 1994, Gupta 1997, van der Zwaan *et al*. 1999).

How far back can modern analogue data be used reliably in paleoenvironmental assessments?

Paleoenvironmental conclusions deduced from fossil foraminiferal faunas based upon our knowledge of modern deep-sea foraminiferal distribution patterns (principle of uniformitarianism) are considered to be largely valid for the Quaternary and Neogene but become progressively more tenuous when extended back through into the Paleogene or Cretaceous (Hornibrook *et al.* 1989, Murray 1991). This is because:

a. Many modern foraminiferal species and genera were present in the Quaternary and Neogene, but fewer than 50% have ranges extending further back in time.

b. Few modern foraminiferal taxa appear to have changed their ecologic requirements and range during the Neogene and Quaternary, but a number of groups have documented changes in ecologic range during the Paleogene. For example the genera *Uvigerina* and *Siphonina* appear to have originated as shallow water inhabitants but migrated into deeper water in the Paleogene (van Morkhoven *et al.* 1986). Fewer genera (e.g., *Elphidium*) appear to have done the reverse, originating in deep water and shifted into shallow water in the Paleogene (Hayward *et al.* 1997c).

c. The vertical structure of modern oceans, with slowly circulating, stratified water masses, is believed to have developed primarily in the late Eocene-Oligocene from a simple "two-layered" ocean of the Cretaceous-Paleocene, as plate tectonic movements progressively subdivided an original single Mesozoic world ocean and the onset of Antarctic glaciation accentuated latitudinal climatic differences. The transition to modern oceanic conditions was complete by about 15 million years ago (Douglas & Woodruff 1981) and paleoenvironmental assessments on deep water faunas older than early middle Miocene are likely to be progressively less reliable.

Many Paleogene and early Neogene taxa (especially species) are extinct. Their paleobathymetric ranges can often be inferred from their consistent occurrences in certain faunal assemblages and geological settings and have been documented in figures 17-22 in Hayward (1986a).

Paleoenvironmental data for geological and paleoceanographic purposes

Geologically, the most useful paleoenvironmental data that can be provided by fossil deep-sea foraminiferal faunas is an estimate of the paleodepth where the sediment in which they are preserved was laid down. For paleoceanographic studies, other potentially useful paleoenvironmental data that can be inferred from fossil deep-sea benthic foraminiferal faunas include: the quantity and seasonality of the organic carbon food flux to the sea floor, oxygen concentrations, corrosiveness of bottom waters, and bottom current strength. Changes through time in paleoproductivity may, for example, be interpreted in terms of increased upwelling of nutrients (e.g., Hayward *et al.* 2004c) or latitudinal migration of more highly productive oceanic fronts between surface water masses (e.g., Nees 1997; Kawagata 1999, 2001), whereas changes in oxygen concentrations or corrosiveness might indicate changes in the depth stratification of the deep water masses (e.g., Hayward *et al.* 2004b, 2005).

Isotope and other geochemical studies using the tests of fossil deep-sea benthic foraminifera can provide moderately accurate estimates of the volume of global ice and past bottom water temperatures, carbon dioxide concentrations, bottom water pH and salinity etc. (Murray 1991, Wefer *et al.* 1999), but here we focus on data that can be derived from the faunal composition.

TAPHONOMIC CHANGES THAT MAY AFFECT PALEOENVIRONMENTAL ASSESSMENTS

Erosion and Reworking

Erosion of older sedimentary rocks sometimes reworks fossil foraminifera into the currently accumulating sediment and fauna (Hayward *et al.* 2002, Hayward & Kawagata 2005). Reworked older foraminifera may be recognised because they are commonly more abraded, infilled or of different preservation and colour than the contemporaneous fauna. From our experience around New Zealand we recognise reworked older foraminifera more commonly in sheltered estuarine and harbour settings, particularly on the east coast of the North Island where soft young sedimentary rocks are rapidly eroding in the feeder catchments. Fortunately reworking and survival of foraminiferal tests into younger sedimentary environments is nowhere near as widespread a problem as it is with some smaller microfossils such as coccoliths, dinoflagellates and palynomorphs.

Winnowing, transport, and faunal mixing

Modern planktic foraminiferal tests are susceptible to far greater transport by currents while they are in suspension than benthic tests. However benthic tests are sometimes subject to winnowing and transport, particularly in high energy environments and particularly with smaller (<0.02 mm), thinner-shelled benthic tests (Murray *et al.* 1982, Reid & Hayward 1997). This needs to be borne in mind when making paleoenvironmental assessments, especially where the fossil fauna appears to be giving conflicting messages.

Transport of live or dead benthic foraminiferal tests can occur in several ways:

a. Large volumes of unconsolidated seafloor sediment may slump or flow (e.g., turbidity currents, debris flows) downslope, displacing entire faunas into much deeper environments. The faunas may be preserved unmixed within a thick deposit of the displaced sediment or may be mixed with other faunas incorporated into the flow from the seafloor as it moved downslope (e.g., Hayward & Buzas 1979).

b. In most situations bottom currents are too weak to lift even small foraminiferal tests into suspension (winnow) and transport them away. Exceptions are in shallow areas with large waves, strong tidal flow or long-shore drift (e.g., Cook Strait, west coast North Island, Vella 1957), in submarine canyons (e.g., Bounty canyon, Hayward *et al.* 2004c), on submarine rises in deep water (e.g., edge of Campbell Plateau, Hayward *et al.* 2007b), or beneath areas of strong upwelling (e.g., off South Island's West Coast, Foster & Battaerd 1985) where strong ocean currents sweep the seafloor (Murray 1991).

Foraminiferal tests generally have a lower specific gravity (0.3-2) than most other bioclasts (2.4-8) on the seafloor (Jell *et al.* 1965) and thus smaller foraminiferal tests (mostly <0.2 mm) may be winnowed out of an in-situ fauna by strong currents and storm waves and can be carried considerable distances before falling out of suspension. These smaller tests in the suspended load may be displaced along slope or into deeper, shallower or even brackish environments dependent on the current movement (Sturrock *et al.* 1982). Many estuaries, quiet tidal inlets and harbours or quieter deep-water regions are the sites of deposition of suspended-load foraminifera which have been carried in from the exposed inner shelf and sink to the bottom in these low energy environments (Wang & Murray 1983, Hayward *et al.* 1994). Recent studies indicates that this form of transport in suspension of proloculi or small, few-chambered juveniles may be the main form of dispersal of live benthic foraminifera (Alve & Goldstein 2002, 2003).

Current displacement, like that described above, may be difficult to recognise in fossil faunas. Clues to possible current displacements may be found in distinct bimodal distribution of test sizes, in distinctly different preservation of different test sizes (e.g., badly abraded larger tests) and in completely different faunal compositions between the large and small test sizes (e.g., Port Perseverance, Campbell Island, Hayward *et al.* 2007c). Winnowing may be recognised in source faunas being composed almost entirely of larger tests.

Bioturbation

Faunas can be extensively mixed by bioturbation within the surface sediments on the sea floor (Murray 1991). For paleoenvironmental analyses this mixing is usually not important unless there have been significant changes in the environment and faunal composition during the period represented by the upper 20 cm or so of sediment.

Disaggregation of agglutinated tests

Most organo- or ferro-cemented agglutinated tests (Banner *et al*. 1991) are usually lost soon after their death through bacterial breakdown of their cement. This is particularly the case for many deep-sea benthic species of agglutinated foraminifera (Loubere & Gary 1990, Loubere *et al.* 1993, Goldstein *et al.* 1995, Ozarko *et al.* 1997, Hayward *et al*. 2001). More resilient calcareous-cemented agglutinated tests usually survive and become fossilised (Banner *et al*. 1991).

Our studies from around New Zealand, show that at depths shallower than 3000 m, most agglutinated taxa are resilient calc-agglutinated species (e.g., Banner *et al.* 1991) that are not lost during early burial.

To investigate the extent of post-mortem loss of agglutinated tests of deeper-water species we undertook census counts of the total benthic foraminiferal faunas in samples from the top 1.2 m in three cores at mid and lower abyssal depths (3000-4000 m), east of central New Zealand (Hayward *et al*. 2001). Our results showed no discernible loss of any calcareous taxa with depth of burial. The relative abundance of agglutinated tests ranged between 8 and 60% in surface sediments and dropped away to 1-2% at a burial depth of 1.2 m (Fig. 81). There was no significant decrease in relative abundance of agglutinated forms in the upper 0.1 m of cores, with the most dramatic taphonomic loss occurring between 0.1 and 0.2 m burial depth. Taphonomic loss of many organo- and ferro-agglutinated tests (e.g., Banner *et al*. 1991) between 0.05 and 0.2 m below the surface has been noted elsewhere by a number of workers (e.g., Schnitker 1980, Fenner *et al*. 1992) and attributed to the dissolution of their organic or iron oxide cement (e.g., De Stigter 1996).

Members of all four orders of agglutinated taxa suffered taphonomic loss with shallow burial, with taxa within the Order Textulariida (e.g., *Dorothia, Eggerella, Martinottiella, Siphotextularia, Spiroplectinella,* and *Textularia*) being the most resistant. Agglutinated species that appear to be largely resistant to taphonomic loss with shallow burial in deep-sea sediments above the CCD are those with calcareous cement and are listed in Table 36.

Thus, data on the relative abundance of modern deep-sea benthic foraminifera that includes significant numbers of organo- and ferro-cemented agglutinated taxa need to be adjusted for taphonomic loss by removing their census counts before the data is used for comparison in paleoenvironmental assessments of fossil faunas.

It should also be noted that some additional agglutinated foraminiferal tests may be present in deep-water sediment samples that have never been dried out (Hayward

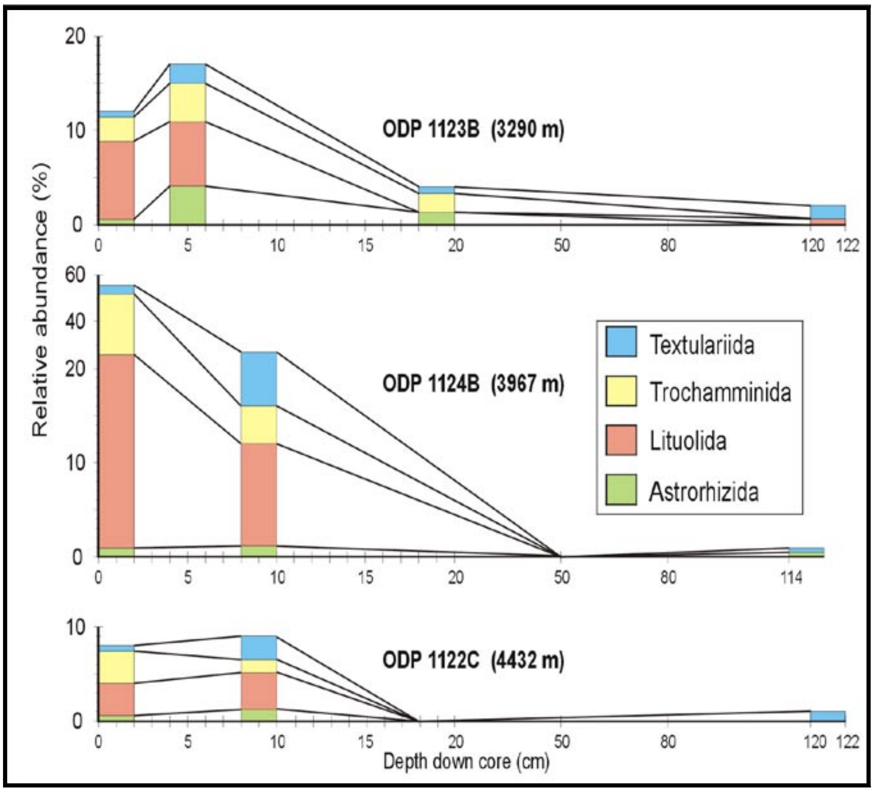


Figure 81. Graphs showing decline in the relative abundance of tests in the four main orders of agglutinated foraminifera due to post-mortem disaggregation with shallow burial in the top of four abyssal cores from east of central New Zealand (modified from Hayward *et al.* 2001).

Table 36. Resilient agglutinated, deep-sea genera that survive post-mortem disaggregation during shallow burial (>0.5 m) and may become fossils.

Astrorhizida	*Bathysiphon* (partial loss)
	Hyperammina (partial loss)
	Lagenammina (partial loss)
Lituolida	*Adercotryma* (partial loss)
	Ammobaculites (partial loss)
	Ammodiscus (partial loss)
	Cyclammina (partial loss)
	Spiroplectinella
	Usbekistania
Trochamminida	*Trochammina* (partial loss)
Textulariida	*Dorothia*
	Eggerella
	Karreriella
	Martinottiella
	Siphotextularia
	Textularia

et al. 2001). We have noted the loss of the tests of several chitinous species (e.g., *Hippocrepinella alba*) that shrivelled up and were unrecognisable once dried. Several additional agglutinated species with loosely cemented tests (unidentified spherical and trochospiral taxa) survived the drying process, but disintegrated into constituent grains when touched with a wet brush during picking. Species lost during processing have the thinnest and most fragile tests and in nature would usually be lost early in their post-mortem burial history. All our modern faunal census counts were made from dried sediment samples, so that comparison with dried fossil faunas is not complicated by this aspect of taphonomic loss.

Abrasion, dissolution, diagenesis and weathering

A number of other taphonomic processes may have selectively altered the taxonomic composition of a fossil foraminiferal fauna and thus impact on the paleoenvironmental assessment of it. These include:

a. Loss of fragile tests (especially some weakly cemented agglutinated species) that may occur in surface sediment through abrasion in high energy environments, especially along exposed beaches and coastlines.

b. Dissolution of calcareous tests on or in the surface sediment, especially in deep water below the lysocline (Douglas & Woodruff 1981) or in more acidic freshwater in brackish estuaries (e.g., Debenay & Guiral 2006, Hayward *et al*. 2006a) or in organic-rich anoxic sediment in salt marshes (Murray 1991, Alve & Murray 1994, Goldstein *et al.* 1995). Some calcareous species are more susceptible to dissolution than others (Corliss & Honjo 1981) and thus partial dissolution can considerably alter the faunal composition.

c. Diagenetic changes long after burial and within the sedimentary rock often results in selective dissolution of aragonitic tests (Robertinina) and sometimes dissolution of all calcareous tests, leaving just the sparse agglutinated elements (Textulariina) of the fauna.

d. Weathering may produce similar changes to diagenesis. Usually the aragonitic tests are first to disappear, followed by the porcellaneous tests (Miliolina) and then the thin-shelled calcareous perforate and finally the thicker-shelled calcareous tests.

Loss of most or all of the calcareous tests through dissolution, diagenesis or weathering is usually easy to determine; sometimes mudstone or pyrite casts are still preserved. Selective dissolution of aragonitic and porcellaneous tests is more difficult to determine, but paleoenvironmental assessments may only be affected if the faunas originally contained abundant Miliolina (inner-mid shelf depths in normal marine salinity).

The loss of all or part of a fossil fauna through surface weathering can usually be negated by excavations to obtain a fresh sedimentary rock sample.

Paleogeographic value of recognised post-mortem changes

Endeavours to recognise post-mortem faunal changes are primarily undertaken so that introduced elements can be removed from the paleoenvironmental analysis or partial faunas that have lost elements can be recognised. Recognition of the kind of post-mortem change that has occurred can provide additional information of value in paleogeographic reconstructions and other geological applications.

For example:

a) Recognition of tests reworked from older rocks provides valuable information on sediment provenance and may also suggest which areas were uplifted as land at the time. These reworked foraminifera are sometimes the only evidence of the former presence of sedimentary rocks of a certain age in the area, prior to their complete removal by erosion. Reworked foraminifera frequently occur in estuarine deposits and provide clues to the rock types eroding in the catchment (Hollis *et al.* 1995) or in fossil examples can indicate the area of the ancient catchment.

b) Recognition of shallow-water faunas in subaqueous mass flow deposits in deep-water sequences provides evidence of a paleoslope and shallow-water nearby, which together with information about the sediment type and sedimentary flow directions helps reconstruct the paleogeography (e.g., Hayward & Buzas 1979).

c) Recognition of individual tests of shallow-water taxa in deep-water faunas may also provide evidence for the shallow-water provenance of some or all of the associated lithic sediment as in lower abyssal sediment in the deep-water Bounty Fan (Hayward *et al*. 2004c).

WATER DEPTH ASSESSMENTS

Depth in itself does not affect the distribution of foraminifera, but the present study, and many others, have shown that variables related to depth (e.g., food flux, oxygen concentrations, water temperature) are among the strongest influences on foraminiferal distribution and thus foraminiferal faunas usually show a depth-related zonation that can be used to infer paleodepths. Food supply to the sea floor is one of the strongest influences on benthic foraminiferal faunas and the quantity reaching the seafloor decreases with increasing depth as organisms in the water column extract their share as the particles sink. Since phytoplankton productivity, which is the primary source of this food flux, varies geographically so too do the absolute-depth distributions of the foraminiferal faunas (e.g., De Rijk *et al.* 2000). Thus in absolute terms the foraminiferal depth stratification is not constant geographically nor through time and thus it is difficult to give precise depth ranges for particular taxa or faunas, especially the further one goes back in the fossil record (Paleogene). Detailed study of defined time periods within a region (eg. Hayward & Buzas 1979, King *et al.* 1993) often results in an understanding of the local faunal depth stratifications, which can then be approximately equated with actual depths, using such data as the known wider depth ranges of their modern descendants. This is the method most commonly employed to infer most of the paleoenvironmental ranges of extinct taxa presented in Hayward (1986a).

Accuracy of paleodepth and sea level height assessments

Most variables influencing the distribution of foraminifera undergo more rapid changes with increasing depth in the uppermost 100 m of the ocean. Foraminiferal faunas at inner and mid shelf depths (<100 m) are therefore generally more stratified and distinctive than those from greater depths, resulting in fairly accurate (+/- 10-20 m) paleodepth assessments in the shallowest (0-50 m) environments. The rate of change of influencing variables usually decreases with depth so that assessments of outer shelf and upper bathyal paleodepths (100-600 m) have intermediate accuracy limits (+/- 100-200 m), and assessments of mid bathyal or deeper (>600 m) have large accuracy limits (+/- 200-1000 m+).

Planktic percentage

If our data is to be used, then the planktic percentage of the total foraminiferal fauna should be determined from the entire sand fraction of a sample (>0.0625 mm or 240 mesh).

Planktic foraminifera live most abundantly in the upper 0-400 m of oceanic water (Bé 1977). Most do not thrive in more turbid, neritic water nor live in brackish water. As a result, faunas that accumulate on the floor of the oceans (above the CCD) beneath oceanic water have abundant planktic foraminifera (c.90-99.9% planktics) and those that accumulate beneath neritic water have few (c.0-30% planktics). In general, there is a broad intermediate zone passing from neritic to oceanic water through which the planktic percentage steadily increases.

Neritic water is usually confined to a narrow belt around large land masses with significant riverine runoff or to enclosed waters cut off from oceanic circulation. Thus planktic percentage can be successfully used to indicate whether the site was beneath open water, near to land or enclosed (i.e., its degree of oceanicity).

Increasing planktic percentage usually correlates well with increasing distance from land (Fig. 13), and since water depth usually also increases in this direction, it follows that planktic percentage usually increases with increasing water depth. Thus the planktic percentage of a sample is often a very simple method for indicating likely paleodepth. It is not infallible and needs to be checked against the benthic faunal interpretation. Certain conditions can produce anomalously high or low planktic percentages: strong, persistent onshore winds and currents can substantially increase the planktic percentage in inshore locations (Hayward 1986b, Hayward *et al.* 1994); deep, enclosed basins nearshore may be sheltered from most oceanic water and have reduced planktic percentages for the actual bathyal depths (e.g.Tongaporutuan of inshore west Taranaki, Hayward *et al.* 1986c).

Using our census data on benthic and planktic foraminifera in normal marine salinity samples at depths from 0 to 5000 m all around New Zealand (this study and Hayward *et al.* 1999) we have constructed a plot of planktic percentage versus depth (Fig. 82). The shaded zone indicates where 95% of all faunas lie and this zone can be used to read off the likely range of depths of accumulation for a fauna with a given planktic percentage (Fig. 82). For samples that have accumulated at depths shallower than foraminiferal lysocline (~3600 m) we have computed an exponential equation ($r^2 = 0.83$) that can be used to provide an estimated average paleodepth for any given planktic percentage.

In general a fauna with less than 25% planktics likely accumulated at inner to mid shelf depths (0-100 m), less than 50% at shelf depths (0-200 m), with 50-90% at bathyal depths (200-2000 m), and >90% at mid bathyal to mid abyssal (600-4000 m). Below the foraminiferal lysocline (>3600 m) planktic percentage starts to decrease because of selective dissolution of planktic tests in preference to infaunal benthics (Fig. 82).

Composition by orders

In lieu of a complete census, the foraminifera can be sorted into their orders and counted and this may provide an indication of their depth of accumulation. The number of specimens in the rarest orders (e.g., Spirillinida, Carterinida and Robertinida) is so low that they can be ignored. We also combine the counts in all four orders of agglutinated foraminifera to obtain meaningful trends. The plots of the percentage compositions in all (444 samples) our quantitative deep-sea and normal-marine salinity shallow (Hayward *et al.* 1999) faunas of the orders Miliolida, Lagenida, Buliminida, Rotaliida and agglutinated shells (Figs 83-84) indicate that it is

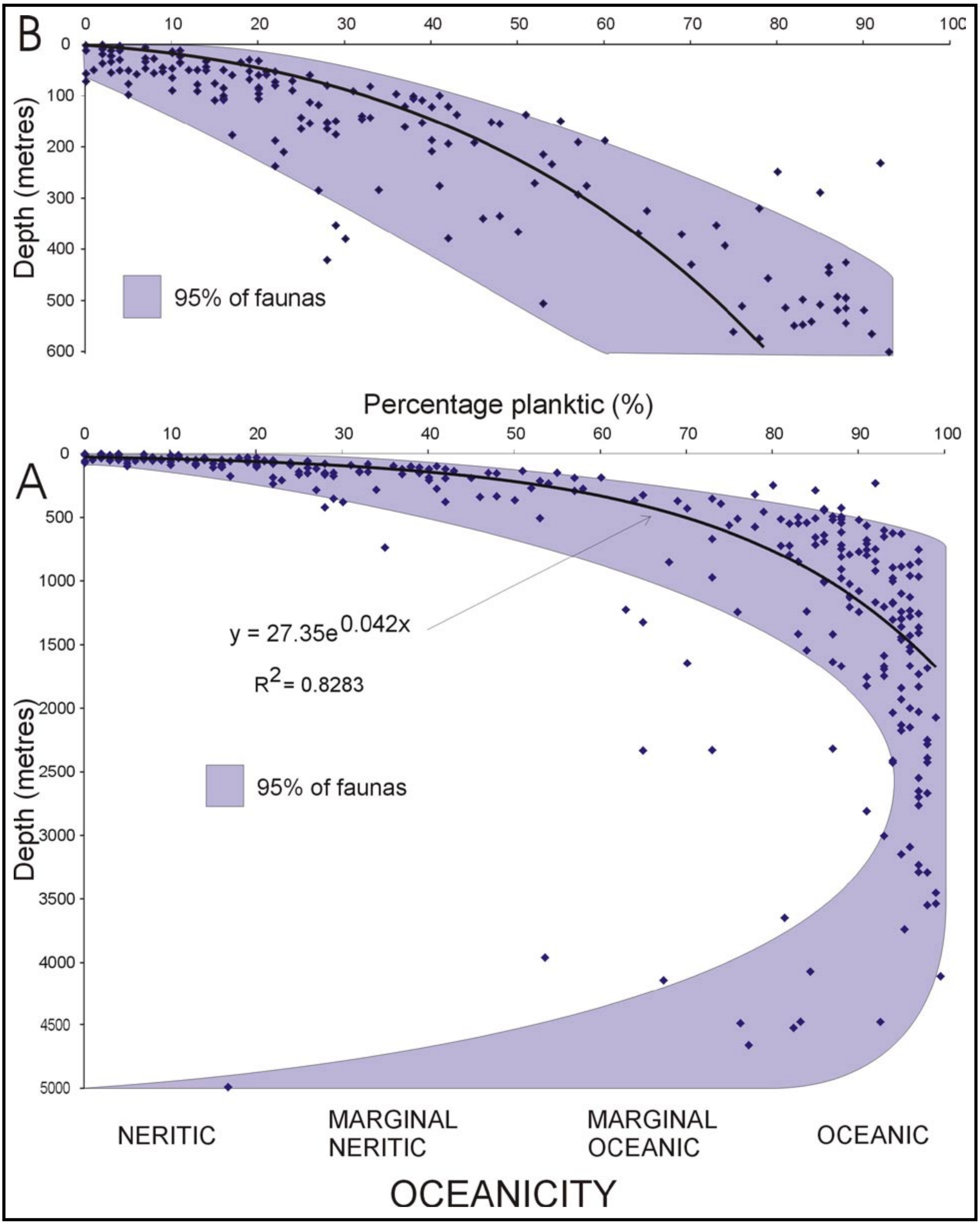


Figure 82. Planktic percent plotted against depth for the whole New Zealand region, based on our deep-sea samples (this study) and those from 0-50 m in normal marine salinity environments in our shallow-water study (Haywared *et al.* 1999). The shaded zone shows the region where 95% of samples plot. The exponential equation can be used to calculate an average water depth for any given planktic percentage for samples above the lysocline (<3600 m). Upper: Plot at shelf and upper bathyal depths for easier reading.

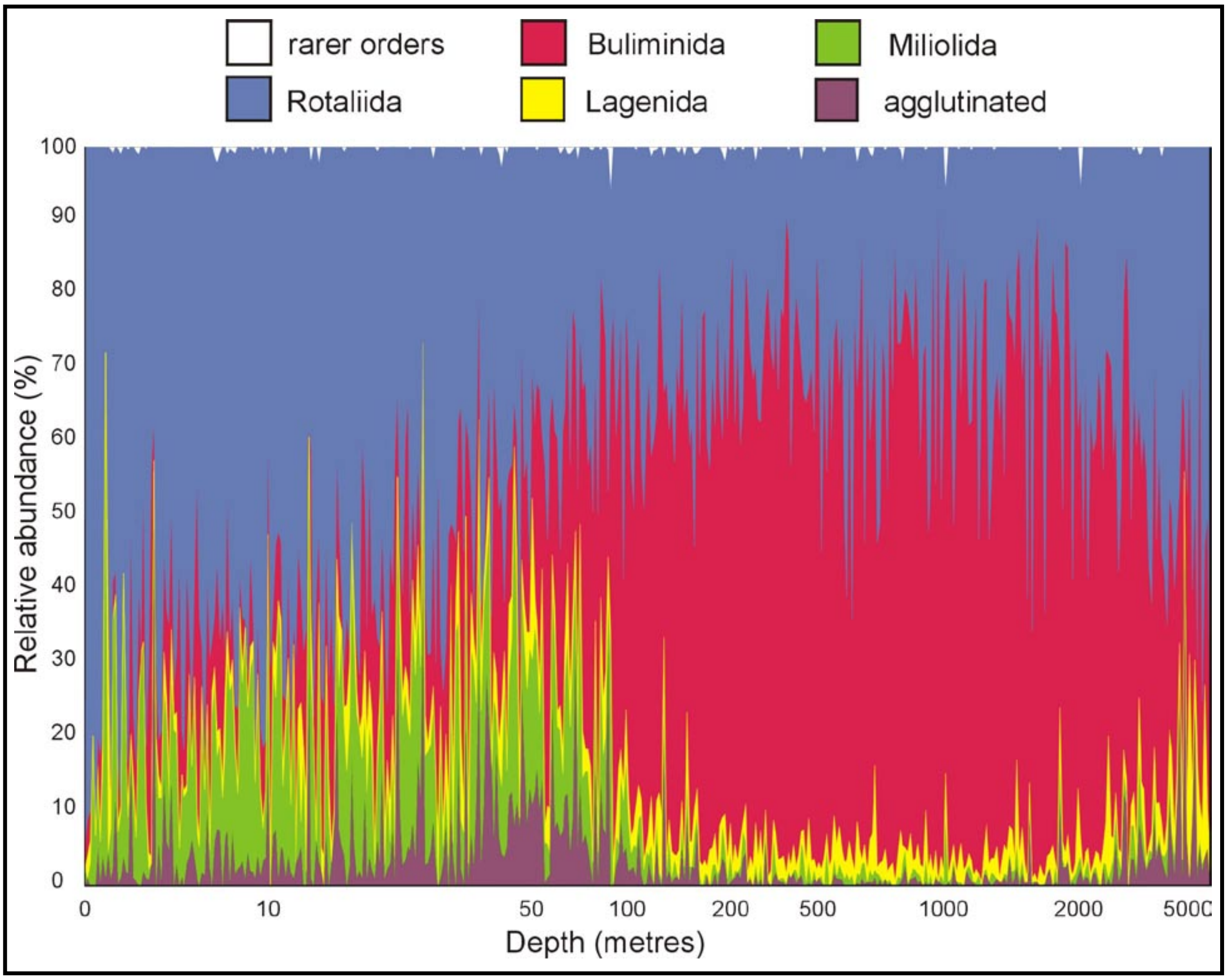


Figure 83. Benthic foraminiferal faunal composition by percentage of the major orders plotted against depth for the full quantitative data set for deep samples (Appendix III) plus the quantitative data set for shallow-water, normal marine-salinity samples (Appendix IV in Hayward *et al.* 1999).

sometimes possible to get an indication of the paleodepth. This method is unlikely however to be of much value in discriminating between the majority of faunas that live in normal marine conditions at outer shelf to abyssal depths.

Faunas dominated (50-100%) by agglutinated forms occur in brackish water, salt marshes or below the CCD (Murray 1973, 1991). Our plot does not extend into brackish, intertidal or hadal environments to show this. Our data (Fig. 84) shows minimum abundances (<3%) of agglutinated taxa at upper to mid bathyal depths (200-1000 m) and two secondary peaks of maximal abundance (up to 30-40%) at mid shelf depths (50-100 m) and at mid-lower abyssal depths (>3500 m). As a quick guide, faunas with >3% agglutinated specimens are either shallower than 200 m (shelf depths) or deeper than 3000 m (mid abyssal to hadal).

Faunas from deeper than 100 m have a maximum of 10% Miliolida (porcellaneous tests) and predominantly have fewer than 6%. While faunas at inner and mid shelf depths (0-100 m) range between 0 and 50% Miliolida, faunas with >20% all occur between 0-70 m. Useful trends in the percentage abundance of Lagenida are hard to see (Fig. 84). Most faunas have fewer than 10% Lagenida, with a zone of low maximal abundance (<5%) in the upper bathyal (200-600 m). There is a higher percentage of faunas with >10% Lagenida at abyssal depths (>2000 m).

Around New Zealand the relative abundance of Buliminida has considerable potential as a guide to water depth. Shallow inner shelf faunas (0-20 m) generally have fewer than 30% Buliminida, whereas faunas between 70 and 3000 m depth all have >30% Buliminida (mostly 50-90%). Most mid-lower abyssal faunas (deeper than 3000 m) have 10-50 %. These abundances reflect the dominance of *Cassidulina carinata* in association with species of *Bulimina*, *Bolivina* and *Uvigerina.*

Rotaliida generally has an inverse pattern of relative abundance to the Buliminida. All inner shelf faunas (0-50 m) have >30% Rotaliida, up to a maximal 100% at intertidal depths (*Ammonia* spp., *Elphidium* spp.). A zone of minimum Rotaliida (10-45%) occurs at outer shelf to upper bathyal depths (Fig. 84).

Composition by genera and species

The generic and specific composition of the benthic fauna is the most precise method available for paleoenvironmental interpretation using foraminifera. The bathymetric and ecologic ranges of present-day genera or species are now moderately well known around New Zealand (Hayward *et al.* 1999, this study). The combined modern ranges for individual taxa should be used to infer a paleodepth range for a fossil fauna. It seems that only a few genera or species have drastically changed their preferred environments through time and most of these changes occurred in the Paleogene (e.g., Hayward *et al.* 1997c). An assessment based on the total fauna, especially on the dominants plus a few depth-specific indicator species, usually overcomes this problem and produces the most reliable results.

DEPTH RANGES OF BENTHIC FORAMINIFERAL ASSOCIATIONS: Recognition of the association of dominant species or genera in a fossil fauna may be one of the most reliable indicators of paleodepth and paleoenvironmental conditions. We have constructed a simplified table of common associations of dominant benthic foraminifera around New Zealand (Table 37), based on the results of the present deep-sea study and our earlier shallow-water study (Hayward *et al.* 1999).

DEPTH RANGES OF BENTHIC FORAMINIFERAL GENERA AND SPECIES: The recorded relative abundances plotted against depth for the more common species in the present study of deep-sea benthic foraminifera are presented in Fig. 85. These data has been combined with the results of our brackish and shallow-water studies (Hayward *et al.* 1999) to produce a set of kite diagrams that summarise the modern New Zealand depth-range distributions and patterns of maximum abundance of most of the common genera and species of benthic foraminifera (Figs 86-87).

Using these figures it should be relatively easy to distinguish brackish, inner shelf, mid, outer shelf to upper bathyal, bathyal-abyssal faunas. The greatest difficulties arise in determining more precise paleodepths within the 200-5000 m bathyal and abyssal range, as many taxa exist throughout this range. It is possible to improve the precision at these depths by using the upper depth limits that have been determined for some more common deep-water-restricted species (see below).

UPPER DEPTH LIMITS OF SOME BENTHIC FORAMINIFERAL GENERA AND SPECIES: Bathyal and to a lesser extent abyssal paleodepth determinations for New Zealand Neogene benthic foraminiferal faunas can be improved by applying the upper depth limits of a number of species to the fossil faunal composition (e.g., Hayward 2004).

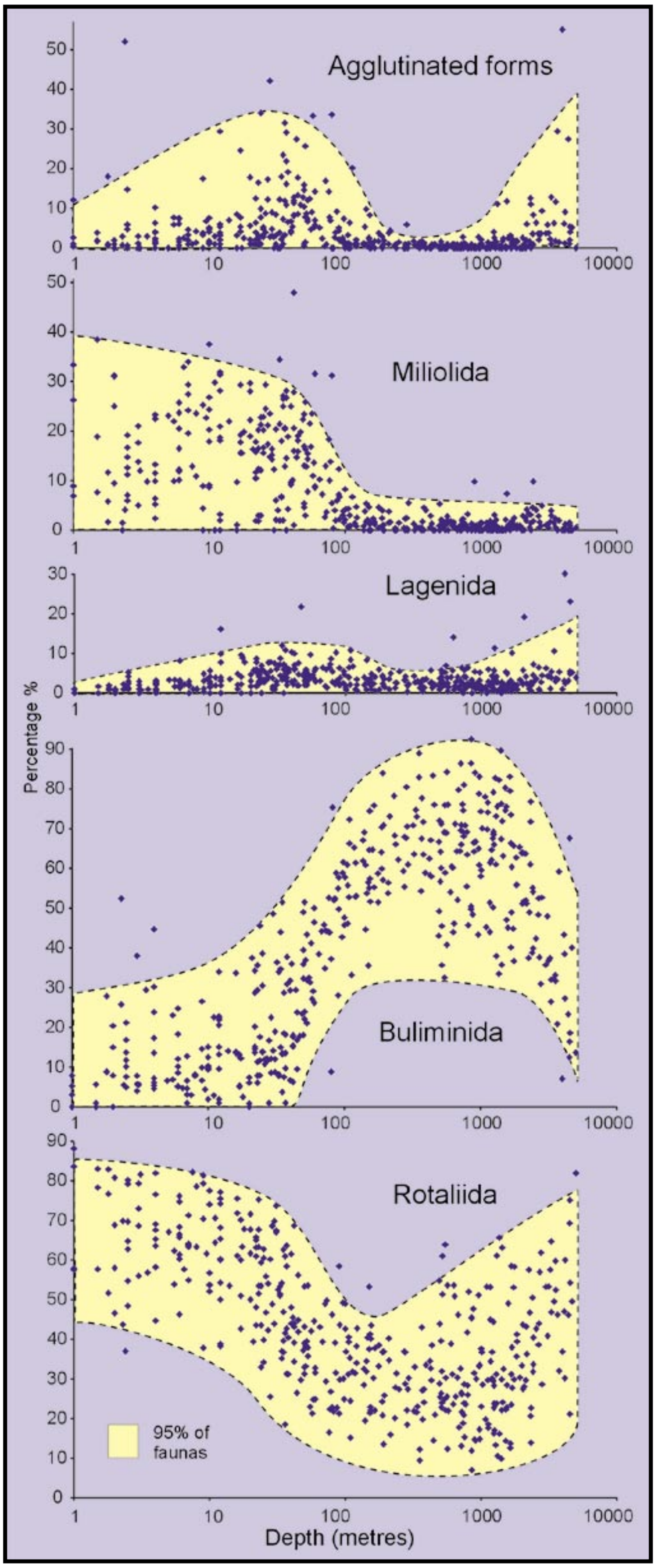


Figure 84. Benthic foraminiferal faunal composition by percentage of the major orders plotted against depth (logarithmic scale) for the full quantitative data set for deep samples (Appendix III) plus the quantitative data set for shallow-water, normal marine samples (Appendix IV in Hayward *et al.* 1999). 95% of all study faunas fall within the yellow shaded areas.

Table 37. Common Recent benthic foraminiferal associations recognised in the New Zealand region and their depth range and other environmental characteristics. Association codes are from this study (A1-G9) and Hayward *et al.* (1999, p.64, alphabetic).

Dominant taxa	New Zealand depth range	Other environmental characteristics	Associations
Trochamminita salsa	EHWS-2	Lowest salinity brackish	Tr
Trochammina inflata - Jadammina	EHWS-EHW	Slightly brackish salt marsh	J, Tn
Haplophragmoides wilberti - Miliammina	MHWS-MHW	Brackish salt marsh or mangroves	H
Miliammina - Ammonia	MHW-3 m	Brackish salt marsh, mangroves, mudflats	M, AM
Ammonia	MHW-10 m	Slightly brackish-marine salinity, unvegetated, sheltered	A
Elphidium excavatum	MHW-MLW	Slightly brackish-marine salinity, unvegetated, sheltered	Ec, Ew
Elphidium charlottensis	MSL-15 m	Moderately sheltered beach or bay	Ech
Rosalina bradyi - Rosalina irregularis	0-10 m	Moderately sheltered, subtidal rocky coast	R
Elphidium advenum – Haynesina depressula	0-20 m	Moderately sheltered bays or harbour entrances	Ea, HE
Zeaflorilus parri	0-25 m	Exposed clean sandy inner shelf	Z
Planoglabratella - Pileolina harmeri	2-10 m	Strong current-swept gravel or coarse sand channels	PP
Notorotalia - Quinqueloculina - Elphidium novozealandicum	2-30 m	Moderately sheltered bays, inlets, harbours	NE, Nf
Cibicides dispars - Gaudryina – Trochulina - Quinqueloculina	2-40 m	Current-swept, exposed clean sand or gravel	Cd, G
Patellinella inconspicua - Quinqueloculina	10-50 m	Moderately exposed clean coarse sand	PQ
Nonionellina flemingi	15-150 m	Quiet, muddy habitat, lower oxic to suboxic	NE, Nf
Bulimina m. f. marginata - Gavelinopsis praegeri - Cassidulina carinata	20-300 m	Quiet muddy environment	G1-3, G5-6, B
Trifarina angulosa - Cassidulina carinata - Cibicides dispars	30-400 m	Moderate to strong bottom currents, oxic	F1-3, Tf
Eilohedra - Gavelinopsis praegeri	50-100 m	Moderately sheltered, beneath neritic water	G4
Cibicides dispars - B. m. f. marginata - Cassidulina carinata	50-400 m	Moderately current swept, high food supply	G8, G9
Bolivina robusta - Globocassidulina canalisuturata	250-700 m	Moderately current-swept, moderate food supply	D2, E1-2, G7
Abditodentrix - Alabaminella - C. carinata	500-2000 m	High carbon flux	D3, D4, D8
Cassidulina carinata - Alabaminella	600-1700 m	High labile carbon flux >2.5-3 g C m-2 yr-1	D5, D7
Bulimina truncana - Cassiculina carinata	1000-1500 m	High sustained carbon flux, OMZ	D1
Trifarina angulosa - Ehrenbergina glabra	1000-2000 m	Strong bottom currents, oxic	B
Bulimina marginata f. aculeata - Alabaminella	1000-4000 m	High labile carbon flux >2.5-3 g C m-2 yr-1, lower oxic	C3, C4
Epistominella exigua - Alabaminella	1000-4500 m	Strongly seasonal carbon flux	C2, C5-7
Cassidulina reniforme - Alabaminella	2000-3000 m	Moderately high sustained carbon flux	C1
Nuttallides umbonifera - Globocassidulina subglobosa	3500-5000 m	Corrossive bottom water, oxic, oligotrophic	A1
Diverse agglutinated fauna - deep-water taxa	>4500 m	Corrosive bottom water, below CCD	A2

These upper depth limits (Table 38) have been determined by three methods:

a. From our present studies of modern foraminiferal depth ranges around all of New Zealand (Table 39).

b. From hydrocarbon exploration well studies (e.g., Scott 1985), that have determined a consistent ordering of the uppermost stratigraphic occurrences (upper paleodepth limits) of a number of deep-water benthic species in the Neogene regressive sequence of western Taranaki Basin. These upper paleodepth limits for each species have been calibrated against the amplitude of the 800-1000 m thick late Miocene and Pliocene Giant Foresets, minus compaction and loading effects (Hayward 1986a, 1990a, Crundwell *et al.* 1994).

c. From studies through the Pliocene-Pleistocene in 22 Ocean Drilling Program cores from bathyal and upper abyssal depths around the globe from which we can derive the approximate global upper depth limits of a number of elongate, cylindrical, biserial (Pleurostomellidae) and uniserial (Stilostomellidae, Nodosariidae) species that became extinct during the mid-Pleistocene Climate Transition (Hayward *et al.* 2007d).

As noted elsewhere in this study, the precise depth ranges of many bathyal and abyssal taxa appear to be influenced by the amount of labile carbon flux reaching the seafloor (e.g., De Rijk *et al.* 2000), and thus may vary between regions and particularly through time and through the late Neogene climate cycles. The bathymetric ordering of these upper depth limits is less likely to vary however. Some variation between regions is evident in the modern upper depth limits of species around New Zealand (Table 39) and in the overall bathymetric ranges of many species (see charts in taxonomic section later). These variations are not generally consistent between species and imply that differences in the flux around New Zealand today are insufficient to have major consistent impacts on bathymetric ranges.

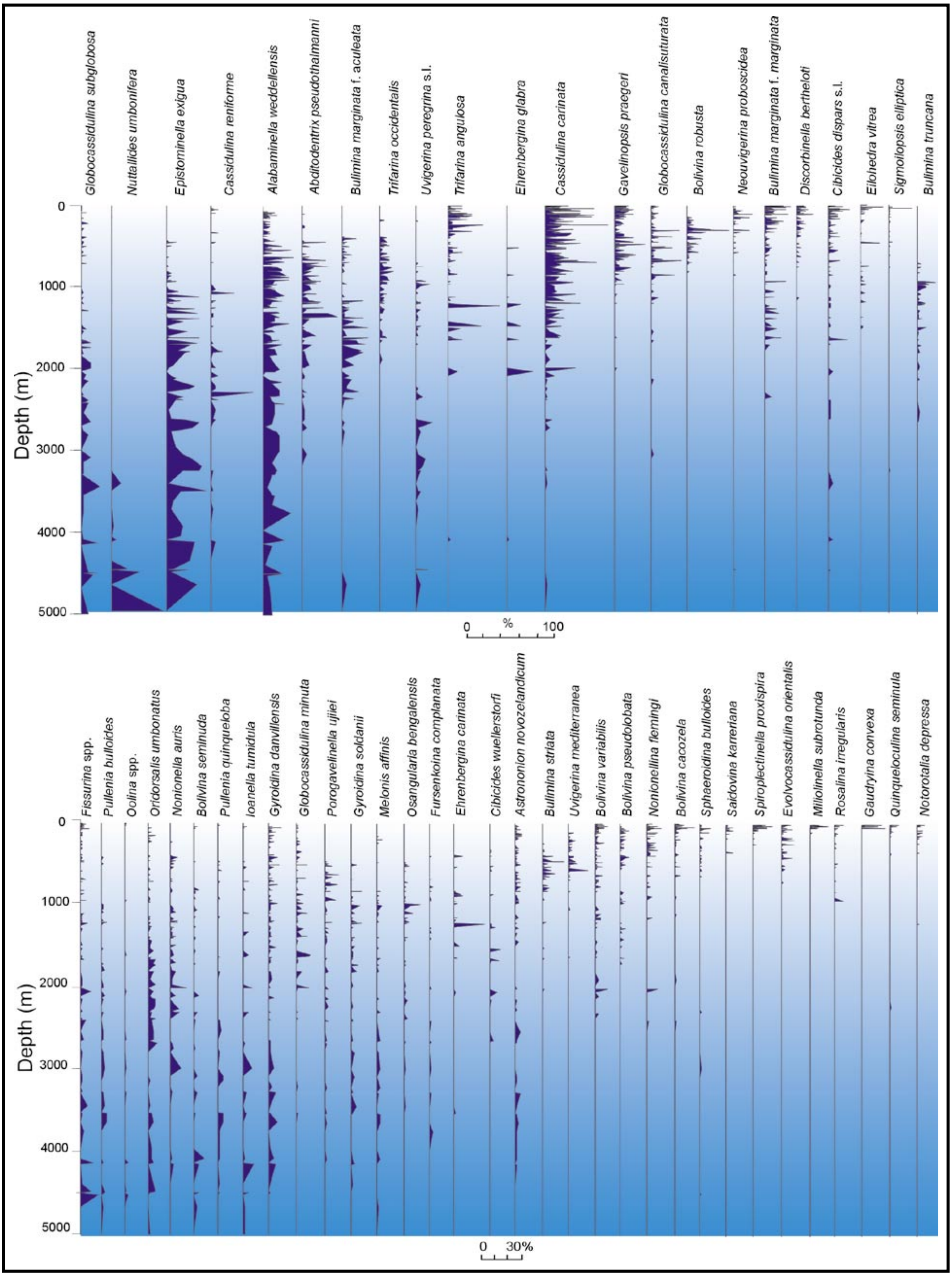


Figure 85. Recorded abundances of the more common deep-sea benthic foraminifera around New Zealand today plotted against water depth, based on the present study.

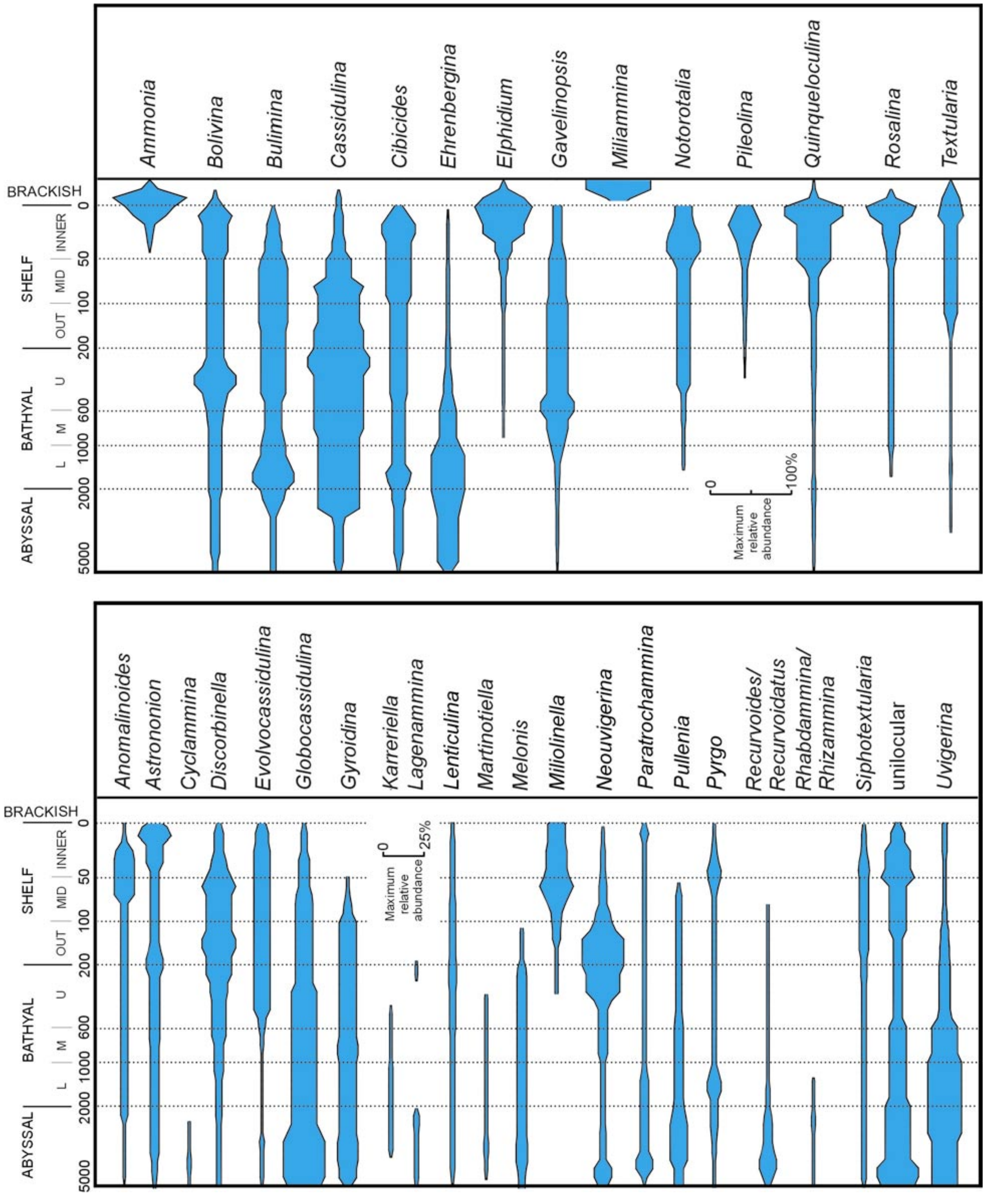


Figure 86. Schematic kite diagrams summarising the modern depth distribution around New Zealand of maximum relative abundance and depth ranges of many of the more common genera of benthic foraminifera. Based on the results of the present study of deep-sea foraminifera and previous studies of shallow-water foraminifera (Hayward *et al*. 1999). Note that the relative abundances shown are the maximum values observed for that depth range and in many faunas the observed abundances will be less.

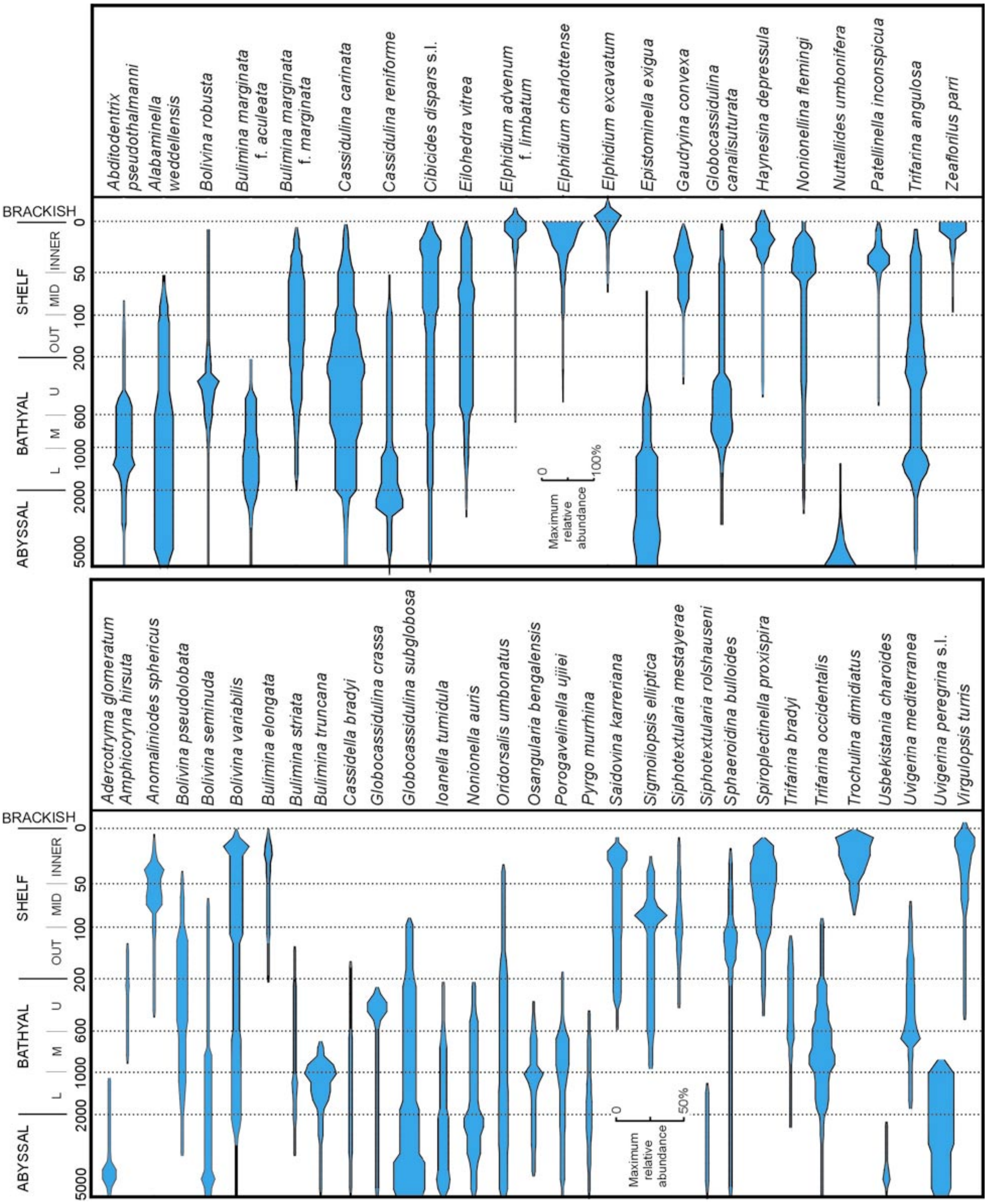


Figure 87. Schematic kite diagrams summarising the modern depth distribution around New Zealand of maximum relative abundance and depth ranges of many of the more common and bathymetrically-diagnostic species of benthic foraminifera. Based on the results of the present study of deep-sea foraminifera and previous studies of shallow-water foraminifera (Hayward *et al.* 1999). Note that the relative abundances shown are the maximum values observed for that depth range and in many faunas the observed abundances will be less.

Table 38. Summary of upper depth limits of key benthic foraminifera, potentially useful for improving paleodepth assessments of New Zealand Neogene faunas. Derived from a combination of modern upper depth limits (Table 39) and those determined from studies in the late Neogene regressive sequence in west Taranaki Basin (Scott 1985, Hayward 1986a, 1990, Crundwell *et al.* 1994).

Bolivina seminuda	100 ± 20 m	modern range
Hoeglundina elegans	100 ± 20 m	modern range
Bulimina striata	120 ± 20 m	modern range
Epistominella exigua	120 ± 20 m	modern range
Laticarinina altocamerata	150 ± 30 m	modern range
Trifarina bradyi	150 ± 30 m	modern range
Gyroidina soldanii	200 ± 50 m	modern range
Rutherfordoides	200 ± 50 m	modern range
Globocassidulina subglobosa	250 ± 80 m	modern range
Bolivinita quadrilatera	300 ± 100 m	modern range
Cibicides neoperforatus	300 ± 100 m	Neogene range
Cibicides wuellerstorfi	300 ± 100 m	modern range
Fursenkoina complanata	300 ± 100 m	modern range
Karreriella cylindrica	300 ± 100 m	Neogene range
Melonis affinis/barleeanus	400 ± 100 m	modern & Neogene range
Nonionella auris	400 ± 100 m	modern range
Porogavelinella	400 ± 100 m	modern range
Martinotiella	500 ± 100 m	modern range
Orthomorphina/Glandulonodosaria	500 ± 100 m	global Pleistocene range
Osangularia	500 ± 100 m	modern range
Pleurostomella	500 ± 100 m	global Pleistocene range
Pyrgo murrhina	500 ± 100 m	modern range
Siphonodosaria	500 ± 100 m	global Pleistocene range
Awhea	600 ± 150 m	global Pleistocene range
Bulimina truncana	600 ± 150 m	modern range
Ellipsoglandulina	600 ± 150 m	global Pleistocene range
Gyroidina kawagatai	600 ± 150 m	modern range
Karreriella bradyi	600 ± 150 m	Neogene range
Quinqueloculina venusta	600 ± 150 m	modern range
Sigmoilopsis schlumbergeri	600 ± 150 m	modern & Neogene range
Spiroloculina novozealandica	600 ± 150 m	modern range
Vulvulina	700 ± 150 m	Neogene range
Eggerella	750 ± 150 m	modern & Neogene range
Neugeborina ovicula	900 ± 250 m	global Pleistocene range
Nodosarella	900 ± 250 m	global Pleistocene range
Stilostomella s.s.	900 ± 250 m	global Pleistocene range
Cibicides bradyi	1000 ± 300 m	modern range
Cibicides robertsonianus	1000 ± 300 m	modern range
Hopkinsina mioindex	1000 ± 300 m	Neogene range
Neouvigerina hispida/notohispida	1000 ± 300 m	Neogene range
Cibicides kullenbergi	1300 ± 400 m	Neogene range
Laticarinina pauperata	1500 ± 500 m	modern range
Melonis pompilioides	1500 ± 500 m	modern range
Siphotextularia rolshauseni	1500 ± 300 m	modern range
Tritaxilina	1500 ± 500 m	Neogene range
Nuttallides umbonifera	2000 ± 700 m	modern range

Table 39. Upper depth limits in the four study regions around New Zealand and New Zealand in general, of key, moderately common, deep-sea benthic foraminifera. Bolded are the names of those species that may be the most useful in paleodepth determinations.

Key species	Overall NZ	North east NZ	East central NZ	West NZ	Subant NZ
Abditodentrix pseudothalmanni	50 m	300 m	100 m	250 m	50 m
Cassidella bradyi	60 m	60 m	1600 m	200 m	500 m
Hoeglundina elegans	70 m	70 m	200 m	90 m	185 m
Laevidentalina haueri	70 m	70 m	-	200 m	670 m
Amphicoryna hirsuta	80 m	80 m	400 m	120 m	670 m
Bolivina seminuda	80 m	200 m	100 m	100 m	80 m
Epistominella exigua	100 m	100 m	100 m	150 m	490 m
Bulimina striata	100 m	150 m	100 m	190 m	175 m
Melonis affinis	100 m	500 m	500 m	100 m	350 m
Pullenia bulloides	100 m	300 m	100 m	320 m	490 m
Laticarinina altocamerata	120 m	120 m	200 m	150 m	600 m
Trifarina bradyi	130 m	130 m	-	140 m	490 m
Cibicides wuellerstorfi	150 m	350 m	350 m	250.m	150 m
Gyroidina soldanii	150 m	600 m	200 m	150 m	2390 m
Rutherfordoides rotundata	150 m	2500 m	300 m	150 m	2750 m
Globocassidulina subglobosa	190 m	1200 m	190 m	200 m	1280 m
Fursenkoina complanata	200 m	400 m	200 m	370 m	430 m
Bolivinita quadrilatera	250 m	400 m	250 m	500 m	1750 m
Porogavelinella ujeii	250 m	900 m	750 m	250 m	490 m
Nonionella auris	320 m	400 m	400 m	320 m	490 m
Martinotiella communis	400 m	500 m	400 m	500 m	600 m
Osangularia bengalensis	400 m	500 m	500 m	400 m	890 m
Pyrgo murrhina	400 m	550 m	400 m	500 m	420 m
Ehrenbergina glabra	400 m	4500 m	-	-	400 m
Ehrenbergina carinata	400 m	900 m	1000 m	-	400 m
Bulimina truncana	450 m	750 m	450 m	500 m	1750 m
Gyroidina kawagatai	450 m	2550 m	450 m	950 m	500 m
Paratrochammina challengeri	450 m	2400 m	450 m	-	2750 m
Spiroloculina novozealandica	500 m	500 m	-	-	-
Pullenia salisburyi	150 m	150 m	950 m	150 m	520 m
Sigmoilopsis schlumbergeri	500 m	750 m	750 m	500 m	1420 m
Quinqueloculina venusta	550 m	550 m	-	-	-
Bolivina pusilla	550 m	1400 m	1700 m	550 m	-
Eggerella bradyi	625 m	750 m	625 m	750 m	630 m
Cibicides bradyi	800 m	800 m	1200 m	970 m	2400 m
Cibicides robertsonianus	800 m	2400 m	1000 m	800 m	-
Melonis pompilioides	1000 m	2000 m	1000 m	2150 m	1750 m
Siphotextularia rolshauseni	1300 m	1600 m	1300 m	-	1650 m
Nuttallides umbonifera	1300 m	-	1300 m	-	3400 m
Laticarinina pauperata	1500 m	2000 m	2000 m	2000 m	1500 m

MODERN ANALOGUE TECHNIQUE: Our combined census count database of modern New Zealand shallow and deep-sea benthic foraminiferal faunas could be used as a set of modern analogues to compare fossil faunal compositions with. This is usually done by comparing chord dissimilarity values between the fossil faunal composition and each of the modern analogue faunas. The paleodepth assessed for the fossil fauna may be taken as the mean depth of the 5, or 10, most similar modern faunas. A guide to the potential accurracy of the assessment is the total depth range of those 5, or 10, most similar samples. Another measure of the potential accurracy of the method is the dissimilarity value between the faunal composition of the fossil and modern faunas. The more dissimilar in composition potentially the less accurate the paleodepth estimate, to a point where it may be declared that the database has no modern analogues equivalent to the fossil fauna.

At a species level, the modern analogue technique (MAT) becomes less useful and less accurate with increasing age of the fossil fauna. Even in the Pliocene and Early Pleistocene there are increasing numbers of extinct species and no modern analogue faunal compositions. While there are many benthic foraminiferal species' extinctions and appearances in the New Zealand Neogene (e.g., Hornibrook *et al.* 1989), most of the genera exist throughout this period (except in the Pleurostomellidae and Stilostomellidae – Hayward *et al.* 2007d). To circumvent this problem, it is possible

Table 40. Morphotype groups of deep-sea benthic foraminifera and their inferred correlation to microhabitat depths in sea floor sediment (from Corliss 1985, 1991, Corliss and Chen 1988).

Microhabitat	Morphotype	Common taxa
Epifaunal	No pores or on one side	
0-1 cm	Trochospiral, plano-convex	*Cibicides, Cibicidoides, Discorbinella, Gavelinopsis, Rosalina*
	Trochospiral, biconvex	*Epistominella, Eponides, Hoeglundina, Lenticulina, Oridorsalis*
	Trochospiral, rounded	*Anomalina, Gyroidina*
	Milioline	*Miliolinella, Pyrgo, Quinqueloculina, Sigmoilopsis, Triloculina*
Shallow infaunal	Pores evenly arranged over entire test	
1-4 cm	Planispiral, rounded	*Astrononion, Melonis, Nonion, Nonionella*
	Tapered cylindrical	*Bulimina, Fursenkoina, Neouvigerina, Trifarina, Uvigerina*
	Flattened ovoid	*Cassidulina, Fissurina*
	Flattened tapered	*Abditodentrix, Bolivina, Bolivinita*
	Spherical	*Globocassidulina, Lagena, Oolina, Pullenia bulloides, Sphaeroidina*
	Agglutinated	
Deep infaunal		
> 4 cm	Cylindrical or ovate, planispiral or triserial	*Chilostomella, Globobulimina*

to use MAT at a generic level to provide paleodepth assessments for Miocene benthic foraminiferal faunas (e.g., Hayward 2004). Using the generic rather than species level reduces some of the potential resolution of the paleodepth assessment.

MICROHABITAT – INFAUNAL VERSUS EPIFAUNAL

Test shape

Some studies have shown that foraminiferal test shape has a moderately good correlation with microhabitat or life position (epifaunal, infaunal, free, attached) and feeding strategy, but not without exceptions (e.g., Brasier 1982, Sturrock & Murray 1981, Corliss 1985, 1991, Corliss & Chen 1988). Corliss's classification of benthic foraminiferal morphotypes into groups that can be generally equated with microhabitat within the soft seafloor sediment (Table 40) is widely used. Subsequent studies of live foraminifera have shown, however, that there are very few truly epifaunal (top 1 cm) or truly infaunal (deeper than 1 cm) benthic forms. The majority of live foraminifera are present in the upper 1 cm of sediment but most taxa can be found alive in lower abundances at greater depths (Barmawidjaja *et al.* 1992, Buzas *et al.* 1993). It has been shown that live foraminifera can migrate up and down and laterally within the surface sediment depending on the food flux and resulting changes in infaunal oxygen concentrations. It has also been shown that in general, Corliss's epifaunal morphotypes prefer oxic oligotrophic conditions and infaunal morphotypes prefer more eutrophic food supply and suboxic conditions (Corliss 1991, Loubere & Fariduddin 1999). The deep infaunal morphotypes (planispiral or triserial with ovate or cylindrical tests) seem to be less influenced by labile organic carbon flux (rain of food supply from above) and more by infaunal factors such as the shallow presence of the redox front, which suggests that they may be feeding on reducing bacteria associated with this boundary (Jorissen 1999, de Rijk *et al.* 2000). No studies have been undertaken on live benthic foraminifera in the deep sea around New Zealand that could locally relevant data on microhabitat.

Within individual species there is often a correlation between dwarfed, thin-walled, less ornamented forms and low oxygen concentrations (Boltovskoy *et al.* 1991). Relationships have also been shown between larger shell sizes of individual species and higher food supply (Corliss 1979, Caralp 1989, Boltovskoy *et al.* 1991).

ORGANIC CARBON FLUX ASSESSMENTS

Total organic carbon flux

Numerous recent studies of deep-sea benthic foraminifera have concluded that the quantity and quality of organic carbon flux to the seafloor is the most significant factor influencing their faunal composition and distribution (e.g., Loubere 1991, 1994, Schmiedl *et al.* 1997, Loubere & Fariduddin 1999, Gooday & Hughes 2002). Our present study shows that depth-related variables are the strongest influences on the distribution of species associations and individual species (Table 4). The environmental proxies having the strongest correlation with depth are bottom water temperature and planktic percentage (Table 4). These two proxies are not generally considered to influence deep-sea benthic foraminiferal patterns. The strong depth-related stratification of benthic foraminiferal faunas is probably explained by the fact that particulate organic carbon is consumed as it sinks, resulting in decreasing food supply as water depth increases (Berger & Wefer 1990, Gooday 2003). Our data does not include direct measurements of flux to the sea floor and therefore does not provide a robust test of any relationship between different species and food supply.

Sediment trap studies on either flank of Chatham Rise, east of central New Zealand, have shown annual total particulate carbon fluxes at 1000 m water depth of 7.5 g m^{-2} yr^{-1} to the north and 1.8 g m^{-2} yr^{-1} to the south (Nodder & Northcote 2001). These flux rates are moderately low compared with rates elsewhere. Differences in the benthic foraminiferal faunas at upper abyssal depths on either flank (north = Assoc. C1 dominated by *C. reniforme*; south = Assoc. C6 dominated by *E. exigua*) are most likely a result of these carbon flux differences. Elsewhere overseas however, studies have pointed out that it is not the total carbon flux that is important but only that fraction which is labile (rapidly decays) and easily consumed and utilised by the foraminifera (Middleburg *et al*. 1993, Loubere & Fariduddin 1999). Thus in this study our data is too imprecise to be useful and we rely on the results of more targeted studies elsewhere to infer which foraminifera prefer high and low carbon flux environments.

Global studies in the deep-sea (e.g., Loubere 1994, Fariduddin & Loubere 1997, Schmiedl *et al*. 1997) have shown that certain genera and species are characteristic of high labile carbon flux and others are more characteristic of lower flux (Table 41). In time series studies in a core, it is possible to use the total relative abundance or flux of the high productivity group as a proxy for paleoproductivity and supply of labile organic carbon (e.g., Kawagata *et al*. 2007). Several studies have indicated that taxa of the high productivity group (Table 41) only dominate bathyal or abyssal benthic foraminiferal faunas when the flux of labile carbon reaching the seafloor exceeds 2.5-3 g C m^{-2} yr^{-1} (Altenbach 1988, de Rijk *et al*. 2000). In the Mediterranean Sea today, the bathymetric boundary between faunas dominated by high productivity species above and by low productivity group below, shallows from west to east in concert with the decreasing primary productivity that supplies the food to the sea floor (de Rijk *et al*. 2000). Around New Zealand, there seems to be little change in the depth of the lower boundary of abundance of such high food supply species as *B. marginata* both forms, *C. carinata*, *N. proboscidea* and *G. praegeri*, suggesting that there may not be a strong variation in the labile carbon flux – with one exception close to the STF (see above).

Table 41. Common deep-sea genera that are indicative of sustained high or low organic carbon flux, and resulting suboxic-dysoxic or oxic conditions (from Loubere 1994, Fariduddin and Loubere 1997, Schmiedl *et al*. 1997, de Rijk *et al*. 2000).

Faunas of high carbon flux
(eutrophic, suboxic-dysoxic)
Bolivina
Bulimina
Cassidulina
Chilostomella
Francesita
Fursenkoina
Globobulimina
Melonis
Neouvigerina
Rutherfordoides
Trifarina
Uvigerina

Faunas of low carbon flux
(oligotrophic, oxic)
Cibicides kullenbergi
C. wuellerstorfi
Globocassidulina subglobosa
Gyroidina
Nuttallides
Oridorsalis
Rhizammina
Psammosphaera

Some studies have suggested that benthic foraminiferal accumulation rates (BFAR = shells generated per unit time) in the deep sea can be used as a proxy for paleoproductivity and labile organic carbon flux (e.g., Gooday 1988, Herguera & Berger 1991, Herguera 1992). This relationship has been quantitatively calibrated in only a limited number of locations in the Pacific Ocean and is not well tested. A major difficulty with BFAR as a proxy is that it is strongly influenced by sedimentation rate and this needs to be known for the site, as BFAR calculates the number of tests generated cm^{-2} kyr^{-1}. Sedimentation rate is not usually available for seafloor samples, but is commonly calculated for well-dated core sequences and it is in these that BFAR may be a useful proxy for sustained organic carbon flux (e.g., Kawagata *et al*. 2005).

Seasonality of organic carbon flux

Several studies have shown that a high abundance of the common deep-sea benthic foraminifer *Epistominella exigua*, and sometimes also *Alabaminella weddellensis*, is a proxy for highly seasonal supply of organic carbon flux related to strongly seasonal phytoplankton blooms (Gooday 1993, Smart *et al*. 1994, Mackensen *et al*. 1995, Loubere 1998, Nees and Struck 1999). This suggests that both species are opportunists that rapidly reproduce and bloom when the seasonal rain of phytodetritus arrives each year. Thus the Ex-Aw Index (= combined relative abundance of *E. exigua* plus *A. weddellensis*) can be calculated and used as a proxy for the strength of seasonal phytodetrital food supply, which may be of most value in time-series studies.

In New Zealand waters *E. exigua* plus *A. weddellensis* exceed 30% of the benthic fauna beneath the areas of strongest seasonality of the phytodetrital food supply, over the Bounty Trough and west Bounty Plateau (Fig. 41).

BOTTOM OXYGEN ASSESSMENTS

Lowered oxygen concentrations in bottom and interstitial waters have often been cited as another important factor that influences benthic foraminiferal distribution (e.g., van der Zwaan 1999, Kaiho 1999). Commonly however, it is difficult to separate out the effects of high primary productivity from lowered oxygen as excessive carbon flux to the sea-floor often results in lower oxygen conditions in the surface sediment. The most widespread oxygen-depleted environments in the marine realm are in subsurface sediment where oxygen consumption by infaunal benthic organisms that live close to the sea water – sediment surface exceeds oxygen supply. The top of the anoxic zone is usually within the upper 10-30 cm of the sediment surface, but it is where it is at or extremely close to the surface that it has greatest impacts on the benthic foraminiferal composition (Bernhard & Sen Gupta 1999). These conditions usually occur where the overlying bottom waters have low oxygen concentrations (e.g., oxygen minimum zone (OMZ) in intermediate depth water; silled basins and fiords) or where carbon flux is particularly high. None of these conditions are particularly strong around New Zealand today, but they may have been in the past and the composition of foraminiferal faunas may help to recognise them.

Bernhard & Sen Gupta (1999) summarise the characteristics of a number of faunas that have been described as living in severely oxygen-depleted conditions, particularly in silled basins off California (e.g., Douglas & Heitman 1979, Bernhard *et al.* 1997), silled fiords in Scandinavia (e.g., Alve 1990) and the OMZ off western central and south America and off Japan (e.g., Ohga & Kitazato 1997). They conclude that no foraminifera are obligate anaerobes (must live in anaerobic conditions) but some are facultative anaerobes and live in higher abundances in low oxygen conditions and can survive for several weeks in anoxic environments (Bernhard & Sen Gupta 1999). Most of the taxa that characterise low-oxygen foraminiferal assemblages are the same as those that characterise high carbon flux conditions and inhabit infaunal or deep infaunal microhabitats (Tables 40-41). Low-oxygen assemblages are dominated by calcareous perforate taxa particularly members of the families Bolivinidae, Buliminidae, Cassidulinidae, Chilostomellidae, Nonionidae and Uvigerinidae (Table 42).

The above generalisations from modern faunas are supported by studies on late Neogene foraminifera associated with oxygen-deficient, carbonaceous sapropels of the Mediterranean (e.g., Cita & Grignani 1982, Jonkers 1984, Verhallen 1991). Here, interglacial periods of high primary productivity with high carbon flux have resulted in lowered seafloor oxygen concentrations leading to anoxia. This resulted in reduced diversity of benthic foraminifera and greatly increased abundance of opportunistic benthic species, such as *Uvigerina* spp. (>50 % of faunas) and smooth-walled species of *Bolivina* (>70% of faunas in environments with highest oxygen deficiency). In some completely anoxic seafloor situations no benthic foraminifera survived (Verhallen 1991).

Table 42. Common deep-sea benthic foraminiferal genera that characterise severely oxygen-depleted deep-sea environments (Bernhard and Sen Gupta 1999).

Bolivina	*Bulimina*	*Buliminella*
Cassidulina	*Chilostomella*	*Favocassidulina*
Fursenkoina	*Gavelinopis*	*Globobulimina*
Neouvigerina	*Nonion*	*Nonionella*
Nonionoides	*Reophax*	*Rosalina*
Saidovina	*Spiroplectammina*	*Uvigerina*

The relative abundance, absolute abundance (specimens g^{-1} sediment) or flux (specimens cm^{-2} kyr^{-1}) of low oxygen tolerating taxa (as listed in Table 42) may be used as a proxy for low oxygen conditions, particularly in time series studies in a core at a single site (e.g., Kawagata *et al.* 2005, O'Neill *et al.* 2007).

Kaiho (1994) proposed a benthic foraminiferal oxygen index (BFOI) based on his observed relationship between specific morphological characters (or species composition) and oxygen levels. He divided calcareous benthic foraminifera into three groups (Table 43) indicative of dysoxic (D), suboxic (S) and oxic (O) conditions (where D, S and O are the relative abundances of each group in the >63 μm foraminiferal fauna) and used the following equations to calculate his BFOI values:

when $O > 0$, $BFOI = 100\{O/(O+D)\}$,

when $O = 0$, $BFOI = 50\{[S/(S+D)]-1\}$

Kaiho (1999) tested his BFOI calculations with a set of globally-distributed deep-sea faunas with a wide range of bottom oxygen levels mostly relating to the age of the bottom water (oxygen gets consumed with time as bottom water circulates) and showed a high correlation between his BFOI and actual dissolved oxygen levels in bottom waters. From this he recognised six dissolved oxygen conditions based on BFOI scores (Table 44).

Virtually all our New Zealand deep-sea samples fall within the high oxic group (3.2-6.5 ml/l) with just nine stations (all lower bathyal, west of New Zealand at 2.8-3 ml/l) in the medium oxic group. Thus the BFOI is not terribly relevant to modern New Zealand faunas but may be applicable to explain some deep-sea faunal changes in the past in this region. These relatively high bottom water oxygen concentrations around New Zealand mean that our correlation analysis between them and different foraminiferal species (Table 4) are in part aliased to depth and will not necessarily reflect a species ability to live in oxygen-depleted conditions. Nevertheless, species in our study that show the strongest correlation with decreasing bottom oxygen (in the OMZ) are similar to those cited above from overseas' studies and are, in decreasing order:

Gyroidina orbicularis, *Bulimina marginata* f. *aculeata*, *B. truncana*, *Uvigerina peregrina*, *Melonis affinis*, and *Osangularia bengalensis* (e.g., Fig. 42). Species preferring the most oxic conditions (strongest correlation coefficients with high levels of bottom oxygen) are, in decreasing order: *Gavelinopsis praegeri*, *Cassidulina carinata* and *Trifarina angulosa.*

Table 43. Common deep-sea benthic foraminiferal genera that have been attributed to oxic, suboxic and dysoxic conditions and used by Kaiho (1994, 1999) to calculate BFOI (benthic foraminiferal oxygen index).

Oxic	Suboxic	Dysoxic
Larger specimens (>350 um) of thick-walled epifauna:	Smaller specimens (<350 um) of thick-walled epifauna, plus:	Thin-walled, elongate, flattened infauna:
Cibicides	*Alabamina*	*Bolivina*
Cibicidoides	*Astrononion*	*Chilostomella*
Globocassidulina subglobosa	*Bulimina marginata* s.l.	*Fursenkoina*
Laticarinina pauperata	*Bolivinita*	*Globobulimina*
Pyrgo	*Cassidulina*	*Laevidentalina* (thin-walled)
Quinqueloculina	*Dentalina* (thick-walled)	*Rutherfordoides*
Triloculina	*Eilohedra*	
	Fissurina	
	Gyroidina	
	Lagena	
	Lenticulina	
	Melonis	
	Nonion	
	Nonionella	
	Oridorsalis	
	Pullenia	
	Rosalina	
	Sphaeroidina	
	Trifarina	
	Uvigerina	

BOTTOM WATER CORROSIVENESS

Indicators of corrosive bottom water are found in signs of dissolution, initially of planktic foraminifera (increased planktic foraminiferal fragmentation index, lowered planktic %) but with strongly corrosive water also of thin-walled, more commonly epifaunal benthic tests, with abyssal benthic faunal assemblages. High fragmentation index values may be recorded at shallower depths but this is either a result of abrasion by strong bottom currents or by dissolution within the sediment as a result of excess organic carbon flux producing more acidic pore water conditions (Emerson & Bender, 1981). At mid abyssal and greater depths (>3500 m), the presence of significant numbers of the benthic *Nuttallides umbonifera* is suggestive of increasingly corrosive, new, oxic, cold bottom waters, like AABW or lower CPDW (e.g., Schnitker 1980, Weston & Murray 1984). This is confirmed in our study, where *N. umbonifera* has by far the greatest positive correlation (r = 0.45) with planktic foraminiferal fragmentation index (Fig. 88). With particularly strong dissolution the benthic foraminiferal fauna may be reduced to a low diversity fauna of dissolution-resistant larger, thick-walled species such as *N. umbonifera*, *Globocassidulina subglobosa*, *Oridorsalis umbonatus* and large uniserial forms, and finally only agglutinated forms remain.

The relative abundance of *N. umbonifera* may be used in combination with the fragmentation index as a proxy for corrosive deep bottom water, particularly in time series studies at one core site (e.g., Hayward *et al.* 2004b).

Table 44. Terminology for dissolved oxygen conditions as defined by Kaiho (1999). BFOI = benthic foraminiferal oxygen index.

Condition	Dissolved oxygen ml/l	BFOI
Anoxic	0	-55 to -50
Dysoxic	0-0.3	-50 to -40
Suboxic	0.3-1.0	-40 to 0
Low oxic	1.0-2.0	0 to 15
Medium oxic	2.0-3.2	15 to 50
High oxic	3.2-6.0	50 to 100

CURRENT STRENGTH ASSESSMENTS

Strong wave or tidal currents are restricted to inner shelf depths and usually winnow away fine sediment and small foraminiferal tests and abrade the remaining larger foraminiferal tests, sometimes completely. These environments may be recognised by clean, well-sorted medium to coarse sand and gravel sediment with abraded faunas dominated by large specimens of typical New Zealand inner shelf taxa, such as *Quinqueloculina*, *Elphidium*, *Pileolina*, *Notorotalia*, *Trochulina, Zeaflorilus, Amphistegina* and *Rosalina* (e.g., Hayward 1982a, Reid & Hayward 1997).

Strong bottom currents in depths below 50 m, particularly those sweeping around or over major bathymetric obstacles, are sometimes strong enough to winnow away mud and very fine sand. They often bring in a lateral supply of food and well-oxygenated bottom waters. In this study around New Zealand faunas from strong current-swept environments may be recognised by high fragmentation index values above the foraminiferal lysocline (<3600 m), and by coarse substrate (low mud). Foraminiferal species with strong negative correlation coefficients with mud, high positive correlations with oxygen and positive or non-significant correlations with fragmentation index all belong to species associations 2 and 6 (Table 4). Most significant of these are in decreasing order: *Cibicides dispars*, *Trifarina angulosa*, *Gavelinopsis praegeri*, *Spiroplectinella proxispira, Globocassidulina canalisuturata*, *Quinqueloculina seminula, Notorotalia depressa* and *Ehrenbergina glabra.* Most of these species generally occur in the shallower parts of the study at mid shelf to upper bathyal depths (50-600 m), but two species that are particularly characteristic of current-swept mid-upper bathyal depths (200-1000 m) right around the fringes of the Southern Ocean are *Trifarina angulosa* and *Ehrenbergina glabra* (Kennett 1968, Echols 1971, Ward *et al*. 1987, Mackensen *et al*. 1990, 1995, Harloff & Mackensen 1997).

A METHOD FOR RAPID PALEOENVIRONMENTAL ASSESSMENT OF FOSSIL NEOGENE FORAMINIFERAL FAUNAS

Based on fossil faunas picked from a split of a sediment sample coarser than 0.063 mm, i.e. entire sand fraction. Note that some researchers use coarser fractions, with subsequent loss of some paleoenvironmental information.

1. SAMPLE LITHOLOGY: Make qualitative assessment of sample grain size before processing. Coarser sediments (medium sand and coarser) are more likely to have winnowed, transported or mixed faunas and are suggestive of strong bottom currents or in shallow water waves or tidal currents. Fine sediments may contain introduced small foraminiferal tests.

2. QUALITATIVE PICK: Make a quick qualitative pick of sufficient benthic and planktic foraminifera to give a reasonable cross-section of what is present. Pick 4 or 5 specimens of the common benthic species and only 1 or 2 of the rarer ones. Usually mount in rough taxonomic order on a gummed slide with a grid painted on it.

3. PERCENTAGE PLANKTIC FORAMINIFERA: While picking, estimate the percentage of the total foraminiferal fauna that is planktic and use graph (Fig. 82) to give assessment of oceanicity and indication of possible paleodepth (Fig. 89). Can be done by counting (not picking) proportion of 100 foraminifera seen that are benthic and planktic.

4. ORDER COMPOSITION: While picking or following a rapid quantitative pick (of say 100 benthics) make an estimate of the composition of the benthic fauna by the four major calcareous orders plus agglutinated taxa (Miliolida, Lagenida, Buliminida, Rotaliida, agglutinated,) and use graphs (Figs. 83-84) to provide a rough indication of possible paleoenvironment. Particularly useful if agglutinated or Miliolida >30% of fauna.

5. FAUNAL ASSOCIATIONS AND DOMINANT BENTHIC TAXA: Make a qualitative estimate of which benthic taxa are the dominant or common members of the fauna and identify these. Check through the list of common faunal associations characterised by 1-3 dominant species (Table 37), and if one matches your fauna use the modern depth range and environmental characteristics as a likely interpretation.

Use the kite diagrams of the ranges of Recent genera and species (Figs 86-87) or if necessary the inferred ranges of fossil taxa (Figs 17-22 in Hayward 1986a) to determine the overlap zone for the depth ranges of the common taxa in your fauna. The zone of coincidence or overlap is the most likely paleodepth range for your fossil fauna. No overlap of some taxon ranges may suggest your fauna has mixed origins (e.g., post-mortem transport).

If a brackish paleoenvironment is indicated refer to the kite diagrams of the ranges of modern New Zealand brackish

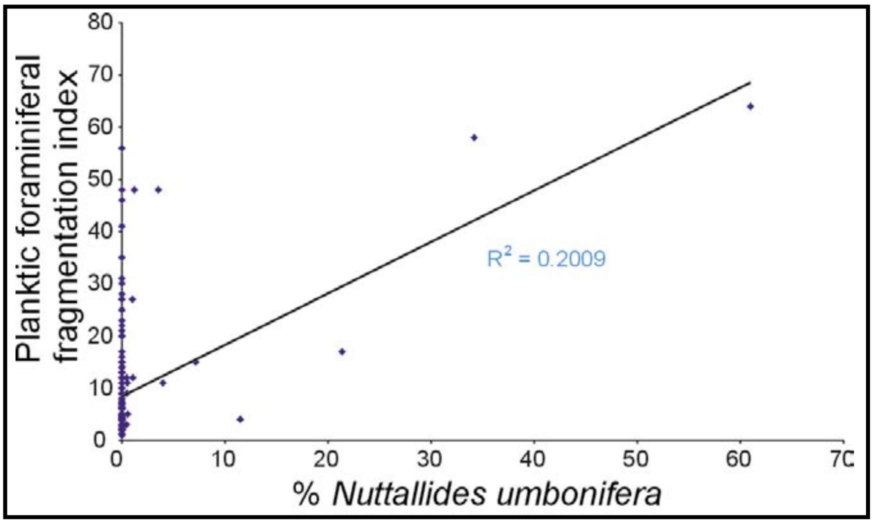


Figure 88. % relative abundance of *Nuttallides umbonifera* plotted against planktic foraminiferal fragmentation index for our New Zealand deep-sea data (this study).

species (Figs 13-14 in Hayward *et al*. 1999) to determine possible tidal level and salinity range of your fossil fauna.

If a bathyal or greater depth is indicated, you may be able to infer paleoceanographic characteristics of the environmental setting. If the fauna is dominated by:

a. *Nuttallides umbonifera* – indicates highly corrosive bottom water (may also have low planktic % and high fragmentation index).

b. *Epistominella exigua* and/or *Alabaminella weddellensis* – indicates strongly seasonal phytodetrital carbon flux to the sea floor.

c. *Trifarina angulosa*, *Cibicides dispars* and/or *Ehrenbergina glabra* – may indicate strong bottom currents winnowing away fines under oxic conditions (usually in medium sand to fine gravel substrates).

d. Species of any of the following *Bulimina*, *Bolivina*, *Uvigerina*, *Neouvigerina*, *Cassidulina*, *Nonionella*, or *Globobulimina* (Tables 41-43) – may indicate either high labile carbon flux to the sea floor (>2.5-3 g C m^{-2} yr^{-1}) or dysoxic, suboxic or low oxic bottom conditions, or quite likely both.

e. *Globocassidulina subglobosa*, *Oridorsalis umbonatus*, *Nuttallides umbonatus*, *Cibicides kullenbergi* or *C. wuellerstorfi* – may indicate low labile carbon flux and oxic bottom conditions.

6. RARER BENTHIC TAXA: Identify all or most of your picked benthic foraminifera and check their known or inferred depth ranges (Figs. 86-87, plus Figs 17-22 in Hayward 1986a) for any having more restricted ranges than indicated by your common species. These may help refine your existing paleoenvironmental assessment or indicate minor mixing from other sources. If your common species indicate a bathyal or abyssal depth, then check your list of rarer taxa to see if any have defined upper depth limits (Table 38) that might give you a more precise estimate (Fig. 89).

7. TEST SIZE RANGE AND PRESERVATION: Check the range of test sizes, their composition and state of preservation (partly abraded or partly dissolved) to assess whether your fauna may have lost or gained tests through transport or dissolution processes which may have produced a mixed or reduced fauna.

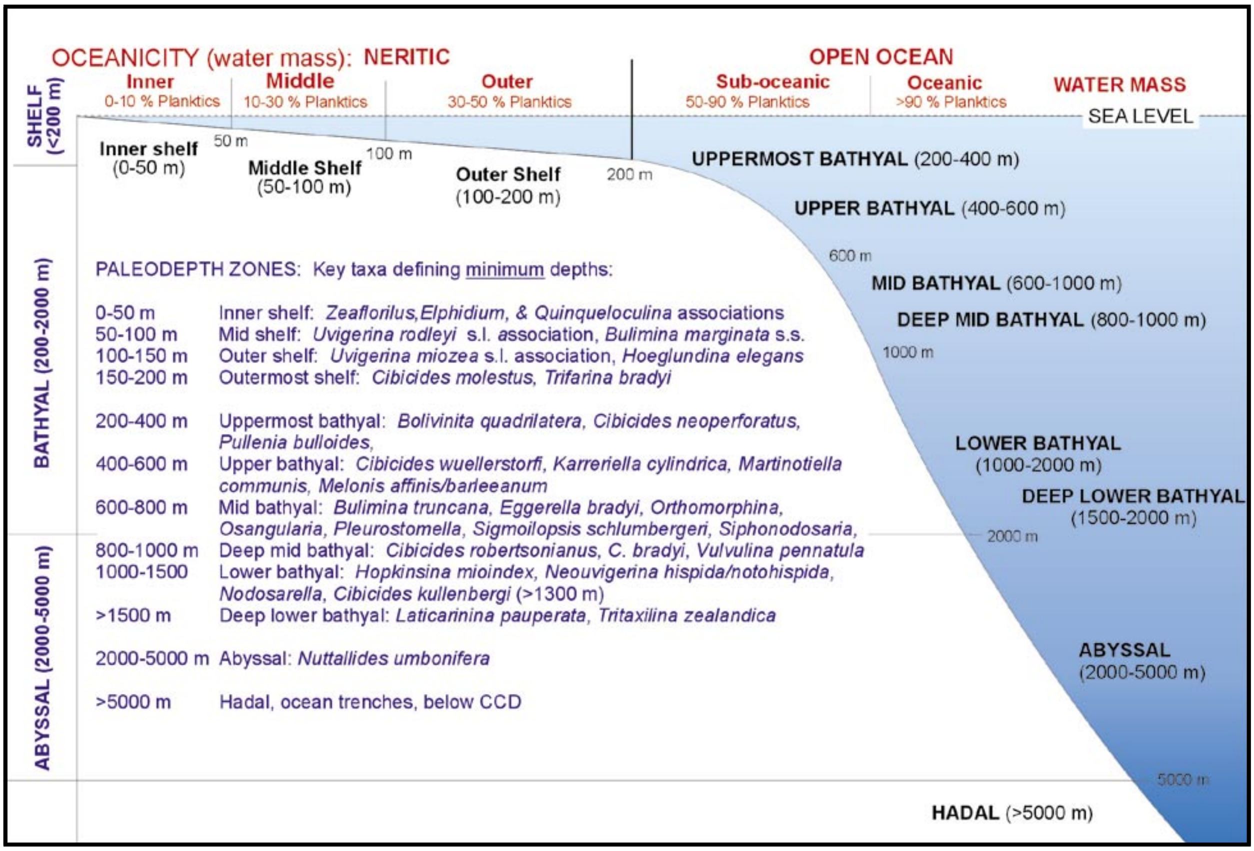


Figure 89. Diagram summarising the use of planktic percentage and the upper depth limits of key benthic taxa to provide assessments of oceanicity and paleodepth from New Zealand Neogene foraminiferal faunas (modified after Morgans and Strong, unpubl.).

NZ DEEP–SEA BENTHIC TAXONOMY

The species included in the following pages are all the common and some of the more distinctive taxa recorded in waters deeper than 50 m from around New Zealand. Species that are more common in inner shelf depths (shallower than 50 m) have been described and figured in Hayward *et al.* (1999) and are generally not included here, except in the keys for distinguishing genera and species, or where the species is also common at greater depths. A more complete reference list of species recognised in deep water around New Zealand is presented in Appendix V. All genera and families follow Loeblich & Tappan (1987), except where otherwise stated. Readers should refer to Loeblich & Tappan (1987) for full descriptions of genera and families. Classification of Orders within the Phylum Foraminifera follows Loeblich & Tappan (1992). Classification at class and higher levels follows Cavalier-Smith (2003). Families, genera and species are presented in alphabetic order within their respective orders, families and genera.

SYNONYMY LISTS: These include the original species description; all species newly synonymised by us; all post-1999 figured New Zealand specimens of that taxon; and where necessary a reference to a good, accessible description and figures that help define the species.

GEOGRAPHIC DISTRIBUTION: The known world distribution of species given here results from a quick internet search and a rapid survey of summary papers (e.g. Boltovskoy *et al.* 1980, Nomura 1981, Culver & Buzas 1980, 1981, 1982, 1984, 1986, Murray 1991, Cimerman & Langer 1991, Hottinger *et al.* 1993, Loeblich & Tappan 1994, Jones 1994, Yassini & Jones 1995). It is not claimed to be fully comprehensive nor has it involved rigorous checking of figured specimens to ensure that records under a single species name are of a single taxon.

NEW ZEALAND STRATIGRAPHIC RANGES: Recorded stratigraphic ranges of species have been compiled from a variety of sources chiefly Hornibrook *et al.* (1989), Hayward & Buzas (1979), Hayward *et al.* (2004b, 2005) and unpublished data held in the files of the Micropaleontology Section, Institute of Geological and Nuclear Sciences (Hayward *et al.* in press). New Zealand stages are cited by their abbreviations in brackets (Fig. 72).

LOCALITY AND SPECIMEN CATALOGUE NUMBERS: The catalogue numbers of type or figured specimens and of sample localities cited in this section and in the plates are from the following collections (prefixes cited):

AU = Sample catalogue numbers of the Geology Department, University of Auckland
BWH = SEM figured specimens (still mounted on stubs), to be housed in GNS Science
F20 = Recent microfossil sample catalogue numbers of GNS Science, Lower Hutt
FP = Figured specimen numbers of isolated specimens (on slides) housed at GNS Science, Lower Hutt
L = Sample catalogue numbers of the Marine Department, Auckland War Memorial Museum
NIWA = Sample catalogue numbers of the National Institute of Water and Atmosphere, Wellington
ODP = Site numbers of the Ocean Drilling Program
TF = Type specimen numbers of GNS Science, Lower Hutt

SUPERKINGDOM – Eukaryota

KINGDOM – Protozoa

SUBKINGDOM – Biciliata

Cavalier-Smith 2003

PHYLUM – Foraminifera

(d'Orbigny 1826) Lee 1990

CLASS – Polythalamea Ehrenberg 1838

ORDER – Allogromiida Hartog in Harmer & Shipley 1906

FAMILY – Hospitellidae Loeblich & Tappan 1984

Test attached and multilocular.

GENUS – *Placopsilinella* Earland 1934

Placopsilinella aurantiaca Earland 1934
Pl. 1, Fig. 1

Placopsilinella aurantiaca EARLAND 1934, p.95, pl.3, fig.18; LOEBLICH & TAPPAN 1987, pl.10, fig.4; THOMAS *et al.* 1990, pl.1, fig.1.

DISTINGUISHING FEATURES: Test small and attached to various foreign matter or other foraminifera; multilocular and elongate. Chamber arrangement irregular, but generally 1–3 chambers in width and up to 50 chambers in length. Chambers reddish in colour, and spherical with no noticeable size change.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: One record from off the east coast of central New Zealand (40°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Thomas *et al.* 1990).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid abyssal depths (3000–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

ORDER – Astrorhizida Lankester 1885

FAMILY – Bathysiphonidae Avnimelech 1952

Test an unbranched, straight and unsegmented tube with an opening at one end. Test wall agglutinated and well cemented.

GENUS – *Bathysiphon* M. Sars 1872

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Bathysiphon argenteus: Minute, flexible, consisting of thin chitinous tube.

Bathysiphon filiformis: Cylindrical, elongate, uniform diameter throughout; wall of randomly oriented siliceous sponge spicules.

Bathysiphon argenteus Heron-Allen & Earland 1913
Pl. 1, Figs 2–3

Bathysiphon argenteus HERON-ALLEN & EARLAND 1913b, p.38, pl.3, figs 1–3; CUSHMAN 1918, pl.12, figs 1–3.

DISTINGUISHING FEATURES: Test slender, elongate, unbranched, open at both ends and internally undivided. Test a thin, brown chitinous tube.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: One record from the New Zealand region, from off the east coast of central North Island (40˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Heron-Allen & Earland 1913b).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper abyssal depths (2000–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Bathysiphon filiformis M. Sars 1872
Pl. 1, Figs 4–5

Bathysiphon filiformis M. Sars in SARS, G.O. 1872, p.251; LOEBLICH & TAPPAN 1987, pl.13, figs 2; HUGHES 1988, pl.1, fig.2; JONES 1994, pl.26, figs 15,17–20; YASSINI & JONES 1995, figs 1–2.

DISTINGUISHING FEATURES: Test cylindrical, elongate, unbranched, open at both ends and internally undivided. Wall composed mostly of randomly-oriented, fine, siliceous, sponge spicules.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records from off the east coast of both islands (34–45˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to lower bathyal (100–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Cretaceous–Recent (Mh–Rec).

FAMILY – Hippocrepinidae Rhumbler 1895

GENUS – *Botellina* Carpenter, Jeffreys & Thomson 1870

Botellina labyrinthica Brady 1881
Pl. 1, Figs 6–7

Botellina labyrinthica BRADY 1881b, p.48. LOEBLICH & TAPPAN 1987, pl.32, figs 4–6; JONES 1994, pl.29, figs 8–18; YASSINI & JONES 1995, figs 3–4.

DISTINGUISHING FEATURES: Large, rounded proloculus followed by elongate tubular, undivided chamber. Aperture terminal, rounded. Wall compact, firmly cemented quartz grains, commonly with sponge spicules that may protrude into the chamber cavity.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Several scattered record off the east coast of the northern North Island (34–37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid–outer shelf depths (50–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Hyperammina* Brady 1878

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Hyperammina cylindrica: Test slender, elongate; coarsely agglutinated exterior.

Hyperammina laevigata: Test slender, elongate; smooth, polished exterior and rough interior.

Hyperammina novaezealandiae: Test with numerous, elongate sponge spicules, longitudinally arranged on outside.

Hyperammina cylindrica Parr 1950
Pl. 1, Figs 8–9

Hyperammina cylindrica PARR 1950, p.254, pl.3, fig.5; JONES 1994, pl.23, figs 4,7.

DISTINGUISHING FEATURES: Pestle-shaped test, consisting of a subglobular proloculus and long cylindrical second chamber, which may taper towards the apertural end; aperture terminal, wide, circular opening; wall coarsely agglutinated with rough exterior and smooth interior.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off both coasts of the North Island (34–40˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Culver & Buzas 1984, Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to abyssal (150–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Hyperammina laevigata Wright 1891
Pl. 1, Figs 10–11

Hyperammina elongata var. *laevigata* WRIGHT 1891, p.466, pl.20, fig.1.

Hyperammina laevigata Wright. SAIDOVA 1975, pl.7, fig.6; JONES 1994, pl.23, figs 9–10; LOBEGEIER & SEN GUPTA 2008, pl.4, fig.8.

DISTINGUISHING FEATURES: Test long, slender; brown wall very finely agglutinated with smooth, polished exterior and rough interior.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off the east coast of the North Island (36–41˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to upper abyssal (150–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Hyperammina novaezealandiae Heron-Allen & Earland 1922
Pl. 1, Figs 12–13

Hyperammina novaezealandiae HERON-ALLEN & EARLAND 1922, p.89, pl.3, figs.1–5; LOEBLICH & TAPPAN 1994, pl.1, figs 9–12.

DISTINGUISHING FEATURES: Test free, elongate tube, closed at one end; circular in cross-section, slightly tapering. Wall made of numerous, elongate sponge spicules in two layers – the inner layer transversely arranged, outer layer longitudinally arranged.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off both coasts of the North Island (34–39˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Heron-Allen & Earland 1922).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to mid bathyal (80–1000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Saccorhiza* Eimer and Fickert 1899

Saccorhiza ramosa (Brady 1879)
Pl. 1, Fig. 14

Hyperammina ramosa BRADY 1879a, p.33, pl.3, figs 14–15.

Saccorhiza ramosa (Brady). LOEBLICH & TAPPAN 1987, pl.32, figs 10–15; UJIIE 1995, pl.1, figs 14–15; LOEBLICH & TAPPAN 1994, pl.1, figs 4–5; JONES 1994, pl.23, figs 15–19; LOBEGEIER & SEN GUPTA 2008, pl.4, fig.23.

DISTINGUISHING FEATURES: Test large, consist of proloculus followed by tubular chamber that may branch dichotomously or show very irregular growth, with terminal stoloniferous projections; aperture rounded, at the open ends of the stolon-like branches. Wall of agglutinated quartz grains, spicules, shell and other minerals held in an organic inner layer, sometimes with a large component of outwardly projecting sponge spicules that give the surface a hirsute to felt-like appearance, dark gray to yellowish in colour.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic records off both coasts of both main islands (34–50˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Bathyal to mid abyssal (400–3500 m), mostly deeper than 1000 m.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Psammosphaeridae Haeckel 1894

Test may be globular to slightly irregular, unilocular or multilocular; wall coarsely agglutinated.

GENUS – *Psammosphaera* Schulze 1875

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Psammosphaera fusca: Spherical; wall composed of coarse sand grains with rough surface.

Psammosphaera parva: Spherical; wall always enclosing a long sponge spicule.

Psammosphaera rustica: Fusiform; wall constructed almost entirely of sponge spicules neatly cemented together (rare, see Loeblich & Tappan 1987, pl.43, figs 1–7).

Psammosphaera testacea: Spherical, large; wall composed of dead shells of foraminifera (rare, see Cushman 1918, pl.15, figs 1–3).

Psammosphaera fusca Schulze 1875
Pl. 1, Fig. 15

Psammosphaera fusca SCHULZE 1875, p.113, pl.2, fig.8. JONES 1994, pl.18, figs 2–3; LOBEGEIER & SEN GUPTA 2008, pl.4, fig.17.

DISTINGUISHING FEATURES: Test large, consisting of one to several loosely joined spherical chambers. Wall loosely agglutinated, composed of coarse sand grains separated by large pores that serve as apertures.

REMARKS: Jones (1994) synonymised this species with *P. parva*, but we retain the separation based on the presence or absence of the long spicule through the test.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrences off the east coast of the North Island (34–40˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to mid abyssal (150–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Psammosphaera parva Flint 1899

Pl. 1, Fig. 16

Psammosphaera parva FLINT 1899, p.268, pl.9, fig.1; CUSHMAN 1918, pl.12, figs 4–6; CUSHMAN 1919, pl.75, fig.3.

Psammosphaera fusca Schulze. JONES 1994, pl.18, fig.4.

DISTINGUISHING FEATURES: Test small, consisting of one spherical free chamber, or one hemispherical attached chamber. Wall of silt grains enclosing one elongate spicule that projects from both sides.

REMARKS: Jones (1994) made this a junior synonym of *P. fusca,* on the basis that the presence of a spicule through the middle did not constitute a specific difference.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrences off the north-east coast of the North Island (34–37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Flint 1899, Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to upper bathyal (150–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – **Rhabdamminidae** Brady 1884

Test a simple or branched, straight or tapered tube that may be slightly inflated. Test wall may be made up of sediment, or other foreign matter, e.g. foraminifera or radiolarian material.

GENUS – *Marsipella* Norman 1878

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Marsipella cylindrica: Slender, of nearly uniform diameter; wall composed almost entirely of acicular sponge spicules (rare, see Jones 1994, pl. 24, figs 20–22).

Marsipella elongata: Test tapering at both end; wall of roughly constructed, medium-sized sand grains and rare sponge spicules.

Marsipella elongata Norman 1878

Pl. 1, Fig. 17

Marsipella elongata NORMAN 1878, p.281, pl.16, fig.7; HAYNES 1973, pl.3, fig.14; LOEBLICH & TAPPAN 1987, pl.15, fig.2; UJIIE 1995, pl.1, fig.4; JONES 1994, pl.24, figs 10–19; UJIIE 1995, pl.1, fig.4.

DISTINGUISHING FEATURES: Test tubular, cylindrical or fusiform; irregularly curved; tapering at both ends. Wall of roughly constructed medium-sized sand grains and rare sponge spicules.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences from east of central New Zealand (36–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal to upper abyssal (500–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Rhabdammina* M. Sars 1869

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Rhabdammina abyssorum: Small central chamber with 3–5 radiating arms, of nearly uniform diameter, thick wall of firmly cemented sand grains of variable size, exterior usually roughened (rare, see Jones 1994, pl.21, figs.1–8, 10–13).

Rhabdammina antarctica: Wall of extremely coarse grains, projecting from surface.

Rhabdammina discreta: Irregularly constricted at intervals; thin wall of firmly cemented sand grains.

Rhabdammina major: Large straight tubes, branch dichotomously in one plane; firmly cemented sand grains.

Rhabdammina antarctica Saidova 1975

Pl. 1, Figs 18–19

Rhabdammina antarctica SAIDOVA 1975, p.16, pl.2, fig.1.

DISTINGUISHING FEATURES: Test a cylindrical tube, open at both ends; wall moderately thick, composed of extremely coarse angular sand grains that project from surface.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrences east of the North Island (36–38˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Southern Ocean (Saidova 1975).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper abyssal (70–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Rhabdammina discreta Brady 1881

Pl. 1, Fig. 20

Rhabdammina discreta BRADY 1881b, p.48; SAIDOVA 1975, pl.93, fig.3; JONES 1994, pl.22, figs 7–10.

DISTINGUISHING FEATURES: Test a cylindrical tube, open at both ends; consisting of a straight or nearly straight tube of indefinite length, spuriously segmented by slight constrictions at irregular intervals; wall thin, composed of angular sand grains firmly cemented.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off both coasts of the North Island (32–40˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal to abyssal (500–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Rhabdammina major de Folin 1887

Pl. 1, Figs 21–22

Rhabdammina major DE FOLIN 1887, figs 12a–b; GOODAY 1986, p.157, figs 1a–g, pl.2, figs 1–6, pl.3, figs 13–19; JONES 1994, pl.21, fig.9.

DISTINGUISHING FEATURES: Test large, straight cylindrical tubes, that branch dichotomously in one plane at angles of 60–100˚; tubes have open ends. Wall composed of angular sand grains firmly cemented.

REMARKS: This species was lectotypified and redescribed in detail by Gooday (1986).

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrences off northern North Island (32–35˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994; Gooday 1986).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to bathyal (150–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Rhizammina* Brady 1879

Rhizammina algaeformis Brady 1879

Pl. 1, Fig. 23

Rhizammina algaeformis BRADY1879a, p.39, pl.4, figs 16–17; JONES 1994, pl.28, figs 1–11; UJIIE 1995, pl.1, fig.7.

DISTINGUISHING FEATURES: Test tubular, branching. Wall thin and flexible, with embedded sand grains, tests of planktic foraminifera, or radiolarians.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrences east of New Zealand (36–50˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid to lower bathyal (500–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Cretaceous–Recent (Mh–Rec).

FAMILY – Saccamminidae Brady 1884

Test elongate to globular or flask shaped with singular or multiple, rounded to slit-like apertures; wall agglutinated.

GENUS – *Lagenammina* Rhumbler 1911

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Lagenammina arenulata: Coarsely agglutinated with indistinct neck.

Lagenammina bulbosa: Moderatley to coarsely agglutinated; long and slender apertural neck.

Lagenammina difflugiformis: Flask-like; exterior neat, fine-grained.

Lagenammina spiculata: Flask-like with projecting sponge spicules.

Lagenammina arenulata (Skinner 1961)

Pl. 1, Figs 24–25

Reophax difflugiformis arenulata SKINNER 1961, p.1239.

Lagenammina arenulata (Skinner). JONES 1994, pl.30, fig.5.

DISTINGUISHING FEATURES: Test irregular flask shape; lacking a distinct apertural neck. Wall coarsely agglutinated.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrences off the east coast of the two main islands (34–47˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to mid abyssal (150–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Lagenammina bulbosa (Chapman & Parr 1937)

Pl. 1, Figs 26–27

Proteonina bulbosa CHAPMAN & PARR 1937, pl.10, fig.42.

DISTINGUISHING FEATURES: Test lageniform, chamber globose, terminating in a long and very slender neck. Test composed of moderately coarse, subangular quartz grains, beautifully fitted together with a minimum of cement. The material of the neck is finely agglutinated. Test a pale reddish brown.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic records off the east coast of the North Island (34–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Southern Ocean (Chapman & Parr 1937).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper and mid abyssal (2000–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Lagenammina difflugiformis (Brady 1879)

Pl. 1, Figs 28–29

Reophax difflugiformis BRADY 1879a, p.51, pl.4, fig.3a–b.

Lagenammina difflugiformis (Brady). JONES 1994, pl.30, figs 1–3; YASSINI & JONES 1995, fig.23; LOBEGEIER & SEN GUPTA 2008, pl.4, fig.11.

DISTINGUISHING FEATURES: Rounded or oval single chamber, with produced neck (flask-like). Wall thin, agglutinate; the constituent particles of sand neatly joined, and presenting a smooth exterior.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off the east coast of New Zealand from 35 to 51˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Predominantly abyssal (2000–5000 m), except for one upper bathyal record.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Lagenammina spiculata (Skinner 1961)
Pl. 1, Fig. 30
Reophax difflugiformis spiculata SKINNER 1961, p.1239.
Lagenammina spiculata (Skinner). JONES 1994, pl.30, fig.4.

DISTINGUISHING FEATURES: Rounded or oval single chamber, with produced neck (flask-like). Wall thin, agglutinate; the constituent particles of sand neatly joined with projecting sponge spicules.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare record from south-east of the South Island (47˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper abyssal (2000–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Saccammina* Carpenter 1869

Saccammina sphaerica Brady 1871
Pl. 1, Figs 31–32
Saccammina sphaerica BRADY 1871, p.183; LOEBLICH & TAPPAN 1987, pl.23, fig.8; JONES 1994, pl.18, figs 11–15,?17; YASSINI & JONES 1995, figs 8–9.

DISTINGUISHING FEATURES: A single globular chamber; aperture rounded and terminal on a slightly produced neck. Wall firm, covered with angular sand-grains strongly united by ferruginous cement.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences east of the South Island (42–45˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower bathyal to upper abyssal (1000–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Technitella* Norman 1878

Technitella legumen Norman 1878
Pl. 1, Figs 33-34
Technitella legumen NORMAN 1878, p.279, pl.16, figs 3–4; LOEBLICH & TAPPAN 1987, pl.23, figs 3–4; JONES 1994, pl.25, figs 8–10.

DISTINGUISHING FEATURES: Test elongate, oval or fusiform; aperture terminal, rounded, slightly produced on a neck or with a thickened border. Wall thin, of agglutinated, longitudinally-aligned, sponge spicules.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Numerous specimens off North Cape (34˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf (100–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Schizamminidae Nørvang 1961.

Tubular to flaring, dichotomously branching or spreading fanlike in a single plane; wall thick and agglutinated.

GENUS – *Jullienella* Schlumberger 1890

Jullienella zealandica Hayward & Gordon 1984
Pl. 2, Figs 1–2
Jullienella zealandica HAYWARD & GORDON 1984, p.111–114, pl.1–2.

DISTINGUISHING FEATURES: Test large, flabelliform; becoming irregular in shape with development of branches, most being broad and compressed whereas a few may be narrow, tubular and almost circular in cross-section. Broad, distal growing edges generally have an open, elongate aperture along full breadth; tubular branches each have small oval to circular terminal aperture. Test surface finely striped with distinct, crescentic growth lines.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Only known from off the west coast of the South Island (42–45˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South–west Pacific (Hayward & Gordon 1984).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid–lower bathyal (900–1400 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

ORDER – Lituolida Lankester 1885

FAMILY – Ammodiscidae Reuss 1867

GENUS – *Ammodiscus* Reuss 1862

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Ammodiscus exsertus: Test moderate size; several coils followed by an uncoiled straight tube.
Ammodiscus gullmarensis: Test small; several narrow, slightly overlapping whorls, biconcave.
Ammodiscus mestayeri: Test large; proloculus large; few, wide whorls.
Ammodiscus planorbis: Test moderate size; numerous, narrow whorls; surface brown, shining, polished.
Ammodiscus profundissimus: Test small, irregular; becoming thicker from center to the periphery.

Ammodiscus exsertus Cushman 1910

Pl. 2, Figs 3–4

Ammodiscus exsertus CUSHMAN 1910, p.75, fig.97; SAIDOVA 1975, pl.17, fig.8.

DISTINGUISHING FEATURES: Test moderately large, biconcave, periphery rounded. Consists of several whorls followed by an uncoiled straight tube with a terminal round aperture. Wall finely agglutinated, colour light brown.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrence off the east coast of the South Island (44˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Cushman 1910).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Bathyal (200–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Ammodiscus gullmarensis Höglund 1948

Pl. 2, Figs 5–6

Ammodiscus planus HÖGLAND 1947 (non *Ammodiscus planus* LOEBLICH 1946), p.127, pl.28, figs 17–18, text-figs 99–100,105–106,108–109.

Ammodiscus gullmarensis HÖGLAND 1948, p.45; LOEBLICH & TAPPAN 1994, pl.3, figs 11–15.

Ammodiscus argenteus ZHENG 1988, p.35, 307, pl.5, fig.7.

DISTINGUISHING FEATURES: Test small, biconcave; periphery rounded. Consists of several narrow, slightly overlapping whorls. Suture distinct and slightly depressed. Wall finely agglutinated, colour light brown and whitish iridescent.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Only recorded in the New Zealand region from off the east coast of the North Island on the Hikurangi Plain (40˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Höglund 1948).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower abyssal (4000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Ammodiscus mestayeri Cushman 1919

Pl. 2, Figs 7–8

Ammodiscus mestayeri CUSHMAN 1919, p.597, pl.74, figs 1–2.

DISTINGUISHING FEATURES: Test large; microspheric form an elongate ovoid proloculus with 3–4 coils; central portion depressed; megalospheric form with large subglobular proloculus followed by one and one–half coils, test thickest in the central portion. Wall composed of fine angular sand grains with whitish or light brown cement.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off the east coast of New Zealand (34–50˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Cushman 1919).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to lower bathyal (80–1500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Ammodiscus planorbis Höglund 1947

Pl. 2, Figs 9–10

Ammodiscus planorbis HÖGLUND 1947, p.125, pl.8, fig.4; pl.28, figs.13–16.

DISTINGUISHING FEATURES: Test regularly planispiral, numerous (up to 11) narrow whorls. Wall finely arenaceous, brown, shining and polished.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences right around New Zealand (36–44˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Höglund 1947).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal (500–800 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Ammodiscus profundissimus Saidova 1970

Pl. 2, Figs 11–12

Ammodiscus profundissimus SAIDOVA 1970, pl.2, fig.6; SAIDOVA 1975, pl.18, fig.2

DISTINGUISHING FEATURES: Test small, irregular in shape due to the irregular coiling of the second chamber; becomes much thicker from the centre to the periphery. Surface rough with a slight lustre.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records from off the east coast of central New Zealand (40–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Saidova 1975).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Abyssal (2000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Ammolagena* Eimer and Fickert 1899

Ammolagena clavata (Jones & Parker 1860)

Pl. 2, Figs 13–14

Trochammina irregularis (d'Orbigny) var. *clavata* JONES & PARKER 1860, p.304; CARPENTER, PARKER, and JONES 1862, p.142, pl.11, fig.6.

Webbina clavata (Jones & Parker). BRADY 1884, pl.41, figs 12–16.

Ammolagena clavata (Jones & Parker). LOEBLICH & TAPPAN 1987, pl.36, fig.16; LOEBLICH & TAPPAN 1994, pl.4, figs 1–4; JONES 1994, pl.41, figs 12–16.

DISTINGUISHING FEATURES: Test compressed, flask–shaped; usually attached to shell fragments or other foraminifera. Ovoid proloculus followed by a long, narrow, neck-like, tubular second chamber. Aperture terminal on tubular last chamber. Wall finely agglutinated and reddish brown colour.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off the east coast of the North Island and the northern end of the South Island (34–44˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to mid bathyal (100–800 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Glomospira* Rzehak 1885

Glomospira gordialis (Jones & Parker 1860)
Pl. 2, Figs 15–16

Trochammina squamata var. *gordialis* JONES & PARKER 1860, p.304.

Glomospira gordialis (Jones & Parker). SAIDOVA 1975, pl.18, fig.4, pl.96, fig.1; LOEBLICH & TAPPAN 1987, pl.38, figs 5–6; JONES 1994, pl.38, figs 7–9.

DISTINGUISHING FEATURES: Proloculus followed by undivided tubular chamber that is irregularly streptospirally coiled; aperture at open end of the tube. Wall finely agglutinated, often golden brown.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off the east coast of the North Island and southern South Island (35–42˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Occurs in low numbers at abyssal depths (2000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Cretaceous–Recent (Ra–Rec).

GENUS – *Tolypammina* Rhumbler 1895

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Tolypammina horrida: Wall of radiating sponge spicules.

Tolypammina vagans: Wall agglutinated, with considerable cement (rare, see Jones 1994, pl.24, figs 1–5).

Tolypammina horrida Cushman 1919
Pl. 2, Fig. 17

Tolypammina horrida CUSHMAN 1919, p.597, pl.74, fig.5.

DISTINGUISHING FEATURES: Test attached to shell or other solid material; subglobular proloculus followed by elongate, meandroid, cylindrical chamber. Wall of fine sponge spicules radiating from the surface.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Recorded from only one locality, off North Cape (34˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Cushman 1919).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf (100–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Usbekistania* Suleymanov 1960

Usbekistania charoides (Jones & Parker 1860)
Pl. 2, Figs 18–19

Trochammina squamata var. *charoides* JONES & PARKER 1860, p.304.

Glomospira charoides (Jones & Parker). UJIIE 1990, pl.1, fig.1; YASSINI & JONES 1995, figs 26–28.

Usbekistania charoides (Jones & Parker). JONES 1994, pl.38, figs 10–16; HAYWARD *et al.* 2001, figs 14E–F.

DISTINGUISHING FEATURES: Proloculus followed by an undivided tubular chamber, trochospirally enrolled around a vertical axis; circular aperture at open end of the tube. Wall finely agglutinated, usually golden brown.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences in the deep water off the east coast of both main islands (37–47˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Abyssal (2000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Cretaceous–Recent (Cn–Rec).

FAMILY – Ammosphaeroidinidae Cushman 1927

GENUS – *Adercotryma* Loeblich & Tappan 1952

Adercotryma glomeratum (Brady 1878)
Pl. 2, Figs 20–21

Lituola glomerata BRADY 1878, p.433, pl.20, figs 1a–c.

Adercotryma glomeratum (Brady). RESIG 1981, pl.10, fig.11; LOEBLICH & TAPPAN 1987, pl.67, figs 1–3; THOMAS *et al.* 1990, pl.2, fig.16; JONES 1994, pl.34, figs 15–18; HAYWARD *et al.* 2001, fig.14A; HAYWARD *et al.* 2002, pl.1, fig.1.

DISTINGUISHING FEATURES: Test small, streptospirally-enrolled, subglobular and slightly elongated along the axis of coiling. 4–5 chambers visible in final whorl. Wall coarsely agglutinated, with considerable cement.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 90): Only recorded in this study from off the east coast of New Zealand at 39–47˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Loeblich & Tappan 1987).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 90): A fairly rare species, not recorded shallower than 1200 m, and with its greatest relative abundance (3–10%) beneath or close to the CCD on the Hikurangi Plateau.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

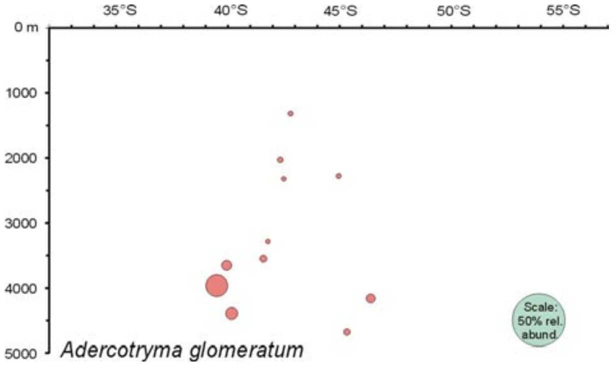


Figure 90. Latitude-depth distribution around NZ of *Adercotryma glomeratum* based on our quantitative study data of samples from >50 m depth.
Red circles are from east of New Zealand.
Circle size is proportional to relative abundance; light green circle = 50%.

GENUS – *Cystammina* Neumayr 1889

Cystammina pauciloculata (Brady 1879)
Pl. 2, Fig. 22
Trochammina pauciloculata BRADY 1879a, p.58, pl.5, figs 13–14.
Cystammina pauciloculata (Brady). RESIG 1981, pl.10, fig.14; LOEBLICH & TAPPAN 1987, pl.68, figs.1–6; ZHENG 1988, pl.41, figs 4–7; THOMAS *et al.* 1990, pl.3, fig.14; JONES 1994, pl.41, fig.1; LOEBLICH & TAPPAN 1994, pl.11, figs 3–5.

DISTINGUISHING FEATURES: Test small, slightly compressed and streptospirally enrolled. Chambers enlarging rapidly and inflated; commonly only 4 chambers per whorl with all 4 visible in the last whorl. Aperture an areal slit just above and paralleling the suture of the last chamber nearest the oldest visible chamber. Wall finely agglutinated and smooth with a slightly polished finish; yellow to brown colour.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered localities off the east coast of central New Zealand (40–46˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower bathyal and abyssal (1000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Recurvoidatus* Saidova 1970

Recurvoidatus parcus Saidova 1970
Pl. 2, Fig. 23
Recurvoidatus parcus SAIDOVA 1970, p.152, pl.4, fig.5; SAIDOVA 1975, pl.21, figs 8–9, pl.97, fig.1; HAYWARD *et al.* 2001, fig.14B.

DISTINGUISHING FEATURES: Test size up to 1 mm. Initial planispiral stage has chambers slowly increasing in size, and as it develops into the trochospiral form they begin to enlarge rapidly forming a deep, open umbilicus. The final stage appears more trochospiral than streptospiral and has an oval aperture at the base of the apertural face nearer the involute side. Sutures radial and depressed. Coarsely agglutinated throughout all stages of the test.

REMARKS: Loeblich & Tappan (1987) state that this genus is of uncertain status on the basis that their translation of Saidova's (1970) type description does not indicate the coiling direction in the initial stages of test growth. However, Ellis & Messina's (1940) translation clearly states that *Recurvoidatus* coils planispirally initially, then trochospiral or almost streptospiral. This differs from *Recurvoides* which begins streptospirally enrolled and later becomes trochospiral or planispiral.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 91): Only recorded in this study from off the east coast of New Zealand at 39–46˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Saidova 1975).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 91): Not recorded shallower than 3200 m, with its greatest relative abundance (3–8%) at mid–lower abyssal depths (3500–4500 m) just above the CCD on the Hikurangi Plateau.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

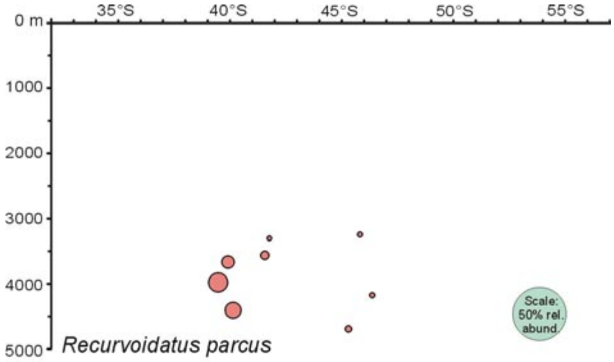


Figure 91. Latitude-depth distribution around NZ of *Recurvoidatus parcus* (red circles are east of NZ).

GENUS – *Recurvoides* Earland 1934

Recurvoides contortus Earland 1934
Pl. 2, Fig. 24
Recurvoides contortus EARLAND 1934, p.91, figs 7–19; SAIDOVA 1975, pl.22, fig.3; BOLTOVSKOY *et al.* 1980, pl.29, figs 17–20; RESIG 1981, pl.10, fig.12; LOEBLICH & TAPPAN 1987, pl.68, figs 7–9; LOEBLICH & TAPPAN 1994, pl.12, figs 1–14.

DISTINGUISHING FEATURES: Test large, subglobular, streptospirally coiled. Few chambers per whorl, later whorls may tend to be trochospiral to planispiral; earliest chambers not visible externally from either side. Aperture areal and ovate, surrounded by a distinct lip. Wall agglutinated, surface roughly finished.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 92): Recorded off both coasts of New Zealand between 34 and 54˚S, but only rare occurrences off the west coast.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Boltovskoy *et al*. 1980).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 92): This species has a wide bathymetric range from mid shelf to lower abyssal (80–5000 m), with greatest relative abundances (2–5%) at mid to upper abyssal depths (2000–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

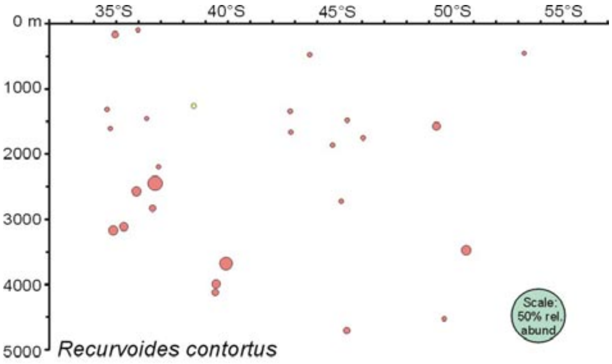


Figure 92. Latitude-depth distribution around NZ of *Recurvoides contortus* (red circles are east of NZ).

FAMILY – Cyclamminidae Marie 1941

GENUS – *Alveolophragmium* Shchedrina, 1936

Alveolophragmium zealandicum Vella 1957
Pl. 2, Figs 25–26

Alveolophragmium zealandicum VELLA 1957, p.15, pl.3, figs 44–45; HEDLEY *et al.* 1965, pl.1, fig.4; SAIDOVA 1975, pl.23, fig.6.

DISTINGUISHING FEATURES: Test large, spheroidal, involute planispiral, slightly umbilicate, with flatly rounded periphery. 6–8 chambers per whorl. Aperture a low slit arch at base of apertural face, with narrow lip. Coarsely agglutinated with rough surface.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off both coasts of the North and northern South Islands (34–44˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Saidova 1975).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf–upper bathyal (80–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Cyclammina* Brady, 1879

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Cyclammina cancellata: Test large, moderately inflated with broadly rounded periphery; 13–16 chambers per whorl (rare, see Jones 1994, pl.37, figs 8–16).

Cyclammina pusilla: Test moderate size, moderately compressed, tapering to acutely rounded periphery; 12–16 chambers per whorl.

Cyclammina trullissata: Test moderately compressed, tapering to acutely rounded periphery; 8–10 chambers per whorl; surface smooth and polished.

Cyclammina pusilla Brady 1881
Pl. 3, Figs 1–2

Cyclammina pusilla BRADY 1881b, p.53; SAIDOVA 1975, pl.24, figs 5–6; JONES 1994, pl.37, figs 20–23.

DISTINGUISHING FEATURES: Test moderate size; biconvex, depressed at the umbilici, flat centrally, tapering to the periphery in profile view. 12–16 chambers in last whorl.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Two records from east of the South Island (45˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower bathyal–abyssal (1500–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Cyclammina trullissata (Brady 1879)
Pl. 3, Figs 3–4

Trochammina trullissata BRADY 1879a, p.56, pl.5, figs 10–11.

Cyclammina trullissata (Brady). BARKER 1960, pl.40, fig.13; SAIDOVA 1975, pl.24, figs 1–4; RESIG 1981, pl.10, fig.8; JONES 1994, pl.40, figs 13,16; LOEBLICH & TAPPAN 1994, pl.14, figs 7–8.

DISTINGUISHING FEATURES: Test small to medium size; biconvex, depressed at the umbilici, flat centrally, tapering to the periphery in profile view. 8–10 chambers in last whorl; sutures essentially straight initially, but in later chambers becoming slightly sigmoidal. Wall light to dark brown colour, with a polished finish.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences right around New Zealand (32–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Abyssal restricted (2000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Discamminidae Mikalevich 1980

GENUS – *Ammoscalaria* Höglund 1947

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Ammoscalaria georgescotti: Test moderately flaring, with a narrow early spiral section; moderately compressed.

Ammoscalria tenuimargo: Test narrow, with a wide early spiral section; strongly compressed (mostly inner shelf, see Hayward *et al.* 1999, pl.1, figs 17–18).

Ammoscalaria georgescotti Hayward n.sp.

Pl. 3, Figs 8–12

Reophax depressus Natland. ZHENG 1988, pl.12, figs 4–6.

Ammoscalaria (?) *compressa* (Cushman & McCulloch). LOEBLICH & TAPPAN 1994, pl.6, figs.3–13.

Ammobaculites sp. nov. JONES 1994, pl.33, figs.7,9–11.

DESCRIPTION: Test large, elongate, narrowly flaring; greatest breadth somewhat above the middle; periphery rounded; moderately compressed in cross-section. Early chambers indistinct, but clearly arranged in a planispiral coil of similar or greater diameter to the first uniserial chamber; usually four uniserial rectilinear chambers in mature specimens separated by horizontal, curved or slightly chevron-shaped sutures that maybe nearly flush or quite deeply incised, particularly between the last two chambers. Early uniserial chambers wider than high, but last one or two may be of equal width and height. Aperture terminal, short slit surrounded by a low lip and usually on the end of a compressed protuberance. Wall coarsely agglutinated of sand particles of different composition glued together in a fine silty matrix; surface rough.

REMARKS: The most similar species to *A. georgescotti* is *Ammofrondicularia compressa* Cushman & McCulloch (1939) but its type population from Galapagos Islands is far more flaring. This new species appears to be conspecific with specimens illustrated by Jones (1994) and Loeblich & Tappan (1994) also from the west Pacific. This species is much larger, less compressed and more coarsely agglutinated than the other New Zealand species *A. tenuimargo.*

TYPE LOCALITY: New Zealand, 6’ east of North Cape, 150 m water depth, Mestayer Stn 20, collected 8 Sept 1914, GNS catalogue number F201517 (17 specimens).

HOLOTYPE: TF1665/1 (GNS Science, Lower Hutt), Pl. 3, Figs 8-10.

PARATYPES: TF16665/2, figured specimens from type locality, Pl. 3, Figs 11–12; TF1665/3–4, 4 specimens from type locality; USNM, 3 specimens from type locality.

SIZE: 2–4 mm long.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Recorded off northern New Zealand and off the west coast of the South Island: F201019, off North Cape, 150 m (31 specimens); F202482, off North Cape (34° 24’ 11” S, 173° 10’ 36” E), 380 m (12 specimens); F201288–9, off Greymouth, 610 m (2 specimens).

WORLD GEOGRAPHIC DISTRIBUTION: Also recorded from 300 m depth in Torres Strait, Queensland (Jones 1994) and from 95–300 m in the Sahul Sea (Loeblich & Tappan 1994). South-west Pacific.

NEW ZEALAND BATHYMETRIC DISTRIBUTION: 150–610 m depth, greatest abundance on outer shelf.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

ETYMOLOGY: Named after well-known New Zealand micropaleontologist George Scott (GNS Science) who has devoted his lifetime career to the study of foraminifera.

GENUS – *Discammina* Lacroix 1932

Discammina compressa (Goës 1882)

Pl. 3, Figs 5-7

Lituola irregularis var. *compressa* GOËS 1882, p.141, pl.12, figs 421–423.

Discammina compressa (Goës). BARKER 1960, pl.33, figs 26–28; LOEBLICH & TAPPAN 1987, pl.52, figs 1–4; JONES 1994, pl.33, figs 26–28.

DISTINGUISHING FEATURES: Test small to moderate in size, planispiral, evolute, biumbilicate; umbilical regions depressed. Sutures hard to distinguish. Wall coarsely agglutinated.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences right around New Zealand (34–49˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to upper abyssal (100–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Globotextulariidae Cushman 1927

GENUS – *Liebusella* Cushman 1933

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Liebusella goësi: Test moderate size; coarsely agglutinated; often only found as triserial juveniles.

Liebusella soldanii: Test large, cylindrical; smoothly finished wall.

Liebusella goësi Höglund 1947

Pl. 3, Fig. 13

Liebusella goësi Höglund 1947, pl.14, figs 4–8.

DISTINGUISHING FEATURES: Test subfusiform, early stage trochospiral to triserial, and in large adults having uniserial chambers. Aperture in triserial juveniles is a high interiomarginal arch in the center of the slightly excavated apertural face; in uniserial adults the aperture is a highly variable fissure, sometimes divided into several openings located near the centre of the face. Wall coarsely agglutinated and the surface roughly finished.

REMARKS: In our New Zealand study we have only encountered triserial juveniles of this species and they are hard to distinguish from the shallow water, herbivorous species *Egerelloides scaber*, which occurs in sheltered, slightly brackish water around southern New Zealand (e.g. Hayward and Grenfell, 1999; Hayward *et al.*, 2007c).

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off the east coast of the South Island and the Subantarctic (43–53˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan

(Höglund, 1947).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper bathyal (200–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Liebusella soldanii (Jones & Parker 1860)
Pl. 3, Figs 14–15
Lituola nautiloidea var. *soldanii* JONES & PARKER 1860, p.307.
Liebusella soldanii (Jones & Parker). LOEBLICH & TAPPAN 1987, pl.152, figs 11–16; JONES 1994, pl.32, figs 12–18.

DISTINGUISHING FEATURES: Test large, stout, with early trochospiral coil; rapidly reducing to uniserial in the adult. Chambers inflated, somewhat overlapping previous chambers; interiors subdivided by vertical partitions. Aperture terminal, slightly produced, commonly of several irregular slit-like openings. Wall thick, commonly with calcareous particles; surface smoothly finished.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Only recorded from off the east coast of the northern North Island (34–37°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones & Parker 1860).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid–outer shelf (50–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Rhumblerella* Brönnimann 1981

Rhumblerella humboldti (Todd & Brönnimann 1957)
Pl. 3, Figs 16–17
Eggerella humboldti TODD & BRöNNIMANN 1957, p.26, pl.2, fig.26, pl.3.
Rhumblerella humboldti (Todd & Brönnimann). LOEBLICH & TAPPAN 1987, pl.151, figs 1–4; LOEBLICH & TAPPAN 1994, pl.20, figs 1–7.

DISTINGUISHING FEATURES: Test tiny, short, subconical; chambers inflated subglobular, in trochospiral arrangement, 3–4 chambers in final whorl. Aperture a narrow opening at the bottom of the suture between the final and second to last chambers. Wall coarsely agglutinated, surface roughly finished.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off the east coast of both islands (35–51°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Loeblich & Tappan 1987, 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal to abyssal (600–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Verneuilinulla* Saidova 1975

Verneuilinulla propinqua (Brady 1884)
Pl. 3, Figs 18–19
Verneuilina propinqua BRADY 1884, p.387, pl.47, figs 8–12.
Verneuilinulla propinqua (Brady 1884). JONES 1994, pl.47, figs 8–12.

DISTINGUISHING FEATURES: Test large, elongate, subconical; short early trochospiral stage followed by longer triserial stage. Chambers inflated globular; sutures incised. Aperture an interiomarginal arch at the base of last chamber. Wall thick, coarsely agglutinated, brown.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare, recorded from east of central New Zealand (42°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Middle abyssal (3000–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Haplophragmoididae Maync 1952

GENUS – *Buzasina* Loeblich & Tappan 1985

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:
Buzasina galeata: Test subglobular; 3 chambers in final whorl; simple aperture.
Buzasina ringens: Test compressed; 4 chambers in final whorl; slit–like aperture (rare, see Jones 1994, pl.40, figs 17–18).

Buzasina galeata (Brady 1881)
Pl. 3, Figs 20–21
Trochammina galeata BRADY 1881b, p.52.
Buzasina galeata (Brady). LOEBLICH & TAPPAN 1987, pl.48, figs 5–7; JONES 1994, pl.40, figs 19–23.

DISTINGUISHING FEATURES: Test planispirally enrolled; 3 strongly overlapping and rapidly enlarging chambers per whorl, in 2–3 whorls. Final chamber comprising more than one–half of the test. Aperture a simple opening on the peripheral face of the final chamber. Wall finely agglutinated.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Several occurrences off the east coast of the North Island and northern South Island, especially the Hikurangi Plain (32–45°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid to lower abyssal (3500–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Cribrostomoides* Cushman 1910

Labrospira Höglund 1947

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:
Cribrostomoides crassimargo: Test subglobose with

lobate periphery; 5–9 inflated chambers per whorl; incised sutures; coarsely agglutinated.

Cribrostomoides jeffreysi: Test compressed with rounded periphery; 5–7 chambers per whorl; moderately coarsely agglutinated.

Cribrostomoides spiculolega: Test compressed; 7–8 chambers per whorl; agglutinated with mix of silt and spicules, smooth finish.

Cribrostomoides subglobosus: Test involute, subglobose; initially streptospiral, later planispiral; 5–7 chambers per whorl; coarsely agglutinated, brown or grey.

Cribrostomoides wiesneri: Test small, moderately compressed with broadly rounded periphery; 7–9 chambers per whorl; finely agglutinated, smooth; yellow or reddish brown.

Cribrostomoides crassimargo (Norman 1892)

Pl. 3, Figs 22–23

Haplophragmium crassimargo NORMAN 1892, p.17.

Labrospira crassimargo (Norman). LOEBLICH & TAPPAN 1987, pl.49, figs 10–11; LOEBLICH & TAPPAN 1994, pl.10, figs 1–3.

Veleroninoides crassimargo (Norman). JONES 1994 pl.35, fig.4.

Cribrostomoides jeffreysi (Williamson). HAYWARD *et al*. 1999, pl.1, figs 23–24.

DISTINGUISHING FEATURES: Test planispiral, slightly evolute. Chambers inflated, 5–9 per whorl; sutures depressed; lobate periphery. Wall coarsely agglutinated.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Two recorded occurrences from off the east coast of the South and southern North Island (40–47˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Inner shelf to abyssal (2–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Cribrostomoides jeffreysi (Williamson 1858)

Pl. 3, Figs 24–25

Nonionina jeffreysi WILLIAMSON 1858, p.34, pl.3, figs 72–73.

Labrospira jeffreysi (Williamson). HÖGLUND 1947, pl.11, fig.3; UJIIE 1995, pl.2, fig.2.

Veleroninoides jeffreysii (Williamson). JONES 1994, pl.35, figs 1–3,5.

Cribrostomoides jeffreysi (Williamson). YASSINI & JONES 1995, figs 70–71.

DISTINGUISHING FEATURES: Test planispiral, partly involute, early whorl clearly visible in the umbilical depression; compressed with rounded periphery. 5–7 chambers per whorl; sutures distinct and sinuous. Aperture an arcuate slit above the base of the final chamber. Wall moderately coarsely agglutinated.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences throughout New Zealand (35–47˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Williamson 1858).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Inner–mid shelf (10–100 m), with a few possibly displaced bathyal records off the east coast of the northern South Island.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Cribrostomoides spiculolega (Parr 1950)

Pl. 3, Figs 26–27

Trochammina spiculolega PARR 1950. p.278, pl.5, figs 8–10.

Cribrostomoides spiculotesta ZHENG 1979, p.113, pl.1, fig.10.

Labrospira spiculotesta (Zheng). LOEBLICH & TAPPAN 1994, pl.10, figs 4–5 (not figs 6–9)

DISTINGUISHING FEATURES: Test small, compressed, planispiral, slightly evolute; periphery rounded, slightly lobulate. 7–8 chambers per whorl; chambers slightly inflated, increasing gradually in size as added. Wall composed of fine sand grains and sponge spicules of various sizes, surface neatly finished.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Only recorded from off the coast of the Auckland Islands (51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Zheng 1979).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Inner–mid shelf (10–100 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Cribrostomoides subglobosus (Cushman 1910)

Pl. 3, Figs 28–29

Haplophragmoides subglobosum CUSHMAN 1910, p.106, text-figs 162–164.

Cribrostomoides subglobosus (Cushman). RESIG 1981, pl.10, fig.7; JONES 1994, pl.34, figs 8–10.

DISTINGUISHING FEATURES: Test subglobose; initially streptospirally coiled, and later planispiral, involute; umbilicus usually depressed. 5–7 broad, moderately lobulate chambers; sutures radial. Aperture an equatorial slit or series of openings at the base of the apertural face. Wall brown or grey.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences in low numbers right around New Zealand (32–48˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Lagoe 1979).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mostly mid bathyal–abyssal (800–5000 m), with one record from shelf depths.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Cribrostomoides wiesneri (Parr 1950)

Pl. 4, Figs 1–2

Labrospira wiesneri PARR 1950, figs 14–15; SAIDOVA 1975, pl.96, figs 8–9.

Veleroninoides wiesneri (Parr), JONES 1994, pl.40, figs 14–15.

Cribrostomoides wiesneri (Parr). THOMAS *et al.* 1990, pl.3, fig.1; YASSINI & JONES 1995, figs 80,85.

DISTINGUISHING FEATURES: Test moderately compressed; periphery broadly rounded, slightly lobulate; planispiral, slightly evolute, with chambers of earlier coils visible in slightly depressed, umbilical region. 7–9 chambers in final whorl. Aperture a narrow slit along base of the apertural face. Wall of fine sand grains with yellowish or reddish–brown cement; surface smooth and polished.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic records from east of the North Island and northern South Island (36–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Thomas *et al.* 1990).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower bathyal to mid abyssal (1000–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Haplophragmoides* Cushman 1910

Haplophragmoides neobradyi Uchio 1960

Pl. 4, Figs 3–4

Haplophragmoides neobradyi UCHIO 1960, p.51, pl.7, figs 15–16.

DISTINGUISHING FEATURES: Test small, planispiral, slightly evolute; moderately compressed in cross-section, periphery broadly rounded; subquadrate in outline, slightly lobulate. 4.5–5 chambers per whorl; chambers as broad or slightly broader than wide; sutures straight radiate, slightly depressed. Aperture a short slit at the base of the apertural face. Wall finely agglutinated, smooth and polished, yellowish–brown.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrences off the east coast of both islands (36–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Uchio 1960).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Rare at bathyal and abyssal depths (300–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Hormosinidae Haeckel 1894

GENUS – *Hormosina* Brady 1879

Hormosina pilulifera (Brady 1884)

Pl. 4, Figs 5–8

Reophax pilulifera BRADY 1884, p. 292, pl. 30, figs 18–20.

Reophax pilulifer Brady. YASSINI & JONES 1995, fig.20.

Hormosina pilulifera (Brady). JONES 1994, pl.30, figs 18–20.

DISTINGUISHING FEATURES: Test large, uniserial, rectilinear or arcuate. 3 to 5 globular chambers, increasing in size as added. Aperture terminal on a short neck. Wall composed of coarse sand grains, with fine-grained cement in the interstices, presenting a nearly smooth exterior. Maybe brown in colour.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off the east coast of northern North Island (34–37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to mid bathyal (150–1000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Hormosinella* Shchedrina 1969

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Hormosinella distans: Fusiform chambers with long slender connections.

Hormosinella guttifera: Squat pyriform chambers with short slender connections.

Hormosinella distans (Brady 1881)

Pl. 4, Figs 9–10

Reophax distans BRADY 1881b, p.50; BRADY 1884, p.296, pl.31, figs 18–22.

Hormosinella distans (Brady). SAIDOVA 1975, pl.10, fig.3; LOEBLICH & TAPPAN 1987, pl.44, figs 6–9; LOEBLICH & TAPPAN 1994, pl.5, figs 15–17; JONES 1994, pl.31, figs 18–22.

DISTINGUISHING FEATURES: Uniserial, rectilinear to slightly arcuate. Chambers ovate to fusiform separated by elongate, delicate, and stolon-like necks. Wall agglutinated, thin.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records off both coasts of the North Island (36–41˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper–mid abyssal (2000–3500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Hormosinella guttifera (Brady 1881)

Pl. 4, Figs 11–12

Reophax guttifera BRADY 1881b, p.49; BRADY 1884, p.295, pl. 31, figs 10–15.

Hormosinella guttifera (Brady). JONES 1994, pl. 31, figs 10–15; UJIIE 1995, pl.1, fig.19; LOBEGEIER & SEN GUPTA 2008, pl.4, fig.6.

DISTINGUISHING FEATURES: Test elongate, uniserial, nearly straight. Chambers squat pyriform, broadest at the base and rather rapidly narrowing to the apex; separated by short slender necks. Wall coarsely agglutinated; yellowish–brown colour.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records east of central New Zealand (39–42˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Abyssal (2000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Reophax* Montfort 1808; emend Brönnimann & Whittaker 1980

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Reophax dentaliniformis: Test elongate; chambers increasing in size gradually; apertural neck; test grey.

Reophax hispidulus: Test small; chambers pyriform with long apertural neck; numerous fine spicules project in all directions.

Reophax nodulosus: Test elongate; chambers ovate; proloculus elongate; finely agglutinated, brown.

Reophax spiculifer: Test large, slender elongate; chambers elongate; wall entirely of long sponge spicules.

Reophax subfusiformis: Test large, with few subovate, rapidly enlarging chambers; coarsely agglutinated; apertural neck; test grey.

Reophax dentaliniformis Brady 1881

Pl. 4, Fig. 13

Reophax dentaliniformis BRADY 1881b, p.49; SAIDOVA 1975, pl.12, figs 1–2; RESIG 1981, pl.5, fig.2; SCHRÖDER *et al.* 1988, pl.5, fig.4; HUGHES 1988, pl.1, fig.27 only (fig. 26 is not *R. dentaliformis*); THOMAS *et al.* 1990, pl.1, fig.5; JONES 1994, pl.30, figs 21–22.

Nodulina dentaliniformis (Brady). LOEBLICH & TAPPAN 1987, pl.44, figs 10–11.

Hormosina dentaliniformis (Brady). BARKER 1960, p.62, pl.30, figs 21–22.

DISTINGUISHING FEATURES: Test large, elongate. Up to 7 cylindrical and gradually enlarging chambers. Aperture terminal, rounded at the end of a short apertural neck. Wall of moderately sized agglutinated sand, grey.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records off both coasts of the North Island and northern South Island (36–42˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper–mid abyssal (2000–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Reophax hispidulus Cushman 1920

Pl. 4, Figs 14–15

Reophax hispidulus CUSHMAN 1920, p.24, pl.5, fig.7.

DISTINGUISHING FEATURES: Test small, fragile. Chambers pyriform with a bluntly rounded base and tapering up to a long neck composed of longitudinally arranged spicules. Wall glassy of sand grains and numerous fine spicules randomnly arranged and projecting in all directions from the test.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: One record off the east coast of central New Zealand (44–45˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Cushman 1920).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower bathyal (1000–1500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Reophax nodulosus Brady 1879

Pl. 4, Figs 16–17

Reophax nodulosus BRADY 1879a, p.52; SCHRÖDER *et al.* 1988, p.35, pl.5, fig.8; JONES 1994, pl.31, figs 6–9.

Pseudonodosinella nodulosa (Brady). LOEBLICH & TAPPAN 1987, pl.46, figs 5–6.

DISTINGUISHING FEATURES: Test slender elongate, slightly tapered. Chambers ovate, widest below mid–length of chamber; sutures incised; proloculus elongate. Wall finely agglutinated, brownish.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered records east of central New Zealand (40–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Abyssal (2000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Reophax spiculifer Brady 1879

Pl. 4, Figs 18–19

Reophax spiculifer BRADY 1879a, p.54, pl.4, figs 10–11; HUGHES 1988, pl.2, figs 8–9; JONES 1994, pl.31, figs 16–17; YASSINI & JONES 1995, fig.13.

DISTINGUISHING FEATURES: Test large, slender elongate; consisting of a few cylindrical chambers. Chambers entirely composed of siliceous sponge spicules, arranged side by side and often protruding more or less from the base of the chambers.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off the east coast of New Zealand (35–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to abyssal (100–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Reophax subfusiformis Earland 1933
Pl. 4, Fig. 20

Reophax subfusiformis EARLAND 1933, p.74, pl.2, figs 16–19; HAYWARD *et al.* 1999, pl.1, figs 15–16.

DISTINGUISHING FEATURES: Test large, with 4–6 rapidly inflating, rounded chambers often on a curving axis. Final chamber nearly half test length and often fusiform; sutures incised. Aperture rounded, terminal, usually on a short tapering neck, which may be damaged or absent. Wall medium to coarsely agglutinated with angular grains.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Recorded from around all three main islands of New Zealand (34–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Murray 1991).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Numerous scattered occurrences in deep, sheltered harbours and inlets and at greater depths (20–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Lituolidae de Blainville 1827

GENUS – *Ammobaculites* Cushman 1910

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Ammobaculites agglutinans: Test large; involute subglobular coil; coarsely agglutinated.

Ammobaculites filiformis: Test small; uniserial chambers higher than broad, periphery slightly lobulate; coarsely agglutinated.

Ammobaculites paradoxus: Test small; involute asymmetrical coil; uniserial chambers as broad as high; parallel–sided uniserial portion; finely agglutinated, brown.

Ammobaculites agglutinans (d'Orbigny 1846)
Pl. 4, Figs 21–22

Spirolina agglutinans D'ORBIGNY 1846, p.137, pl.7, figs 10–12.

Ammobaculites agglutinans (d'Orbigny). HEDLEY *et al.* 1965, pl.1, figs 2–3; LOEBLICH & TAPPAN 1987, pl.58, figs 3–4; JONES 1994, pl.32, figs 19–20, 24–26.

DISTINGUISHING FEATURES: Test large; involute subglobular initial coil. A few large, inflated uniserial chambers; sutures slightly depressed. Wall coarsely agglutinated.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic records east of the northern North Island (34–36˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf (100–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Cretaceous–Recent (Mh–Rec).

Ammobaculites filiformis (Earland 1934)
Pl. 4, Figs 23–24

Ammobaculites agglutinans var. *filiformis* EARLAND 1934, p.92, pl.3, figs 11, 13.

Ammobaculites filiformis (Earland). SAIDOVA 1975, pl.25, figs 9–10; JONES 1994, pl.32, figs 22–23.

DISTINGUISHING FEATURES: Test small, slender, elongate; small initial coil slightly wider than lower part of uniserial section. Small uniserial chambers are generally higher than broad; sutures distinct. Sides of uniserial section usually slightly lobulate. Aperture small, circular, on short neck. Wall coarsely agglutinated, usually grey.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: One rare record off the east coast of the southern North Island (40˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper abyssal (2000–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Ammobaculites paradoxus Clark 1994
Pl. 4, Figs 25–26

Ammobaculites paradoxus CLARK 1994, p.110–113, pl.1, figs 5–22.

DISTINGUISHING FEATURES: Test minute, elongate slender. Numerous uniserial chambers separated by weakly depressed horizontal sutures; chambers as broad as high. Sides of uniserial section usually smooth and parallel, very slightly tapered. Wall fine-grained, polished, often brownish.

REMARKS: The synonomy of this species is published in both Clark (1994) and Hess (1998). Inclusion in their synonymy of Brady's figured specimens in Barker (1960, pl.32, figs 21–23) appears to be in error, as these are coarsely agglutinated *A. filiformis.*

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Moderately frequent records, but only from off the east coast of the southern North Island on the Hikurangi Plateau (39–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Clark 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower bathyal to lower abyssal (1200–4500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Ammomarginulina* Wiesner 1931.

Ammomarginulina ensis Wiesner 1931
Pl. 4, Figs 27–28

Ammomarginulina ensis WIESNER 1931, p.97; SAIDOVA 1975, pl.26, fig.6; LOEBLICH & TAPPAN 1987, pl.60, fig.7.

DISTINGUISHING FEATURES: Test strongly compressed; enrolled and planispiral in early stage, later uncoiled and rectilinear with oblique sutures. Aperture terminal, necked. Wall coarsely agglutinated with roughly finished surface.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences around both main islands of New Zealand (36–47˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Loeblich & Tappan 1987).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower bathyal to abyssal (1000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Eratidus* Saidova 1975

Eratidus foliaceus (Brady 1881)
Pl. 4, Figs 29–30

Haplophragmium foliaceum BRADY 1881b, p.50.*Eratidus foliaceus* (Brady). SAIDOVA 1975, pl.26, fig.4; JONES 1994, pl.33, figs 20–25; LOEBLICH & TAPPAN 1987, pl.59, figs 1–3.

DISTINGUISHING FEATURES: Test elongate, flattened, delicate early portion planispiral, later rectilinear, with broad and centrally arched chambers. Rectilinear portion of lesser diameter than the coiled portion. Aperture terminal, elongate. Wall agglutinated, thin, and transparent.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Records so far restricted to east of the southern North Island on the Hikurangi Plateau (39–42˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid abyssal (3000–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – **Pseudobolivinidae** Wiesner 1931

GENUS – *Parvigenerina* Vella 1957

Parvigenerina arenacea (Heron-Allen & Earland 1922)
Pl. 4, Figs 31–32

Bifarina porrecta (Brady) var. *arenacea* HERON-ALLEN & EARLAND 1922, p. 132.

Parvigenerina arenacea (Heron-Allen & Earland). LOEBLICH & TAPPAN 1987, pl.123, figs 13–16.

DISTINGUISHING FEATURES: Test tiny, biserial, later loosely twisted, biserial, and finally uniserial. Aperture terminal, produced on a distinct neck. Wall finely agglutinated, fragile.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: One record off the east coast of northern North Island (37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South–west Pacific (Loeblich & Tappan 1987).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf (200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – **Spiroplectamminidae** Cushman 1927

GENUS– *Spiroplectammina* Cushman 1927

Spiroplectammina carteri Hayward **n.sp.**
Pl. 4, Figs 33–37

Spiroplectammina biformis (Parker and Jones). JONES 1994, pl.45, figs 25–27; HAYWARD *et al.* 2001, figs 14C–D; MAJEWSKI & ANDERSON 2009, fig.3.3.

NOT *Textularia agglutinans* var. *biformis* PARKER & JONES 1865, p.370, pl.15, figs 23a–b, 24.

NOT *Spiroplectammina biformis* (Parker and Jones). LOEBLICH & TAPPAN 1987, pl.119, figs 19–20.

DESCRIPTION: Test free, tiny, elongate. Early planispiral coil with a few chambers, followed by an uncoiled, biserial part; width of the biserial part only slightly narrower than initial coil. Biserial portion ovoid in cross-section with broadly rounded margins. Biserial portion parallel-sided to weakly lobulate. Aperture a low, interiomarginal arch at the base of the last chamber. Wall moderately coarsely agglutinated.

REMARKS: Our specimens are identical to two from deep-water in the South Atlantic Ocean that have been illustrated and incorrectly identified by Brady (1884) and all other subsequent revisers of his plates as *Spiroplectammina biformis* (Parker & Jones 1865). Our deep-water species differs from true *S. biformis* that lives in shallow water in the Arctic and Subantarctic (e.g. Hayward *et al.* 2007c) in having a wider biserial portion, less incised sutures, less lobular periphery, and finer agglutinated test.

TYPE LOCALITY: New Zealand, Hikurangi Plateau, 40° 09’ 55” S, 176° 08.05’ 00” W, 4394 m depth, sample RR050333, collected by RV Roger Revelle; GNS catalogue number F202615.

HOLOTYPE: TF1666/1 (GNS Science, Lower Hutt) from type locality, Pl. 4, Figs 35–37.

PARATYPES: TF1666/2, 3 one figured (Pl. 4, Figs 33-34) and four unfigured specimens from Hikurangi Plateau, GNS catalogue number F202369, 3654 m depth; USNM, 3 specimens from Hikurangi Plateau, ODP 1124B–1H–1, 0–2 cm, 3967 m depth.

SIZE: 0.08–0.12 mm long.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 93): Limited recorded range at lower bathyal or greater depths in this study from east of New Zealand between 39 and 45˚S.

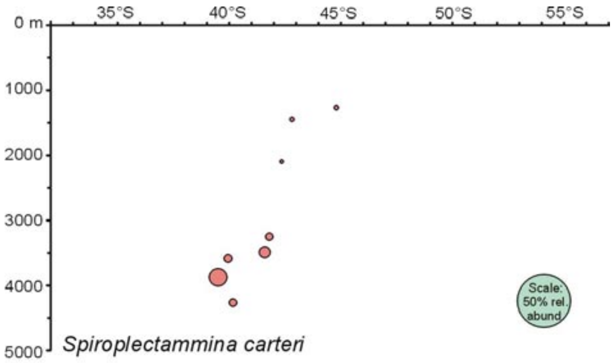


Figure 93. Latitude-depth distribution around NZ of *Spiroplectammina carteri* n.sp. (red circles are east of NZ).

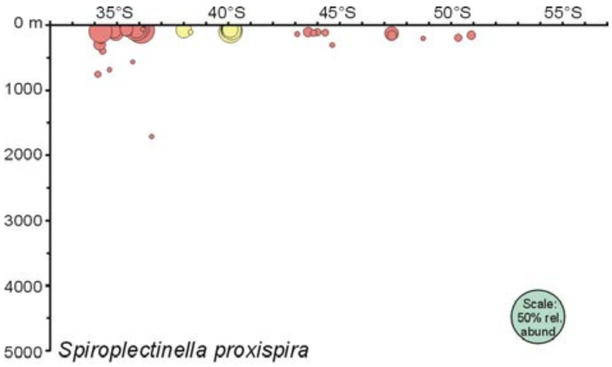


Figure 94. Latitude-depth distribution around NZ of *Spiroplectinella proxispira* (red circles are east of NZ, yellow circles are west of NZ; circle size is proportional to relative abundance; light green circle = 50%).

WORLD GEOGRAPHIC DISTRIBUTION: Southern Ocean (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 93): In this study *S. carteri* has been recorded from lower bathyal and abyssal depths (1000–4500 m) with greatest relative abundances (1–8%) at mid–lower abyssal depths (3000–4500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

ETYMOLOGY: Named after our colleague Rowan Carter, who picked and identified most of the New Zealand specimens of this species as part of our study of the deep-water foraminifera from east of New Zealand (Hayward *et al.* 2001, 2002).

GENUS – *Spiroplectinella* Kisel'man 1972

Spiroplectinella proxispira (Vella 1957)
Pl. 4, Figs 38–40

Textularia proxispira VELLA 1957, p.15–16, pl.3, figs 48,52.

Textularia ensis VELLA 1957, p.16, pl.3, figs 46–47.

Spiroplectinella proxispira (Vella). HAYWARD *et al.* 1999, pl.2, figs 9–11.

DISTINGUISHING FEATURES: Test twice as long as wide, may be initially coiled then biserial and rapidly increasing in size; early chambers often wedge-shaped in profile, with carinate periphery, later part of the test has sub–parallel sides with more inflated rounded chambers; sutures distinct, straight or slightly curved. Final chamber usually rounded with a small crescentic aperture in the middle of the inner margin.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 94): Widespread around all of New Zealand, between 28˚S (Kermadec Islands) and 51˚S (Auckland Islands).

WORLD GEOGRAPHIC DISTRIBUTION: Possibly a New Zealand endemic; records unknown from further afield.

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 94): A common species at deep inner to mid shelf depths (reaching abundances up to 20% of benthic faunas above 80 m depth) off exposed coasts. Also widespread but not so abundant (up to 5%) at outer shelf depths shallower than 150 m. Several records of rare specimens from bathyal depths could be the result of downslope transport.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Spirotextularia* Saidova 1975

Spirotextularia fistulosa (Brady 1884)
Pl. 4, Figs 41–43

Textularia saggitula Defrance var. *fistulosa* BRADY 1884 (part), p.362, pl.42, figs 20–22.

Spirotextularia fistulosa (Brady). HAYWARD *et al.* 1999, pl.2, figs 12–13.

DISTINGUISHING FEATURES: Test with planispiral coil of one whorl; later biserial with chambers laterally produced. Internally a second septum cuts off the outer part of each chamber leaving no connection from the distal chamberlet to the main chamber. Aperture interiomarginal, a low arch against the previous chamber. Wall agglutinated, commonly of calcareous fragments.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences in low numbers off the east coast of northern North Island (28–37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Widespread in the Pacific Ocean (Nomura 1981, Loeblich & Tappan 1987, 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Occurs at inner shelf to uppermost bathyal depths (30–300 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Textulariellidae Grönhagen & Luterbacher 1966

GENUS – *Textulariella* Cushman 1927

Textulariella barrettii (Jones & Parker 1876)
Pl. 4, Figs 44-47

Textularia barrettii JONES & PARKER 1876, p.99.
Textulariella barrettii (Jones & Parker). LOEBLICH & TAPPAN 1987, pl.154, figs 5–6; JONES 1994, pl.43, fig.17, pl.44, figs 3,6–8.

DISTINGUISHING FEATURES: Test large, subconical; almost circular in cross-section; flat to concave apertural end. Early tochospiral coil, becoming biserial; sutures slightly limbate. Lipped, slit aperture terminal at base of last chamber. Wall finely agglutinated.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs in three samples off North Cape (34˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf–uppermost bathyal (150–250 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Verneuilinidae Cushman 1911

GENUS – *Gaudryina* d'Orbigny 1839

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:
Gaudryina convexa: Biserial part triangular or rounded ovate in cross-section; wall moderately finely agglutinated.
***Gaudryina quadrangularis*:** Biserial part more or less quadrangular in cross-section; wall coarsely agglutinated.

Gaudryina convexa (Karrer 1865)
Pl. 4, Figs 48–51
Textularia convexa KARRER 1865, p.78, pl.16, fig.8.
Gaudryina convexa (Karrer). HAYWARD *et al.* 1999, pl.2, figs 14–15.

DISTINGUISHING FEATURES: This species is characterised by its triangular test, flat to concave faces, and rounded, keeled peripheries. Triangular to rounded ovate cross-section in biserial stage. Wall finely to moderately coarsely agglutinated.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 95): Recorded from off both sides of New Zealand and at the Kermadec Islands, north of Christchurch and the Chatham Islands, between 28 and 44˚S, with a solitary record from 50˚S on the outer shelf around the Auckland Islands.

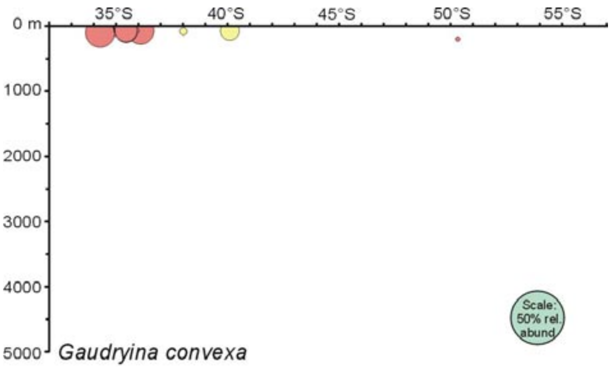


Figure 95. Latitude-depth distribution around NZ of *Gaudryina convexa* (red circles are east of NZ, yellow circles are from west of NZ).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Li *et al.* 1998, Culver & Buzas 1980).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 95): Common to abundant (up to 25% of benthic faunas) in exposed, inner–mid shelf, often coarse sediment environments that are frequently subjected to strong current or storm wave activity.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Po–Rec).

Gaudryina quadrangularis Bagg 1908
Pl. 4, Figs 52–53
Gaudryina quadrangularis Bagg 1908, p.133, pl.5, fig.1; LOEBLICH & TAPPAN 1994, pl.17, figs 22–23.

DISTINGUISHING FEATURES: Test large, elongate, tapering abruptly at the initial end. Early triserial part short and triangular; later biserial part more or less quadrangular in cross-section. Wall coarsely agglutinated and rough.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Several records from east of northern North Island (34–36˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Culver & Buzas 1982).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf (100–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

ORDER – Trochamminida Saidova 1981

FAMILY – Trochamminidae Schwager 1877

GENUS – *Alterammina* Brönnimann & Whittaker 1988

Alterammina alternans (Earland 1934)
Pl. 5, Figs 1-4
Trochammina alternans EARLAND 1934, p.103, pl.3, figs 24–27.
Alterammina alternans (Earland). BRÖNNIMANN & WHITTAKER 1988, p.123, figs 45–46.

DISTINGUISHING FEATURES: Test small, initially trochospiral for the first whorl, followed by biserial coils of two alternating chambers per whorl. Chambers inflated and increasing rapidly in size as added. Aperture single opening on the umbilical side, at the base of the last chamber.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic records from off the east coast of the two main islands (36–46˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan

(Earland, 1934).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper and mid abyssal (2000–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Paratrochammina* Brönnimann 1979 emend. Brönnimann & Whittaker 1988

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Paratrochammina bartrami: Test small, concavo-convex; 5–8 chambers per whorl, umbilical sutures sigmoid (mostly inner shelf, see Hayward *et al.* 1999, pl.2, figs 1–3).

Paratrochammina challengeri: Test large; chambers globose, 4 per whorl, strongly lobulate outline.

Paratrochammina simplissima: Test small, moderately compressed; 4–5 chambers per whorl, umbilical sutures radial.

Paratrochammina challengeri Brönnimann & Whittaker 1988.

Pl. 5, Figs 5–7

Paratrochammina challengeri BRÖNNIMANN & WHITTAKER 1988, p.43–44, figs 16H–K; JONES 1994, pl.35, fig.10; LOEBLICH & TAPPAN 1994, pl.22, figs 7–12; UJIIE 1995, pl.2, fig.5; HAYWARD *et al.* 2001, fig.14G; HAYWARD *et al.* 2002, pl.1, fig.2.

DISTINGUISHING FEATURES: Test trochospiral, depressed umbilicus, strongly lobulate outline. Up to 3 whorls, with 4 globose chambers in final whorl; sutures deeply depressed. Small umbilical–extraumbilical aperture. Wall coarsely agglutinated.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered records from throughout New Zealand (34–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to mid abyssal (150–4000 m), most frequent at lower bathyal and greater depths (1000 m+).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Paratrochammina simplissima (Cushman & McCulloch 1948)

Pl. 5, Figs 8–10

Trochammina pacifica Cushman var. *simplex* CUSHMAN & McCULLOCH 1939, p.104, pl.11, fig.4.

Trochammina pacifica Cushman var. *simplissima* CUSHMAN & McCULLOCH 1948, p.76.

Paratrochammina simplissima (Cushman & McCulloch 1948). BRÖNNIMANN 1979, p.10, figs 2,3,6,8; LOEBLICH & TAPPAN 1994, pl.24, figs 1–12; UJIIÉ 1995, pl.2, fig.7.

DISTINGUISHING FEATURES: Test small, slightly concavo-convex or plano-convex, umbilicus depressed; periphery slightly lobulate, almost circular in outline. Low trochospiral coil of 2–4 whorls, with 4–5 chambers in each whorl. Sutures slightly curved and depressed on spiral side; radial on umbilical side.Wall finely agglutinated.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off the east coast of the southern North Island and South Island (37–47˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Brönnimann 1979).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Bathyal to mid abyssal (200–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Polystomammina* Seiglie 1965

Polystomammina nitida (Brady 1881)

Pl. 5, Figs 11–13

Trochammina nitida BRADY 1881b, p.52; BRADY 1884, pl.41, figs 5–6.

Polystomammina nitida (Brady). LOEBLICH & TAPPAN 1987, pl.135, figs 6–9; JONES 1994, pl.41, figs 5–6.

DISTINGUISHING FEATURES: Test compressed, low trochospiral coil; periphery weakly lobate. 6–9 chambers per whorl; spiral side almost flat with slightly depressed, slightly curved radial sutures. Primary aperture a curved slit; supplementary apertures at the umbilical tip of each chamber. Wall agglutinated, thin and fragile.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records from east of central New Zealand (42–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to lower bathyal (100–1500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Tritaxis* Schubert 1921

Tritaxis fusca (Williamson 1858)

Pl. 5, Figs 14–16

Rotalina fusca WILLIAMSON 1858, p.55, pl.5, figs 114,115.

Tritaxis fusca (Williamson). SAIDOVA 1975, pl.28, fig.6; LOEBLICH & TAPPAN 1987, pl.128, figs 1–4; LOEBLICH & TAPPAN 1994, pl.25, figs 1–10; JONES 1994, pl.49, fig.13.

DISTINGUISHING FEATURES: Test planoconvex, trochospiral, with few whorls. 3 chambers per whorl, with final chamber occupying about one-half the face of the umbilical side. Chambers crescentic; sutures strongly oblique on spiral side. Free living in the early stage, some adult specimens attached to the substrate by a spongy calcareous substance.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION:

Single record from off the west coast of the South Island (42˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal (600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Trochammina* Parker & Jones 1859

Trochammina tasmanica Parr 1950

Pl. 5, Figs 17–19

Trochammina tasmanica PARR 1950, p.279, pl.5, fig.18; SAIDOVA 1975, pl.27, fig.7.

DISTINGUISHING FEATURES: Test tiny, low trochospiral; about two and one-half whorls; periphery rounded and lobulate. Chambers globose, 4 in last whorl, rapidly increasing in size as added; sutures in early portion indistinct, in final whorl depressed and slightly recurved. Aperture a low slit at the base of final chamber, opening into the umbilical depression. Wall surface smoothly to moderately roughly finished; umbilical side made of finer grains than spiral side. Colour brown, becoming lighter in later chambers.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrences off the east coast of both main islands (36–45˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Saidova 1975).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Bathyal and abyssal (300–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

ORDER – Textulariida Lankester 1885
Saidova 1981

FAMILY – Eggerellidae Cushman 1937

GENUS – *Dorothia* Plummer 1931

Dorothia scabra (Brady 1884)

Pl. 5, Figs 20–22

Gaudryina scabra BRADY 1884. p.381, pl.46, fig.7.

Dorothia scabra Brady. JONES 1994, pl.44, figs 12–13.

Gaudryina rotunda CHAPMAN 1902, p.409, pl.36, fig.11.

Dorothia rotunda (Chapman). LOEBLICH & TAPPAN 1994, pl.29, figs 1–15.

Gaudryina paupercula CUSHMAN 1911, p.66, fig.106.

Dorothia paupercula (Cushman 1911). SAIDOVA 1975, pl.30, fig.2.

DISTINGUISHING FEATURES: Test elongate, tapering, somewhat compressed; triserial part small but distinct, biserial chambers numerous and inflated. Aperture a simple arched fissure at the inner margin of the final chamber. Wall coarsely agglutinated, brown. Remarks: In view of their great similarity in size, form and occurrence, we consider *D. rotunda* (Chapman 1902) and *D. paupercula* (Cushman 1911) to be junior synonyms of *D. scabra*. In one sample we found a wide variety of short to elongate forms that cover the differences between these species.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off both coasts of the North and northern South Islands (31–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to abyssal (150–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Po–Rec).

GENUS – *Eggerella* Cushman 1933

Eggerella bradyi (Cushman 1911)

Pl. 5, Figs 23-24

Verneuilina bradyi CUSHMAN 1911, p.54, text fig.87.

Eggerella bradyi (Cushman). SAIDOVA 1975, pl.32, fig.1; LOEBLICH & TAPPAN 1987, pl.189, figs 1–4; LOEBLICH & TAPPAN 1994, pl.28, figs 9–14; JONES 1994, pl.47, figs 4–7; UJIIE 1995, pl.3, fig.4.

DISTINGUISHING FEATURES: Test subconical, triserial. Chambers inflated, subspherical. Aperture an elongate slit near the base of the apertural face, sometimes with a thickened lip. Wall finely agglutinated, surface smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 96): Recorded from all around New Zealand between 34 and 56˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 96): Commonly occurring species but with relatively low abundance. Not recorded from shallower than 600 m and with its greatest relative abundances (up to 5%) at lower bathyal depths (1000–2000 m).

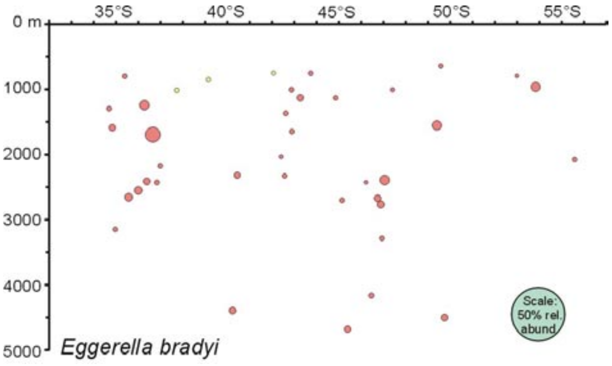


Figure 96. Latitude-depth distribution around NZ of *Eggerella bradyi* (red circles are east of NZ, yellow circles are from west of NZ).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene–Recent (Tt–Rec).

GENUS – *Karreriella* Cushman 1933

KEY FEATURES OF COMMON NEW ZEALAND DEEP-WATER SPECIES:

Karreriella bradyi: Biserial chambers added at regular 180° angle; sutures often filled with cement that may dribble over preceding chamber.

Karreriella novangliae: Chambers added at >180° resulting in torsion of the test; chambers globose; sutures distinct (see Jones 1994, pl.46, figs 8-10).

Karreriella bradyi (Cushman 1911)

Pl. 5, Figs 25–27

Gaudryina bradyi CUSHMAN 1911, p.67, text-fig 107.

Karreriella bradyi (Cushman). SAIDOVA 1975, pl.32, fig.3; SCHRÖDER *et al.* 1988, p.34, pl.6, fig.14; THOMAS *et al.* 1990, pl.3, fig.17; LOEBLICH & TAPPAN 1994, pl.30, figs 8–9; JONES 1994, pl.46, figs 1–4; YASSINI & JONES 1995, figs 978–979.

DISTINGUISHING FEATURES: Test large, elongate, initially triserial then biserial. Chambers inflated and slightly overlapping the preceeding chamber. Sutures depressed and often partly filled with cement. Sometimes dribbles of this fine cement have flowed over the outside of the preceding chamber. Aperture an elongate, lipped slit, at the base of the apertural face of the last chamber. Wall finely agglutinated.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic and widespread occurrences south–east of the South Island (46–54˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal–mid abyssal (500–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Eocene–Recent (Ab–Rec).

GENUS – *Martinottiella* Cushman 1933

KEY FEATURES OF COMMON NEW ZEALAND DEEP-WATER SPECIES:

Martinottiella communis: Wall finely agglutinated.

***Martinottiella omnia*:** Wall coarsely agglutinated.

Martinottiella communis (d'Orbigny, 1846)

Pl. 6, Figs 1–3

Clavulina communis D'ORBIGNY 1846, p.196, pl.12, figs 1–2.

Martinotiella bradyana (Cushman). HUGHES 1988, pl.3, fig.15; LOEBLICH & TAPPAN 1994, pl.31, figs 1–4.

Martinottiella communis (d'Orbigny). LOEBLICH & TAPPAN 1987, pl.190, figs 1–4; JONES 1994, pl.48, figs 1–2,?3,4–8; LOBEGEIER *et al.* 2008, pl.4, fig.13.

DISTINGUISHING FEATURES: Test large, elongate and cylindrical; initial stage trochospiral, later biserial, followed by a relatively elongate final uniserial stage. Sutures horizontal, almost flush and fairly indistinct. Aperture terminal produced on a short neck. Wall finely agglutinated, white to grey colour.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Recorded from off both coast of the two main islands (38–50˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper bathyal to abyssal (300–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Eocene–Recent (Dp–Rec).

Martinottiella omnia Saidova 1975

Pl. 6, Figs 4–5

Martinottiella omnia SAIDOVA 1975, p.114, pl.33, figs 3–4.

DISTINGUISHING FEATURES: Test large, elongate and cylindrical; initial stage trochospiral, with a relatively elongate final uniserial stage. Sutures horizontal, almost flush and fairly indistinct. Aperture terminal produced on a short neck. Wall coarsely agglutinated, white to grey colour.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic records from right around New Zealand (34–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Saidova 1975).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to mid abyssal (150–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Prolixoplectidae Loeblich & Tappan 1985

GENUS – *Karrerulina* Finlay 1940

Karrerulina conversa (Grzybowski 1901)

Pl. 6, Figs 6–7

Gaudryina conversa GRZYBOWSKI 1901, p.224, pl.8, figs 15–16.

Karrerulina conversa (Grzybowski). JONES 1994, pl.46, figs 17–19.

DISTINGUISHING FEATURES: Test small, elongate, triserial in the early portion then biserial with chambers added at greater than 180º to the previous chamber, resulting in 1–2 whorls about the main axis. Chamber size enlarging rapidly in the first third of the test, then minimal increase in size over the remaining biserial portion. Aperture terminal on a slightly produced neck. Wall grey to brown. with fine to coarse agglutinated grains.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off both coasts of the North Island (35–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower bathyal–abyssal (1000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Pseudogaudryinidae Loeblich & Tappan 1985

GENUS – *Pseudoclavulina* Cushman 1936

Pseudoclavulina serventyi (Chapman & Parr 1935)
Pl. 6, Figs 8–10

Clavulina serventyi CHAPMAN & PARR 1935, p.5, pl.1, fig.7.

Pseudoclavulina serventyi (Chapman & Parr). LOEBLICH & TAPPAN 1994, pl.45, figs 12–19; JONES 1994, pl.48, figs 14–16; YASSINI & JONES 1995, fig.96; LOBEGEIER *et al.* 2008, pl.4, fig.19.

DISTINGUISHING FEATURES: Test large, elongate; triserial and triangular in early stage, then uniserial and cylindrical. Aperture terminal, circular to semicircular or lunate. Wall coarsely agglutinated, sometimes with sponge spicules.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off the east coast of the North and northern South Island (34–42˚S).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to mid bathyal (150–800 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Textulariidae Ehrenberg 1838

GENUS – *Siphotextularia* Finlay 1939

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Siphotextularia blacki: Test moderate to large, inflated, twisted; faces concave; angles with rounded keel.

Siphotextularia flintii: Test triangular in profile; chambers low and broad, inflated, rapidly increasing in size; surface smooth and polished.

Siphotextularia foliosa: Test small and compressed, leaf-shaped; sutures curved strongly downwards.

Siphotextularia fretensis: Test of moderate size, subcylindrical, narrowly flaring; coarsely agglutinated.

Siphotextularia mestayerae: Test of moderate size, compressed; faces flat; angles rounded, no keel.

Siphotextularia rolshauseni: Test small, slightly compressed, cylindrical, narrowly flaring; chambers inflated, periphery rounded, lobulate.

Siphotextularia blacki Vella 1957
Pl. 6, Figs 11–13

Siphotextularia blacki VELLA 1957, p.16–17, pl.4, figs 53–54; HAYWARD *et al.* 1999, pl.2, figs 16–18.

DISTINGUISHING FEATURES: Test large and expanding regularly from small initial end to inflated apertural end; larger specimens tending to twist about the longitudinal axis. Faces of test strongly concave, sides flat to convex with angle between having a rounded keel. Many chambers, broader than high. Aperture large and elongate with a thin lip. Wall agglutinated with fine grains in much cement.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread right around all three main islands, as well as the Chathams, Auckland and Snares Islands (35–53˚S).

WORLD GEOGRAPHIC DISTRIBUTION: No records known from outside New Zealand.

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Relatively low numbers at deep inner to outer shelf depths (20–150 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Siphotextularia flintii (Cushman 1911)
Pl. 6, Figs 14–15

Textularia flintii Cushman 1911, p.21, text-figs 36.

Siphotextularia flintii (Cushman). UJIIE 1990, pl.1, figs 6–8; LOEBLICH & TAPPAN 1994, pl.41, figs 8–15.

DISTINGUISHING FEATURES: Test triangular, rapidly increasing in size from the early portion; irregularly rhombic in cross-section. Chambers low and broad, inflated; sutures incised, curved. Aperture an elongate slit with raised lip, near the base of the last chamber. Wall finely agglutinated with smooth and polished surface.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off both coasts of both islands (36–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Almogi-Labin *et al.* 2000).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to abyssal (150–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Siphotextularia foliosa Zheng 1988
Pl. 6, Figs 16–18

Siphotextularia foliosa ZHENG 1988, p.126, pl. 38, figs 1–2; LOEBLICH & TAPPAN 1994, pl.42, figs 1–6.

DISTINGUISHING FEATURES: Test small, moderately compressed; profile leaf-shape, initial end narrowly rounded, slowly increasing in width toward the apertural end; test thickest in the median line, thinning toward the acutely rounded periphery; irregularly rhombic in cross-section. Chambers slightly inflated; sutures distinct, incised, curved downwards. Aperture raised slightly above the base of the apertural face, lipped, small, subcircular or oblong. Wall finely to moderately coarsely agglutinated.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off both coasts of New Zealand

(35–54˚S).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Low numbers at bathyal depths (300–1300 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Siphotextularia fretensis Vella 1957
Pl. 6, Figs 22–23

Siphotextularia fretensis VELLA 1957, p.17, pl.4, figs 58–59; LOEBLICH & TAPPAN 1994, pl.41, figs 1–4.

DISTINGUISHING FEATURES: Test small to moderate in size, subcylindrical, narrowly flaring. Sutures slightly depressed between later chambers, obscure and flush between earlier chambers. Aperture ovate, surrounded by a low, thin lip; situated near the inner margin of the last chamber. Wall coarsely agglutinated with rough surface.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Frequent occurrences right around New Zealand (34–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Endemic to New Zealand (Vella 1957).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Essentially occurs at outer shelf and upper bathyal depths (100–600 m), with a few deeper, possibly displaced records.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Siphotextularia mestayerae Vella 1957
Pl. 6, Figs 19–21

Siphotextularia mestayerae VELLA 1957, p.17, pl.4, figs 55–57; HAYWARD *et al*. 1999, pl.2, figs 19–21.

DISTINGUISHING FEATURES: Test moderate size, compressed; faces of test flattened with gently convex sides with rounded angles between. Final chambers rounded. Sutures straight and sloping, initially obscure, depressed in later chambers. Aperture oblique and elongate with a thin protruding lip.

REMARKS: Distinguishable from *S. blacki* by overall shape, in particular flatness versus concavity of the front and back of the test.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 97): Widespread around all three main islands, as well as the Chathams, Auckland and Snares Islands, between 34 and 53˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Also recorded from Indonesian waters (Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 97): Occurs in relatively low numbers at deep inner shelf to uppermost bathyal depths (30–400 m).Three rare records below 1000 m may be displaced specimens.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Siphotextularia rolshauseni Phleger & Parker 1951
Pl. 6, Figs 24–25

Siphotextularia rolshauseni PHLEGER & PARKER 1951, p.4, pl.1, figs 23–24; NEES & STRUCK 1994, pl.1, figs a–c; JONES 1994, pl.43, fig.11; HAYWARD *et al.* 2001, figs 14H–I; HAYWARD *et al.* 2003, fig.4A.

DISTINGUISHING FEATURES: Test small, slightly compressed, cylindrical; narrowly flaring, slightly twisted about the longitudinal axis; periphery rounded, lobulate. Chambers slightly inflated; sutures depressed. Aperture rounded, on a short terminal siphon. Wall moderately coarsely agglutinated.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 98): Widespread between 33 and 56˚S off the east coast of New Zealand, but with no west coast records so far.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Phleger & Parker 1951).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 98): Widespread in moderately low relative abundances (up to 2%) at lower bathyal and abyssal depths (1300–5000 m). Not recorded shallower than 1300 m.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Pliocene–Recent (Wm–Rec).

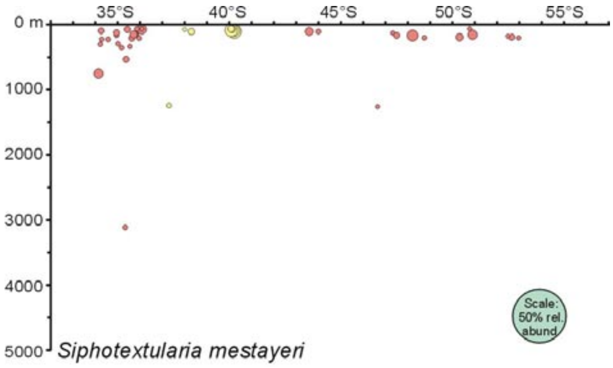


Figure 97. Latitude-depth distribution around NZ of *Siphotextularia mestayeri* (red circles are east of NZ, yellow circles are from west of NZ).

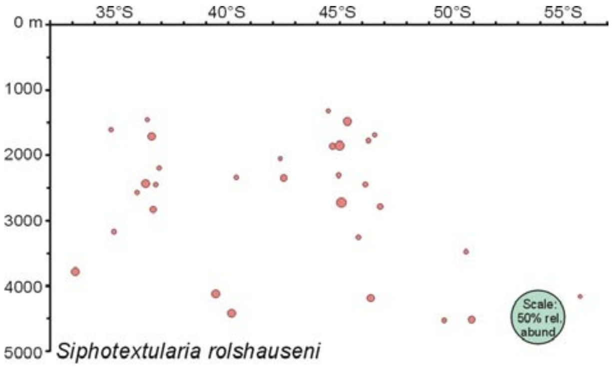


Figure 98. Latitude-depth distribution around NZ of *Siphotextulria rolshauseni* (red circles are east of NZ).

GENUS – *Textularia* Defrance *in* de Blainville 1824

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Textularia candeiana: Test conical; final chamber large, inflated with broadly rounded periphery (mostly inner shelf, see Hayward *et al.* 1999, pl.2, figs.24–26).

Textularia earlandi: Test small, elongate; broadly rounded periphery; surface slightly rough (mostly inner shelf, see Hayward *et al.* 1999, pl.2, figs.22–23).

Textularia lythostrota: Test compressed, broad; truncate periphery; sutures deeply incised; rough surface.

Textularia pseudogramen: Test tapered, elongate; periphery subacute early, later broadly rounded.

Textularia stricta: Test large, long, narrow; smooth surface with corroded portions common.

Textularia lythostrota (Schwager 1866)
Pl. 6, Figs 26–29

Placanium lythostrotum SCHWAGER 1866, p.194, pl.4, fig. 4a–c

Textularia lythostrota (Schwager). GUPTA 1994, pl.1, figs 4,15.

DISTINGUISHING FEATURES: Test moderately compressed and broad, slowly flaring to maximum width and thickness near apertural end. Periphery truncate, lobulate. Sutures deeply incised and angled at approximately 45° to median line. Coarsely agglutinated with rough surface.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences right around New Zealand (36–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Schwager 1866).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid–lower bathyal (500–1500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Pleistocene–Recent (Wc–Rec).

Textularia pseudogramen Chapman & Parr 1937
Pl. 6, Figs 30–32

Textularia pseudogramen CHAPMAN & PARR 1937, p.153; HAYWARD *et al.* 1999, pl.2, figs 27–29.

DISTINGUISHING FEATURES: Test large, tapered elongate; subacute periphery thickens near the apertural end to broadly rounded. Sutures distinct. Aperture a low arch at the base of the apertural face. Wall agglutinated with grains projecting from the surface of the test.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered records from throughout New Zealand, including the Kermadec, Snares and Auckland Islands (30–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Murray 1991, Yassini & Jones 1995).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Occurs in low–moderate numbers at deep inner shelf to upper bathyal depths (30–400 m) off exposed coasts.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Textularia stricta Cushman 1911
Pl. 6, Figs 33-36

Textularia stricta CUSHMAN 1911, p.11, fig.13; LOEBLICH & TAPPAN, 1994, pl.38, figs 1–9.

Spiroplecta sagittula var, *fistulosa* Brady. CHAPMAN 1906, pl.3, fig.4.

DISTINGUISHING FEATURES: Test large, long and narrow; early part somewhat compressed, later becoming nearly circular in cross-section. Numerous subquadrate chambers; later chambers inflated, giving a lobular outline to the test. Surface smoothly finished with corroded portions common, especially along the periphery. Up to 6 mm long.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: In high numbers at several sites off the east coast of northern North Island (34–36˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Kaminski *et al.* 2002).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf (100–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Valvulinidae Berthelin 1880

GENUS – *Cylindroclavulina* Bermúdez & Key 1952

Cylindroclavulina bradyi (Cushman 1911)
Pl. 6, Figs 37–40

Clavulina bradyi CUSHMAN 1911, p.74, text-figs 118,119.

Cylindroclavulina bradyi (Cushman). LOEBLICH & TAPPAN 1987, pl.201, figs 7–13; LOEBLICH & TAPPAN 1994, pl.48, figs 7–19; JONES 1994, pl.48, figs 32–38.

DISTINGUISHING FEATURES: Test large, stout, cylindrical; circular in section. 1–5 chambers arranged uniserially after initial triserial stage. Aperture terminal, rounded, usually on a neck with a flaring lip; small tooth sometimes present. Wall coarsely agglutinated, usually almost completely consisting of planktic foraminiferal tests.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off both coasts of the North and northern South Island (34–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to upper bathyal (150–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Oligocene–Recent (Lwh–Rec).

ORDER – Miliolida Lankester 1885

FAMILY – Hauerinidae Schwager 1876

GENUS – *Miliolinella* Wiesner 1931

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Miliolinella subrotunda: Test oval in cross-section; sutures depressed.

Miliolinella vigilax: Test triangular in cross-section; sutures flush (mostly inner shelf, see HAYWARD *et al.* 1999, pl.3, fig.25).

Miliolinella subrotunda (Montagu 1808)
Pl. 7, Figs 1–3
Vermiculum subrotundum MONTAGU 1808, p.521.
Miliolinella subrotunda (Montagu). HAYWARD *et al.* 1999, pl.3, fig.24; HAYWARD *et al.* 2003, fig.4B; LOBEGEIER & SEN GUPTA 2008, pl.3, figs 15a–c.

DISTINGUISHING FEATURES: Test with 3–5 inflated chambers visible in adult. Sutures depressed in adult and chambers arranged almost planispirally. In juveniles chamber arrangement is quinqueloculine and sutures are almost flush. Aperture a terminal arch with a broad apertural flap. Wall shiny, smooth and translucent.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 99): Widespread records right around New Zealand between 34 and 53˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Murray 1991, Cimerman & Langer 1991, Yassini & Jones 1995).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 99): Widespread and common (up to 15% of some benthic faunas) in fully marine, exposed or moderately sheltered environments at inner and mid shelf depths (0–80 m). Lower levels of abundance and occurrence on the outer shelf (100–200 m). A few rare occurrences at bathyal or abyssal depths are probably transported specimens.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Pleistocene–Recent (Wc–Rec).

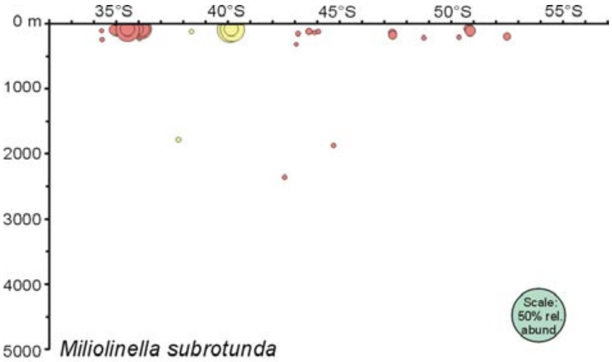


Figure 99. Latitude-depth distribution around NZ of *Miliolinella subrotunda* (red circles are east of NZ, yellow circles are from west of NZ).

GENUS – *Nummoloculina* Steinmann 1881

Nummoloculina contraria (d'Orbigny 1846)
Pl. 7, Figs 4–6
Biloculina contraria D'ORBIGNY 1846, p.266, pl.16, figs 4–6.
Nummoloculina contraria (d'Orbigny). PAPP & SCHMID 1985, pl.83, figs 7–9; LOEBLICH & TAPPAN 1987, pl.355, figs 17–23; JONES 1994, pl.11, figs 10–11.

DISTINGUISHING FEATURES: Test large, subcircular in outline; moderately compressed to discoidal in cross-section. Sides flat to gently convex, periphery rounded. Up to five planispiral chambers per whorl in adult; lateral wall extensions overlap the umbilical area and hide early coils. Aperture large, subcircular, mostly filled with a broad flap leaving a crescentic slit. Wall thick, smooth, polished.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences east of the northern North Island (34–37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Loeblich & Tappan, 1987).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper bathyal (50–400 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Pyrgo* Defrance 1824

KEY FEATURES OF MORE COMMON NEW ZEALAND SPECIES:

Pyrgo clypeata: Test elongate–ovate; subcircular cross-section. Aperture a slightly elongate slit, flap-like tooth.

Pyrgo comata: Test ovate; inflated, subcircular in cross-section. Chambers finely striate. Aperture subcircular.

Pyrgo depressa: Test subcircular; lenticular in cross-section; periphery sharp, flange narrow or lacking. Aperture an elongate slit.

Pyrgo inornata: Test ovate; inflated, subcircular in cross-section. Chambers smooth. Aperture subcircular.

Pyrgo murrhina: Test subcircular; moderately compressed; flange-like periphery with distinct notch at aboral end. Aperture circular on short neck.

Pyrgo oligocenica: Test ovate; inflated, subcircular in cross-section. Chambers costate. Aperture subcircular (see Hayward *et al.* 1999, pl.4, figs 3–4, as *P. comata*).

Pyrgo ringens: Test circular to slightly ovate in outline; inflated and circular in cross-section. Aperture a slightly elongate slit, with bifid tooth.

Pyrgo serrata: Test subcircular; moderately compressed; flange-like periphery with long spines. Aperture circular on short neck.

Pyrgo tasmanensis: Test subcircular; lenticular in cross-section; wide flange-like periphery. Aperture an elongate slit.

Pyrgo williamsoni: Test elongate–ovate; inflated. Aperture subcircular (see Jones 1994, pl.2, fig. 9).

KEY TO NZ RECENT *PYRGO* SPECIES

1. Aperture circular or subcircular 2
   Aperture elongate, slit-like 7

2. Test costate or striate 3
   Test smooth 4

3. Test costate *Pyrgo oligocenica*
   Test finely striate *Pyrgo comata*

4. Test moderately compressed, with peripheral flange, short apertural neck 5
   Test inflated, no peripheral flange, no apertural neck 6

5. Peripheral flange lacks spines, but possesses distinct aboral notch *Pyrgo murrhina*
   Peripheral flange with spines, no aboral notch *Pyrgo serrata*

6. Test ovate, inflated *Pyrgo inornata*
   Test elongate ovate, inflated *Pyrgo williamsoni*

7. Test inflated, circular to subcircular cross-section 8
   Test compressed; flattened in cross-section with peripheral flange 9

8. Test circular outline, short slit aperture with bifid tooth *Pyrgo ringens*
   Test elongate-ovate; short slit aperture with bifid to flap-like tooth *Pyrgo clypeata*

9. Wide peripheral flange *Pyrgo tasmanensis*
   Peripheral flange narrow or lacking *Pyrgo depressa*

Pyrgo clypeata (d'Orbigny 1846)

Pl. 7, Figs 7–10

Biloculina clypeata D'ORBIGNY 1846, p.263, pl.15, figs 19–21.

Pyrgo clypeata (d'Orbigny). PAPP & SCHMID 1985, pl.82, figs 4–6.

Biloculina ringens '*typica*' WILLIAMSON 1858, pl.6, figs 169–171.

Biloculina williamsoni Silvestri, 1923, p.73.

Pyrgo williamsoni (Silvestri). GUDMUNDSSON 1998, p.252, figs 15f–h.

Pyrgo guerreri (Silvestri). HAYWARD *et al.* 1999, pl.4, figs 7–8.

Pyrgo aff. *ezo* Asano. VELLA 1957, p.29, pl.7, figs 138,139.

DISTINGUISHING FEATURES: Test ovate, sometimes more elongated towards the aperture, especially in juveniles; moderately inflated, ovate–subcircular in cross-section. Periphery rounded, never with grooves along peripheral suture. Aperture an elongate slit with a large flap-like inner lip or elongate tooth plate. Wall porcellaneous, smooth.

REMARKS: Large populations of this species show that it has considerable variability in outline and shape of the apertural tooth. Smaller, juvenile specimens commonly have the apertural end slightly more produced and elongate than adult specimens. This species is consistently more inflated than *P. depressa* and less inflated than *P. inornata* and *P. ringens*. It is more elongate in outline than the circular *P. depressa* and *P. ringens*.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread around all three main islands, as well as the Auckland and Snares Islands (35–51°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan, probably recorded under a variety of names (d'Orbigny 1846).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Widespread in low numbers in fully marine, exposed to slightly sheltered, inner shelf to mid bathyal depths (20–1000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Pyrgo comata (Brady 1881)

Pl. 7, Figs 11–12

Biloculina comata BRADY 1881a, p.144, pl.3, fig.9.

Pyrgo comata (Brady). JONES 1994, pl.3, fig.9.

Pyrgo imlimba SAIDOVA 1975, pl.42, fig.6.

NOT *Pyrgo comata* (Brady). HAYWARD *et al.* 1999, pl.4, figs 3–4.

DISTINGUISHING FEATURES: Test ovate in outline; strongly inflated and subcircular in cross-section. Periphery obtusely angled and subrounded. Aperture subcircular on a neck, with a pronounced bifid tooth. Wall porcellaneous; with fine, lengthwise, raised striae over chambers.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered rare occurrences right around New Zealand (38–51°S).

WORLD GEOGRAPHIC DISTRIBUTION: Widespread in lower latitudes (Culver & Buzas 1981, Cimerman & Langer 1991, Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower bathyal (1000–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Pyrgo depressa (d'Orbigny 1826)

Pl. 7, Figs 13–14

Biloculina depressa D'ORBIGNY 1826, p.298, modèles no.91.

Pyrgo depressa (d'Orbigny). UJIIE 1990, pl.4, fig.1; JONES 1994, pl.2, figs 12,16,17; GUDMUNDSSON, 1998, p.249, figs 14a–c; HAYWARD *et al.* 1999, pl.4, figs 5–6.

Biloculina lunula D'ORBIGNY 1846, p.264, pl.15, figs 22–24.

Pyrgo lunula (d'Orbigny). PAPP & SCHMID 1985, pl.82, figs 7–9.

DISTINGUISHING FEATURES: Test circular to subcircular in outline; quite strongly compressed in cross-section. Periphery acutely angled with a weak keel. Aperture an elongate narrow slit, with a thin lip. The inner lip is an elongate tooth plate. Wall porcellaneous, smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread around all three main islands, as well as the

Auckland and Snares Islands (34–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Culver & Buzas 1980, 1986, Loeblich & Tappan 1994, Yassini & Jones 1995).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Widespread in low numbers in inner shelf to upper abyssal depths (20–2500 m), mostly at shelf depths.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Pl–Rec).

Pyrgo inornata (d'Orbigny 1846)

Pl. 7, Figs 15–19

Biloculina inornata D'ORBIGNY 1846, p.266, pl.16, figs 7–9.

Pyrgo inornata (d'Orbigny). PAPP & SCHMID 1985, pl.84, figs 1–3.

Biloculina anomala SCHLUMBERGER 1891, p.569, pl.11, figs 84–86, pl.12, fig.101; VELLA 1957, p.29, pl.7, figs 135,136.

Biloculina vespertilio Schlumberger. CHAPMAN 1909, pl.13, fig.4.

Pyrgo anomala (Schlumberger). HAYWARD *et al.* 1999, pl.4, figs 1–2.

DISTINGUISHING FEATURES: Test ovate in outline, slightly produced towards the aperture; inflated and subcircular in cross-section. Periphery obtusely angled to subrounded. Aperture terminal, subcircular, with a pronounced bifid tooth. Wall porcellaneous, smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread from around all three main islands and also Auckland Islands (32–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Widespread in warmer areas (Culver & Buzas 1981, Cimerman & Langer 1991, Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Widespread in low numbers at shelf depths (0–200 m), with two rare, deeper-water records that may be transported.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

Pyrgo murrhina (Schwager 1866)

Pl. 7, Figs 20–23

Biloculina murrhina SCHWAGER 1866, p.203, pl.4, figs 15a–c.

Pyrgo murrhina (Schwager). UJIIE 1990, pl.4, figs 3–4; LOEBLICH & TAPPAN 1994, pl.91, figs 11–15; JONES 1994, pl.2, figs 10–11,15; GUDMUNDSSON 1998, p.250, figs 14d–e.

DISTINGUISHING FEATURES: Test ovate to subovate in outline; moderately inflated in cross-section. Periphery with moderately wide peripheral flange and keel, aboral notch prominent often with small spine on either side. Aperture circular to ovate on a short neck; tooth plate Y-shaped becoming cubic. Wall porcellaneous and smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 100): Scattered occurrences recorded between 33 and 55˚S off the east coast of New Zealand. No records so far from the Tasman Sea. More widespread north of 38˚S.

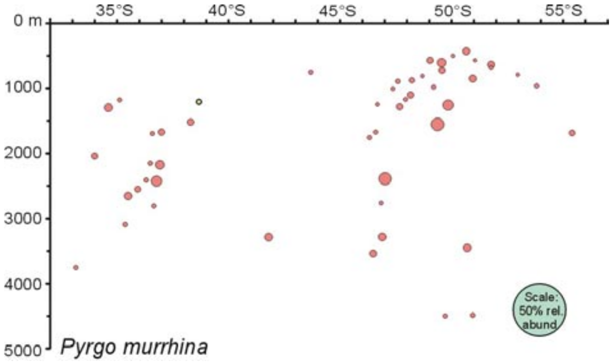


Figure 100. Latitude-depth distribution around NZ of *Pyrgo murrhina* (red circles are east of NZ, yellow circles are from west of NZ).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 100): Most records are at lower bathyal to mid abyssal depths (1000–4000 m). The upper depth limit seems to shallow southwards, being at 1100 m north of 42˚S, at 700 m at 45˚S and at outer shelf depths (100–200 m) at 51˚S around the Subantarctic islands.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

Pyrgo ringens (Lamarck 1804)

Pl. 8, Figs 1–4

Miliolites ringens LAMARCK 1804, p.351, pl.17, fig.1.

Pyrgo ringens (Lamarck). GUDMUNDSSON 1998, p.251, figs 14l–n.

Pyrgo vellai SAIDOVA 1975, pl.43, fig.10.

DISTINGUISHING FEATURES: Test circular in outline; strongly inflated in cross-section. Periphery rounded and angled, but lacking a groove along the peripheral suture; lacks a keel. Aperture ovate to elongate ovate, with a broad, often curved, T-shaped tooth plate. Wall porcellaneous, smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences right around New Zealand (32–51˚S), but most commonly east of northern North Island.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Gudmundsson 1998).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Inner shelf to upper bathyal (30–600 m), mostly at mid-outer shelf depths (50–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Pyrgo serrata (Bailey 1861)

Pl. 8, Figs 5–6

Biloculina serrata BAILEY 1861, p.350, pl.8, fig.E.

Biloculina depressa var. *serrata* BRADY 1884, p.146, pl.3, figs 3a–c.

Pyrgo serrata (Bailey). UJIIE 1990, pl.4, figs 6–7; LOEBLICH & TAPPAN 1994, pl.92, figs 3–6; JONES 1994, pl.3, fig.3; GUDMUNDSSON 1998, p.250, figs 14f–g.

DISTINGUISHING FEATURES: Test ovate to subovate in outline; moderately inflated in cross-section. Periphery with moderately wide peripheral flange and keel; evenly-spaced spines right around peripheral keel, stronger around aboral end. Aperture circular to ovate on a short neck; tooth plate Y-shaped becoming cubic. Wall porcellaneous, smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences right around New Zealand (36–50˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Gudmundsson 1998).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal to upper abyssal (500–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Pyrgo tasmanensis Vella 1957
Pl. 8, Figs 7–8

Pyrgo tasmanensis VELLA 1957, p.30, pl.7, figs 141–142; SAIDOVA 1975, pl.43, fig.9; LOEBLICH & TAPPAN 1994, pl.94, figs 15–16.

DISTINGUISHING FEATURES: Test large, circular to subcircular in outline; strongly compressed in cross-section, especially towards the periphery. Periphery thin with a wide, often ragged keel. Aperture an elongate, narrow slit; inner lip of aperture is an elongate tooth plate. Wall porcellaneous, smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrences right around New Zealand (35–50˚S).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid-lower bathyal (600–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

GENUS – *Pyrgoella* Cushman and White 1936

Pyrgoella sphaera (d'Orbigny 1839)
Pl. 8, Figs 9–11

Biloculina sphaera D'ORBIGNY 1839b, p.66, pl.8, figs 13–16.

Planispirina sphaera (d'Orbigny). CHAPMAN 1906, pl.3, fig.1.

Pyrgoella sphaera (d'Orbigny). LOEBLICH & TAPPAN 1987, pl.351, figs 1–4; JONES 1994, pl.2, fig.4.

DISTINGUISHING FEATURES: Test subglobular to spherical; adult chambers biloculine with each strongly overlapping preceding chamber. Early aperture with a large triangular tooth; in adults tooth is attached at both ends dividing the aperture into two or more elongate slits, sometimes joined at the middle, often sinuous and sometimes with an additional short slit.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Single record from off North Cape (34˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf depths (100–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Quinqueloculina* d'Orbigny 1826

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Quinqueloculina agglutinans: Test with an arenaceous coating; chambers rounded in section. Tooth simple (mostly inner shelf, see Hayward *et al.* 1999, pl.4, figs 11–12).

Quinqueloculina auberiana: Test smooth, broadly oval in outline; chambers sharply angled to slightly sub-rounded, often with weak keel.

Quinqueloculina* aff. *bicornis: Test chambers ornamented with numerous strong, fine, longitudinal costae. Aperture narrow, keyhole-shaped, bordered by a low flange (mostly inner shelf, see Hayward *et al.* 1999, pl.4, figs 15–17).

Quinqueloculina bicostoides: Test of moderate size, oval in outline; wall slightly textured by fine irregular stria. Chambers acutely bicarinate with concave sides and periphery (mostly inner shelf, see Hayward *et al.* 1999, pl.4, figs 18–20).

Quinqueloculina boueana: Test subovate to subrectangular. Chambers longitundinally striate, especially on periphery, subquadrate in section. Aperture almost circular.

Quinqueloculina carinatastriata: Test of moderate size, length about one and a half times the width, with numerous costae. Aperture circular, often on a produced neck, with a delicate tooth (mostly inner shelf, see Hayward *et al.* 1999, pl.5, figs 14–15, as *Q. tenagos*).

Quinqueloculina cooki: Test moderately large, sub-rectangular. Chambers with concave sides, slightly concave to convex periphery and rounded angles. Aperture elongate, keyhole-shaped, narrow tooth occupying the full length of the aperture (mostly inner shelf, see Hayward *et al.* 1999, pl.4, figs 21–22).

Quinqueloculina delicatula: Test elongate, smooth, twice as long as broad. Chambers weakly carinate, subquadrate in section with a concave periphery. Aperture circular (mostly inner shelf, see Hayward *et al.* 1999, pl.4, figs 23-24).

Quinqueloculina incisa: Test sub-ovate to sub-rectangular, glossy. Chambers rounded with incised sutures. Aperture circular; Y-shaped tooth with a large arcuate trough (mostly inner shelf, see Hayward *et al.* 1999, pl.4, figs 25–26).

Quinqueloculina oblonga: Test elongate, somewhat compressed, oval in cross-section; apertural end commonly extended. Aperture narrow elongate, with a simple tooth (mostly inner shelf, see Hayward *et al.* 1999, pl.4, figs 27–28).

Quinqueloculina parvaggluta: Test with a fine arenaceous coating. Chambers quadrate in section with concave sides and periphery, and rounded angles. Aperture small, circular.

Quinqueloculina rebeccae: Test moderately large, sub-rectangular. Chambers with concave sides; periphery ornamented with 2–3 broad, strong, rounded ribs (mostly inner shelf, see Hayward *et al*. 1999, pl.5, figs 3–5).

Quinqueloculina seminula: Test variably ovate and of moderate to large size, sub-trigonal in section; glossy. Aperture small with a thin, bar-like tooth, which may protrude slightly above the periphery.

Quinqueloculina suborbicularis: Test of moderate to large size, sub-circular in profile, with length only slightly greater than breadth. Periphery broadly rounded, chambers inflated. Aperture elongate with narrow tooth.

Quinqueloculina subpolygona: Test irregularly sub-rectangular outline; moderately large with strongly concave sides; periphery flattened, with acutely carinate, knife-edged angles on chambers. Aperture elongate; tooth narrow.

Quinqueloculina venusta: Test of moderate size, elongate–ovate. Chambers strongly curved around end of test; carinate at periphery. Aperture circular often on short neck.

KEY TO NZ RECENT *QUINQUELOCULINA* SPECIES

1. Test with arenaceous coating 2
   Test without arenaceous coating 3

2. Chambers rounded in section *Q. agglutinans*
   Chambers quadrate in section *Q. parvaggluta*

3. Test ornamented 4
   Test not ornamented 7

4. Test weakly ornamented with fine striae *Q. boueana*
   Test more strongly ornamented with costae 5

5. Test with numerous costae 6
   Test with a few strong, peripheral ribs *Q. rebeccae*

6. Aperture keyhole-shaped *Q.* aff. *bicornis*
   Aperture circular, often on a produced neck *Q. carinatastriata*

7. Test carinate (keeled) 8
   Test not carinate 12

8. Test bicarinate 9
   Test weakly unicarinate 11

9. Aperture keyhole-shaped 10
   Aperture circular *Q. delicatula*

10. Test elongate, irregularly sub-rectangular; chambers strongly bicarinate *Q. subpolygona*
    Test ovate; chambers bicarinate, not inflated, somewhat quadrate in section, periphery and sides concave *Q. bicostoides*

11. Test broadly ovate, weakly carinate periphery *Q. auberiana*
    Test elongate, aperture circular, often on neck *Q. venusta*

12. Chambers rounded in section 13
    Chambers not rounded in section, test sub-rectangular in profile. *Q. cooki*

13. Sutures not deeply incised 14
    Sutures deeply incised, aperture circular *Q. incisa*

14. Test elongate, apertural end commonly extended *Q. oblonga*
    Test sub-circular in profile *Q. suborbicularis*
    Test ovate in profile *Q. seminula*

Quinqueloculina auberiana d'Orbigny 1839
Pl. 8, Figs 12–14

Quinqueloculina auberiana D'ORBIGNY 1839a, p.193, pl.12, figs1–3; HAYWARD *et al*. 1999, pl.4, figs 13–14.

Quinqueloculina lamarkiana d'Orbigny. VELLA 1957, p.23, pl.6, figs 105–107.

DISTINGUISHING FEATURES: Test broadly oval; of moderate size. Chambers sharply angled to slightly sub-rounded, subdued carina may be present and sutures distinct. Aperture relatively small, subcircular, terminal; aperture may be slightly hooded with a small simple tooth, sometimes protruding slightly above periphery. Wall smooth, porcellaneous.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 101): Widespread off both coasts of New Zealand between 33 and 51˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Haynes 1973, Culver & Buzas 1981).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 101): Most recorded occurrences are of low numbers in fully marine, exposed to moderately sheltered, inner shelf to mid bathyal depths (shallower than 1000 m). Off the north-east coast of the North Island, five records at lower bathyal to upper abyssal depths (1000–3000 m) may be in-situ or displaced downslope.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

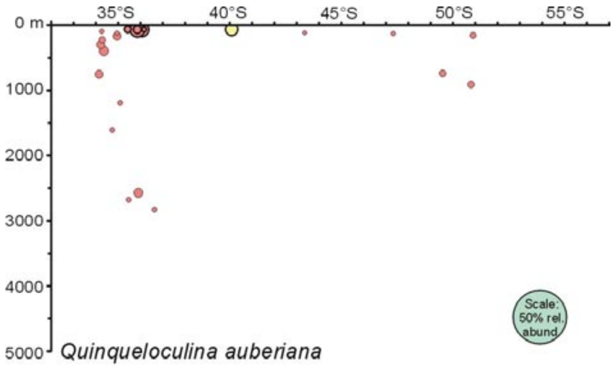


Figure 101. Latitude-depth distribution around NZ of *Quinqueloculina auberiana* (red circles are east of NZ, yellow circles are from west of NZ).

Quinqueloculina boueana d'Orbigny 1846
Pl. 8, Figs 15–17

Quinqueloculina boueana D'ORBIGNY 1846, p.293, pl.19, figs 7–9; PAPP & SCHMID 1985, pl.96, figs 8–9; pl.97, figs 1–2.

Quinqueloculina miles VELLA 1957, p.27, pl.6, figs 109–111.

DISTINGUISHING FEATURES: Test subovate, of large size. Chambers subquadrate in section, with flat to slightly concave sides; chamber angles rounded. Walls ornamented with faint longitudinal striations, especially on peripheral areas. Aperture relatively large, circular, surrounded by a lip; bears a short heavy tooth. Wall matt, pitted to striate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered records around the North Island (34–40°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1846).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid to outer shelf (50–200 m); with one specimen from the upper bathyal that may be displaced.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Quinqueloculina parvaggluta Vella 1957
Pl. 8, Figs 18–19

Quinqueloculina parvaggluta VELLA 1957, p.27, pl.4, figs 71–73; HAYWARD *et al*. 1999, pl.5, figs 1–2.

Quinqueloculina pittensis ALBANI 1974, p.33,35, pl.1, figs 1–3.

DISTINGUISHING FEATURES: Test small and ovate; one and a half times as long as wide. Chambers quadrate in section, usually with concave sides, but sometimes convex with rounded edges; sutures depressed and distinct. Aperture hardly produced and nearly circular with a small tooth. Test coating finely arenaceous but often areas of the test appear smooth, especially the outer faces of the chambers.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 102): Widespread off both coasts of both islands with its southernmost record at 45°S. Not known from the Subantarctic zone.

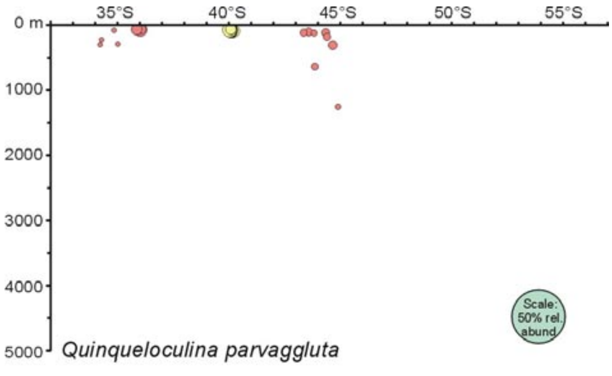


Figure 102. Latitude-depth distribution around NZ of *Quinqueloculina parvaggluta* (red circles are east of NZ, yellow circles are from west of NZ).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Albani 1974, Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 102): Moderately common in fully marine, exposed, inner shelf environments and shallow mid shelf depths (shallower than 80 m) with a few scattered outer shelf and bathyal records that may be displaced specimens.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Quinqueloculina seminula (Linnaeus 1758)
Pl. 8, Figs 20–22

Serpula seminulum LINNAEUS 1758, p.786

Quinqueloculina triangularis D'ORBIGNY 1846, p.288, pl.18, figs 7–9.

Quinqueloculina seminula (Linnaeus). HAYWARD *et al*. 1999, pl.5, figs 9–10; HAYWARD *et al.* 2003, fig.4C.

DISTINGUISHING FEATURES: Test ovate, usually about one and a half times as long as wide, subtrigonal in cross-section. Aperture small with a thin, bar-like tooth with an incipiently bifid margin. The tooth may protrude slightly above the periphery.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 103): Widespread around all coasts of New Zealand, including Chatham, Snares and Auckland Islands.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Murray 1991).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 103): Widespread and abundant (up to 50% of benthic foraminifera in shallow exposed environments less than 10m deep) in fully marine, inner shelf environments in both exposed and sheltered situations; also extending in lower numbers out to outer shelf depths (100-200 m). A few scattered deeper records of rare specimens are possibly displaced, especially in the Bounty Trough.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

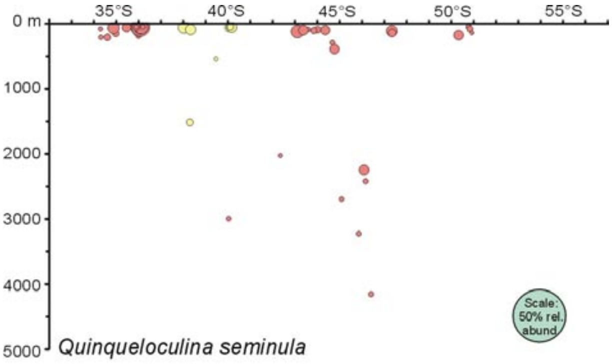


Figure 103. Latitude-depth distribution around NZ of *Quinqueloculina seminula* (red circles are east of NZ, yellow circles are from west of NZ).

Quinqueloculina suborbicularis d'Orbigny 1826 in Fornasini 1905
Pl. 8, Figs 23–25

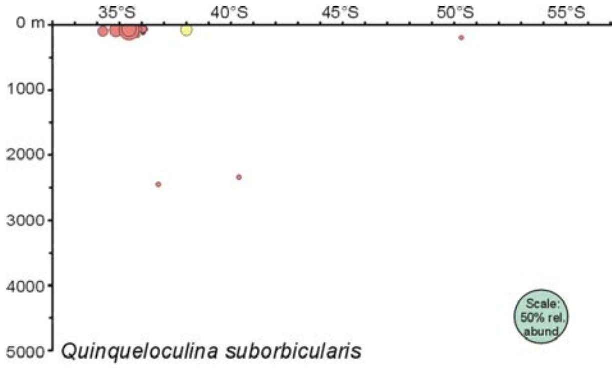


Figure 104. Latitude-depth distribution around NZ of *Quinqueloculina suborbicularis* (red circles are east of NZ, yellow circles are from west of NZ).

Quinqueloculina suborbicularis D'ORBIGNY 1826, p.302, modèles no.29 (*nomem nudum*).

Quinqueloculina suborbicularis d'Orbigny in FORNASINI 1905a, p.67, pl.4, figs 3a–b; HAYWARD *et al*. 1999, pl.5, figs 6–8.

DISTINGUISHING FEATURES: Test of moderate to large size; subcircular in profile, with the length only slightly greater than the breadth; periphery well rounded. Chambers inflated, sutures distinct, slightly depressed. Aperture rounded, subquadrate, relatively small, with a short simple tooth.

REMARKS: This species resembles *Q. seminula* but differs in its greater relative breadth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 104): Common at inner shelf depths around all three main islands, plus Kermadec, Chatham, Snares and Auckland Islands. At mid shelf depths its distribution is off both the east and west coasts of the northern North Island, mostly north of 39˚S. Exceptions are a single specimen from 50˚S and two upper abyssal records that may be of transported specimens.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1846).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 104): Widespread and common in exposed, inner shelf environments (up to 20% of benthic foraminifera at 30–50m depth), with lower numbers at mid shelf depth (shallower than 80 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Lw–Rec).

Quinqueloculina subpolygona Parr 1945
Pl. 9, Figs 1–4

Quinqueloculina subpolygona PARR 1945, p.196, pl.12, figs 2a–c; HAYWARD *et al.* 1999, pl.5, figs 11–13.

Quinqueloculina colleenae VELLA 1957, p.25, pl.5, figs 86,93.

DISTINGUISHING FEATURES: Test moderately large, sub-rectangular, with strongly concave sides, flattened periphery and acutely carinate, usually knife-edged angles on the chambers. Aperture elongate, sub-rectangular with a slightly reflexed rim. A simple tooth occupies half the opening.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs around all of New Zealand (28–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Also recorded from south-eastern Australia (Yassini & Jones 1995). Temperate Southwest Pacific.

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lives at all shelf depths (0–200 m) with its greatest abundances in current-swept coarse sediment environments on the inner shelf (0–30 m). A few upper bathyal records may be of displaced specimens.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Quinqueloculina venusta Karrer 1868
Pl. 9, Figs 5–7

Quinqueloculina venusta KARRER 1868, p.147, pl.2, fig.6; UJIIE 1990, pl.3, fig.3; JONES 1994, pl.5, fig.7.

DISTINGUISHING FEATURES: Test of moderate size, elongate–ovate in outline, rounded triangular in cross-section; sides flat to gently concave, periphery weakly unicarinate. Chambers strongly curved around end of test. Aperture circular, slightly necked, with strong rim and short simple tooth. Wall weakly striate to smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Recorded from off the east coast of the North and northern South Island (33–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal to mid abyssal (500–4000 m), but mostly at upper and mid abyssal (2000–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

GENUS – *Sigmoilina* Schlumberger 1887

Sigmoilina sigmoidea (Brady 1884)
Pl. 9, Figs 8–9

Planispirina sigmoidea BRADY 1884, p.197, pl.2, figs 1–3.

Sigmoilina sigmoidea (Brady). LOEBLICH & TAPPAN 1987, pl.356, figs 21–24; JONES 1994, pl.2, figs 1–3.

DISTINGUISHING FEATURES: Test of moderate size, ovate in outline, asymmetrically biconvex in cross-section. Periphery acutely angled to carinate. Chambers one-half coil in length with sigmoid curve arrangement. Aperture small, terminal, circular, slightly necked, with small tooth. Wall smooth, thickened, giving biloculine appearance.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrences off the east coast of New Zealand (34–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Loeblich & Tappan, 1987).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper and mid bathyal (200–1000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Sigmoilopsis* Finlay 1947

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Sigmoilopsis elliptica: Finely arenaceous wall; deeply incised sutures.

Sigmoilopsis schlumbergeri: Moderately coarse arenaceous wall; visible sutures.

Sigmoilopsis wanganuiensis: Coarsely arenaceous wall; indistinct sutures.

Sigmoilopsis elliptica (Galloway & Wissler 1927)
Pl. 9, Figs 10–11

Sigmoilina elliptica GALLOWAY & WISSLER 1927, p.39, pl.7, figs 2a,b.

Sigmoilopsis elliptica (Galloway & Wissler). HAYWARD *et al*. 1999, pl.5, figs 16–18; HAYWARD *et al.* 2007b, pl.1, fig.1.

DISTINGUISHING FEATURES: Test small, elongate, fusiform–ovate. Chambers with rapidly changing planes in early stages, later stages becoming planispiral. Chambers long, tubular and slightly inflated. Aperture a circular opening with a slightly overturned lip; aperture terminal on a neck. Wall porcellaneous with a fine arenaceous outer layer.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 105): Relatively common off both coasts of New Zealand between 34 and 54˚S, although it seems to be missing east of central New Zealand in the vicinity of the Chatham Rise.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Culver & Buzas 1986, Yassini & Jones 1995).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 105): Largely confined to mid bathyal or shallower depths (0–1000 m), where it occurs in quiet or sheltered locations. Its greatest relative abundances (up to 30%) are at mid shelf depths in Carnley Harbour, Auckland Islands. Two abyssal records of rare specimens may have been transported downslope.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

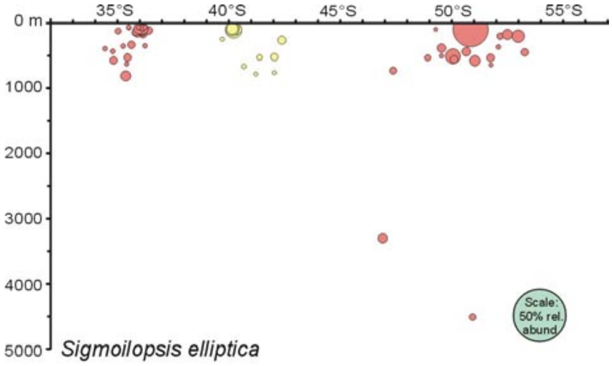


Figure 105. Latitude-depth distribution around NZ of *Sigmoilopsis elliptica* (red circles are east of NZ, yellow circles are from west of NZ).

Sigmoilopsis schlumbergeri (Silvestri 1904)
Pl. 9, Figs 12–16

Sigmoilina schlumbergeri SILVESTRI 1904a, p.267,269.

Sigmoilina (*Planispirina*) *celata* SCHLUMBERGER 1887, pl.7, figs 12–14.

Sigmoilopsis schlumbergeri (Silvestri). LOEBLICH & TAPPAN 1987, pl.356, figs 8–13; LOEBLICH & TAPPAN 1994, pl.103, figs 9–12; JONES 1994, pl.8, figs 1–4; UJIIE 1990, pl.3, fig.10; LOBEGEIER & SEN GUPTA 2008, pl.4, figs 1a–b.

DISTINGUISHING FEATURES: Test of moderate size, one and a half times as long as wide, rather compressed. Chambers acutely rounded at the periphery; sutures usually visible, but not incised. Aperture circular, situated on a short neck with a narrow, phialine lip and a small tooth. Wall coated with medium-sized grains.

REMARKS: Distinguished from *S. wanganuiensis* by its finer arenaceous texture, which allows the chambers to be discerned, and by its greater compression in cross-section and more acute periphery.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 106): Widespread off both coasts of New Zealand between 33 and 48˚S. Seems to be missing from the Subantarctic southern part of the New Zealand region.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Silvestri 1904a).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 106): Common occurrence but low abundance (up to 3%), in mid bathyal to upper abyssal depths (500–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

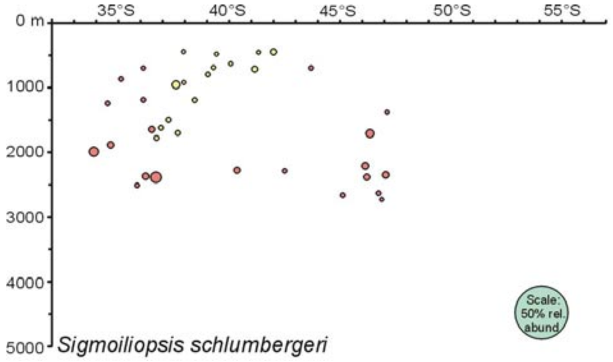


Figure 106. Latitude-depth distribution around NZ of *Sigmoilopsis schlumbergeri* (red circles are east of NZ, yellow circles are from west of NZ).

Sigmoilopsis wanganuiensis Vella 1957
Pl. 9, Figs 17–18

Sigmoilopsis wanganuiensis VELLA 1957, p.20, pl.4, figs 67–70; HAYWARD *et al.* 1999, pl.5, figs 19–20.

DISTINGUISHING FEATURES: Test of moderate to large size, one and a half times as long as wide, ovate in cross-section. Chambers broadly rounded at the periphery, sutures indistinct. Aperture circular, situated on a short neck with a phialine lip and a narrow, pronounced, ridge-like tooth. Wall coated with coarse sand grains.

REMARKS: Distinguished from *S. schlumbergeri* by its coarser arenaceous ornament which obscures the chamber arrangement, and in being more inflated overall.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Common records from right around New Zealand (34–54˚S).

WORLD GEOGRAPHIC DISTRIBUTION: No known records from beyond New Zealand.

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Occurrences mostly at mid shelf to lower bathyal depths (50–2000 m), most abundantly at mid and outer shelf depths (50–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Pliocene to Recent (Wp–Rec).

GENUS – *Spirosigmoilina* Parr 1942

Sigmoilinita Seiglie, 1965

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Spirosigmoilina pusilla: Test narrowly fusiform in outline.

Spirosigmoilina tenuis: Test ovate in outline.

Spirosigmoilina pusilla (Earland 1934)

Pl. 9, Figs 19–20

Spiroloculina pusilla EARLAND 1934, p.47, pl.1, figs 3–4.

Spirosigmoilina pusilla (Earland). JONES 1994, pl.10, figs 9–10.

DISTINGUISHING FEATURES: Test narrowly fusiform, strongly compressed; periphery rounded. Numerous extremely narrow chambers added in a sigmoid series in the inflated early portion; adult chambers planispiral on opposite sides of test. Aperture terminal, with a short neck; with or without a small tooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences east of both islands (35–47˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Southern Ocean (Earland 1934).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower bathyal-mid abyssal (1000–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Spirosigmoilina tenuis (Czjzek 1848)

Pl. 9, Figs 21–22

Quinqueloculina tenuis CZJZEK 1848, p.149, pl.13, figs 31–34.

Spirosigmoilina tenuis (Czjzek). JONES 1994, pl.10, figs 7,8,11; HAYWARD *et al*. 1999, pl.5, figs 21–22.

Sigmoilinita tenuis (Czjzek). LOEBLICH & TAPPAN 1987, pl.356, figs 14–18.

DISTINGUISHING FEATURES: Test oval, strongly compressed; periphery rounded. Numerous narrow chambers added in a sigmoid series in the inflated early portion; adult chambers planispiral on opposite sides of test. Aperture terminal, sometimes with a short neck.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Recorded from right around the North Island and northern South Island (35–45˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Cimerman & Langer 1991).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Sporadic occurrences in low numbers, mostly at mid shelf to lower bathyal depths (80–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Mid Eocene to Recent (Ab–Rec).

GENUS – *Triloculina* d'Orbigny 1826

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Triloculina chrysostoma: Test large, elongate–ovate; aperture elongate with a particularly long tooth (mostly inner shelf, see Hayward *et al*. 1999, pl.5, figs 27–28).

Triloculina insignis: Test large, broad, almost circular in side view; chambers costate (mostly inner shelf, see Hayward *et al*. 1999, pl.5, figs 23–24).

Triloculina striatotrigonula: Test roundly ovate in side view; wall costate (mostly inner shelf, see Hayward *et al*. 1999, pl.5, figs 25–26).

Triloculina tricarinata: Test triangular in apertural view, with angles sharp, almost carinate.

Triloculina trigonula: Test ovate, inflated; aperture rounded with a bifid tooth (mostly inner shelf, see Hayward *et al*. 1999, pl.5, figs 31–32).

Triloculina tricarinata d'Orbigny 1826 *sensu* Parker, Jones & Brady 1865

Pl. 9, Figs 23–24

Triloculina tricarinata D'ORBIGNY 1826, p.299, no.7, modèles no.94; HAYWARD *et al*. 1999, pl.5, figs 29–30.

DISTINGUISHING FEATURES: Test ovate in outline, triangular in cross-section, with angles sharp, almost carinate. Aperture sub-triangular, often with a bifid tooth. Wall porcellaneous, smooth to weakly striate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 107): Numerous scattered rare occurrences off the

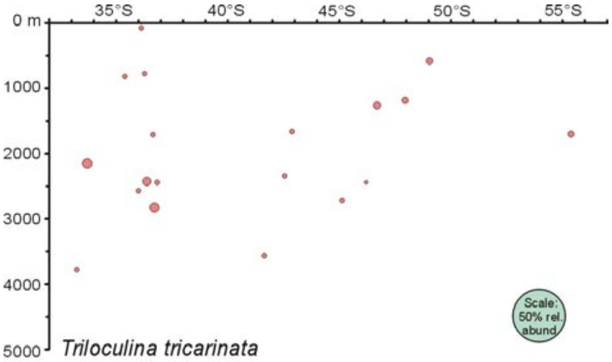


Figure 107. Latitude-depth distribution around NZ of *Triloculina tricarinata* (red circles are east of NZ).

east coast of New Zealand between 33 and 56°S. Not yet recorded from off the west coast.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Nomura 1981).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 107): Has a wide bathymetric range from moderately sheltered inner shelf to mid abyssal (10–4000 m), with slightly higher abundances (up to 2 %) at upper abyssal depths in the north shallowing to bathyal depths in the south.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

FAMILY – Spiroloculinidae Wiesner 1920

GENUS – *Inaequalina* Luczkowska 1971

Inaequalina disparilis (Terquem 1878)
Pl. 9, Figs 25–29

Spiroloculina disparilis TERQUEM 1878, p.55, pl.5, fig.12.

Inaequalina disparilis (Terquem). HAYWARD *et al.* 1999, pl.6, figs 1–3.

DISTINGUISHING FEATURES: Test plano–concave, ovate with slightly elongate apertural neck; periphery truncate. Chambers one half coil in length added on alternate sides; all chambers visible on both sides. Aperture terminal, slit-like. Wall smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs around all three main islands and Chatham Islands (34–47°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Nomura 1981, Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Occurs in low numbers at shelf depths (10–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Lw–Rec).

GENUS – *Nummulopyrgo* Hofker 1983
Pseudopyrgo Hofker 1976

Nummulopyrgo globulus (Hofker 1976)
Pl. 9, Figs 30–32

Pseudopyrgo globulus HOFKER 1976, p.112.

Nummulopyrgo globulus (Hofker 1976). LOEBLICH & TAPPAN 1987, pl.339, figs 7–14; 1994, pl.65, figs 8–16.

DISTINGUISHING FEATURES: Test subglobular with two hemispherical chambers visible with slightly depressed peripheral suture. Chambers tubular early, then nummuloculine to biloculine in adult. Surface smooth. Crescentic aperture with a broad flap-like lip.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences east of the North and northern South Islands (34–45°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Hofker 1976).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper bathyal (80–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Spiroloculina* d'Orbigny 1826

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Spiroloculina antillarum: Test large, ovate; periphery rounded. Strong, regular longitudinal costae. Apertural neck (mostly inner shelf, see Hayward *et al.* 1999, pl.6, figs 4–5).

Spiroloculina carinata: Test large, broadly ovate; periphery truncate, sharply angled. Slightly roughened surface. Aperture large, terminal, little or no neck (mostly inner shelf, see Hayward *et al.* 1999, pl.6, figs 6–7).

Spiroloculina communis: Test medium-sized; periphery truncate, sharply angled. No surface ornament. Slender apertural neck.

Spiroloculina novozealandica: Test medium–large, fusiform outline; periphery broadly rounded. No surface ornament. Necked, circular aperture.

Spiroloculina subaequa: Test large, broadly ovate; periphery rounded. Slightly roughened surface. Aperture large, terminal, little or no neck (mostly inner shelf, see Hayward *et al.* 1999, pl.6, figs 10–11).

Spiroloculina communis Cushman & Todd 1944
Pl. 10, Figs 1–5

Spiroloculina communis CUSHMAN & TODD 1944, p.28, pl.1, figs 1,6, pl.5, figs 1–9; HAYWARD *et al.* 1999, pl.6, figs 8–9.

DISTINGUISHING FEATURES: Test ovate, higher than broad, biconcave. Periphery truncate with sharp angles. Chambers one half coil in length within a single plane. Sutures smooth to slightly stepped as later chambers overlap earlier ones. Toothed aperture on end of slender neck. Wall smooth, translucent in early chambers.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Recorded sporadically around the North Island and in the Marlborough Sounds, as well as the Kermadec Islands (28–42°S).

WORLD GEOGRAPHIC DISTRIBUTION: One of most common shallow water *Spiroloculina* species throughout the Indo-Pacific (Cushman & Todd 1944).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Occurs in low numbers at shelf depths (30–200 m) with one possibly displaced upper bathyal record.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Spiroloculina novozealandica Cushman & Todd 1944
Pl. 10, Figs 6–10

Spiroloculina novozealandica CUSHMAN & TODD 1944, p.27, pl.4, fig.23.

Spiroloculina rotundata KREUZBERG 1930, p.276, pl.20, fig.2 (homonym).

DISTINGUISHING FEATURES: Test medium to large;

fusiform in outline, higher than broad, biconcave. Periphery and chambers broadly rounded; sutures weakly incised; last chamber projecting at both ends. Circular aperture on end of stout neck. Wall smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences from off both coasts of the North and northern South Islands (34–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Not known from beyond the South-west Pacific (Cushman & Todd 1944).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal (500–800 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

ORDER – Lagenida Lankester 1885

KEY FEATURES OF COMMON NEW ZEALAND UNILOCULAR GENERA:

1. Possess an entosolenian tube (Family Ellipsolagenidae) -
Cushmanina: Test circular in end-view; longitudinal costae, each with 1–2 rows of large punctae.
***Exsculptina*:** Test circular–rounded in end-view; incised sculpture around base of test; rounded aperture protruding from chamber or on short neck.
Favulina: Test circular in end-view; ornament of polygonally-reticulated costae; rounded aperture.
Fissurina: Test compressed in end-view; terminal, symmetric, slit aperture protruding from chamber.
Galwayella: Test triangular in end-view; aperture flush with test.
***Homalohedra*:** Test circular in end-view, pyriform; simple longitudinal costae; circular, necked aperture.
Laculatina: Test quadrangular in end-view; rounded aperture protruding from chamber.
Lagenosolenia: Test compressed in end-view, usually with single peripheral carina; symmetric, slit aperture on end of a neck.
Lagnea: Test compressed in end-view; peripheral keel with struts, tubes or reticulations; circular aperture on a neck.
Oolina: Test circular–rounded in end-view; radiate aperture protruding from chamber.
Parafissurina: Test circular-rounded in end-view; asymmetric slit aperture protruding and enclosed by a hood.
Palliolatella: Test compressed in end-view, with multiple peripheral keels; symmetric, slit aperture on end of a neck.
Vasicostella: Test compressed in end-view, with single peripheral keel; round aperture on a neck.
***Ventrostoma*:** Test compressed in end-view; with single carina; aperture flush with test, on ventral side.
Wiesnerina: Test compressed in end-view; aperture flush with periphery; wall ornamented.

2. Lack an entosolenian tube (Family Lagenidae) -
Hyalinonetrion: Test circular in end-view, elongate or fusiform in side-view; no ornament; aperture on a neck.
Lagena: Test circular in end-view; rounded–ovate in side-view; aperture on a neck.
Procerolagena: Test circular in end-view; elongate or fusiform in side-view; ornamented; aperture on a neck.

FAMILY – Ellipsolagenidae Silvestri 1923

Possess an entosolenian tube.

GENUS – *Cushmanina* Jones 1984

Globular to fusiform, circular in cross-section. Ornament of longitudinal costae; each costa with one or two rows of large punctae. Aperture circular on end of a neck.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION: Scattered occurrences right around New Zealand (32–56˚S) at mid bathyal to abyssal depths (600–5000 m).

Cushmanina striatopunctata (Parker & Jones 1865)
Pl. 10, Figs 11–13

Lagena sulcata (Walker & Jacob) var. *striatopunctata*. PARKER & JONES 1865, p.350, pl.13, figs 25–27.
Cushmanina striatopunctata (Parker & Jones). JONES 1994, pl.58, figs 37,40.
Cushmanina feildeniana (Brady). JONES 1994, pl.58, figs 38–39.

DISTINGUISHING FEATURES: Test circular in cross-section; elongate–ovate in side view with acutely rounded aboral end and tapering apically to a slender neck. Numerous, narrow, vertical costae extend most of length of test and bear a row of elongate slit punctae on their surface and a row of larger oval punctae along each side. Ends of some of the costae appear to fuse together apically to form a slender neck with a tiny terminal aperture.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Exsculptina* Patterson & Richardson, 1988

Test circular-rounded in end-view; incised sculpture around base of test; rounded aperture protruding from the chamber or on a short neck.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION: Scattered occurrences from around New Zealand (36–56˚S) at lower bathyal to abyssal depths (1000–5000 m).

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:
Exsculptina eccentrica: Test pyriform with basal oval ridge, otherwise unornamented.
Exsculptina exsculpta: Test pyriform with wide band of vertical grooves around lower third of test.

Exsculptina eccentrica (Sidebottom 1912)
Pl. 10, Figs 14–15
Lagena stelligera var. *eccentrica* SIDEBOTTOM 1912, p.392, pl.16, figs 5–6.

DISTINGUISHING FEATURES: Test medium to small size, pyriform, with produced tapering apertural neck; circular to slightly oval in cross-section. Peripheries broadly rounded. Narrow oval-shaped ridge encircles the basal part of the test. Aperture on terminal end of tapering neck. Test wall smooth, finely perforate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare at middle and lower bathyal depths off eastern New Zealand.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Exsculptina exsculpta (Brady 1881)
Pl. 10, Figs 16–17
Lagena exsculpta BRADY 1881b, p.61, pl.58, fig.1, pl.61, fig.5.
Oolina exsculpta (Brady). JONES 1994, pl.58, fig.1, pl.61, fig.5.

DISTINGUISHING FEATURES: Test subcircular in cross-section; pear-shaped in side-view, with broadly rounded aboral end; tapering to produced apical end. Most of test surface smooth, except for wide band of incised grooves around the lower third. Aperture small, subcircular opening.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Favulina* Patterson & Richardson, 1988

Globular to ovoid; circular in cross-section. Ornament of polygonally-reticulated costae. Rounded aperture on slight neck or with collar-like rim.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION: Occurs right around New Zealand (33–56˚S) at all depths from inner shelf to lower abyssal (0–5000 m).

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:
Favulina favosopunctata: Fine hexagonal–reticulate ornament tending towards circular; no distinct longitudinal costal elements. Short, octagonal, star-like collar around aperture.
Favulina hexagona: Coarse hexagonal–reticulate ornament; no distinct longitudinal costal elements. Short, slender apertural neck.
Favulina hexagoniformis: Fine hexagonal–reticulate ornament; no distinct longitudinal costal elements. Elongate–subovate test, tapering to a drawnout apical end with a short apertural neck.
Favulina melo: About 20 strong, longitudinal costae linked by transverse straight costae. Low collar around aperture (mostly inner shelf, see Hayward *et al.* 1999, pl.8, fig.3 as *Oolina melo*).
Favulina melosquamosa: About 20 longitudinal costae linked by transverse arching costae, like overlapping fish scales. Low raised collar around aperture.
Favulina squamosa: Coarse reticulate ornament in irregular near vertical rows, forming irregular rectangular–hexagonal patterns. Globose–pyriform test, greatest width below midpoint, tapering to apertural end (see Jones 1994, pl.58, figs 28–29, 31).
Favulina vadosa: Moderately coarse, weakly hexagonal–reticulate ornament with a longitudinal accent to the reticulate pattern. Small apertural collar.

Favulina favosopunctata (Brady 1881)
Pl. 10, Figs 18–19
Lagena favoso-punctata BRADY 1881b, p.62; BRADY 1884, pl.58, fig.35 (Lectotype).
Conolagena favosopunctata (Brady). LOEBLICH & TAPPAN 1994, pl.137, figs 1–8.
Oolina favosopunctata (Brady). JONES 1994, pl.58, fig.35.
Lagena punctatiformis McCULLOCH 1977, p.43, pl.54, fig.18.

DISTINGUISHING FEATURES: Test elongate–subovate; greatest width at midpoint, tapering to produced apical end. Small, compact, hexagonal reticulate ornament, slightly finer than in *F. hexagoniformis*, with no distinct longitudinal costae; hexagons become less distinct and more circular over upper part of test. Tiny terminal aperture with star-shaped, octagonal collar and minute hexagonal ornament on the side.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific Ocean (McCulloch 1977; Jones 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Favulina hexagona (Williamson 1848)
Pl. 10, Figs 20–21
Entosolenia squamosa var. *hexagona* WILLIAMSON 1848, p.20, pl.2, fig.23.
Oolina hexagona (Williamson). HAYWARD *et al*. 1999, pl.8, fig.2.

DISTINGUISHING FEATURES: Test ovoid. Wall with a coarse, reticulate, hexagonal ornament; anterior and posterior ends of hexagons pointed, with no distinct longitudinal costal elements. Apical end slightly produced with a distinct short, slender apertural neck.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread around New Zealand, including Chatham and Auckland Islands (33–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Culver & Buzas 1981, 1986, Yassini & Jones 1995).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Widespread in low numbers at shelf depths (0-200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Latest Eocene to Recent (Ar–Rec).

Favulina hexagoniformis (McCulloch 1997)
Pl. 10, Figs 22–23
Lagena hexagoniformis McCULLOCH 1977, p.36, pl.54, fig.19.

DISTINGUISHING FEATURES: Test elongate–subovate; greatest width below midpoint, tapering to a drawnout shoulder. Compact, fine hexagonal reticulate ornament with no distinct longitudinal costae. Tiny terminal aperture with short protruding neck or collar.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific Ocean (McCulloch 1997).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Favulina melosquamosa (McCulloch 1977)
Pl. 10, Figs 24–25
Oolina melosquamosa McCULLOCH 1977, p.82, pl.54, figs 26–28.

DISTINGUISHING FEATURES: Test globose–elongate to subovate, tapering to apical end. About 20 longitudinal costae linked by many transverse arching costae, like overlapping fish scales. Small, round aperture with a collar but no neck.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific Ocean (McCulloch 1977).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Favulina vadosa (McCulloch 1977)
Pl. 10, Figs 26–27
Oolina squamosa vadosa McCULLOCH 1977, p.86, pl.54, figs 21,23,24.

DISTINGUISHING FEATURES: test globose–subovate, greatest width at midpoint, tapering to the apical end. Moderately coarse, hexagonal reticulate ornament with anterior and posterior ends of hexagon straight and perpendicular to test axis, giving a longitudinal accent to the reticular pattern. Tiny terminal aperture surrounded by a small collar.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific Ocean (McCulloch 1977).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Fissurina* Reuss 1850

Test rounded to ovate in outline; compressed in cross-section. May be keeled. Aperture terminal, ovate to slit-like in a depressed fissure at the test apex. Entosolenian tube may or may not be attached to inner wall.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION (Fig. 108): Species of this genus occur throughout the New Zealand region and at all depths from innermost shelf to lower abyssal (0–5000 m). Their relative abundance can range up to 5–10% at all depths, with a slight trend towards greater relative abundances in lower bathyal to lower abyssal depths (1000–5000 m) in the south.

KEY FEATURES OF SOME COMMON NEW ZEALAND SPECIES:

Fissurina annectens: Subcircular, apertural end produced; keel with slender opaque band on inner margin (mostly inner shelf, see Hayward *et al.* 1999, pl.7, fig.16, as *F. claricurta*).

Fissurina bispinosa**:** Elongate ovate, periphery acutely rounded; wide apertural lips; two basal spines.

Fissurina clathrata: Subovate, compressed; tricarinate keel; 5 longitudinal costae on face (mostly inner shelf, see Hayward *et al.* 1999, pl.7, fig.17).

Fissurina* aff. *fimbriata: Slightly compressed, triangular outline; keel with two basal fimbriate wings.

Fissurina laevigata: Subovate, moderately compressed; small keel (mostly inner shelf, see Hayward *et al.* 1999, pl.7, figs 18–19).

Fissurina laureata: Subovate, moderately compressed; periphery with five keels; ornament of short peripheral costae and medial punctae.

Fissurina lucida: Compressed pyriform; rounded, unkeeled periphery; two broad opaque bands parallel periphery (mostly inner shelf, see Hayward *et al.* 1999, pl.7, figs 20–21).

Fissurina marginata: Circular, compressed; sharp keel (mostly inner shelf, see Hayward *et al.* 1999, pl.7, figs 22–23).

Fissurina orbignyana: Subovate, moderately compressed; tricarinate keel (mostly inner shelf, see Hayward *et al.* 1999, pl.7, fig.24).

Fissurina* cf. *southbayensis: Subovate, tapering towards aperture; narrow keel. Longitudinal costae over face (mostly inner shelf, see Hayward *et al.* 1999, pl.7, figs 25–26).

Fissurina spinosa: Subovate, with strongly produced apertural flange; rounded keel, with three basal spines.

Fissurina bispinosa (Heron-Allen & Earland 1932)
Pl. 10, Figs 28–29
Lagena quadrata (Williamson) var. *bispinosa* HERON-ALLEN & EARLAND 1932, p.375, pl.11, figs 1–2.

DISTINGUISHING FEATURES: Test moderately compressed in cross-section; elongate ovate to quadrate in outline. Periphery acutely rounded, lacking a keel, but possessing two short, solid spines on each side of

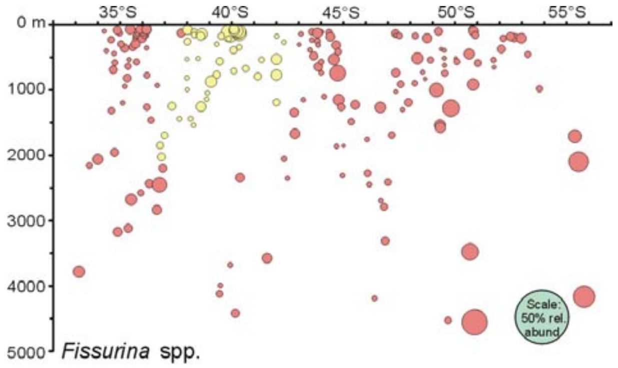


Figure 108. Latitude-depth distribution around NZ of *Fissurina* spp. (red circles are east of NZ, yellow circles are from west of NZ).

the aboral end. Surface smooth. Aperture terminal, symmetric, long slit with a raised lip.

WORLD GEOGRAPHIC DISTRIBUTION: Southern Ocean (Heron-Allen & Earland 1932).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Fissurina* aff. *fimbriata (Brady 1881)
Pl. 10, Figs 30–31

Lagena fimbriata BRADY 1881b, p.61, pl.60, figs 26–27.

Fissurina fimbriata (Brady). UJIIE 1990, pl.8, fig.6; JONES 1994, pl.60, figs 26–27.

DISTINGUISHING FEATURES: Test slightly compressed in cross-section; subtriangular in side view. Chamber smooth except for a band of tiny tubercles around the aboral end. Peripheral keel around entire test, but broadening out into two aboral fimbriate wings. Aperture symmetrical, terminal, short slit.

REMARKS: Our illustrated specimen differs slightly in the form of the peripheral keel from the illustrated types, which themselves probably represent two different species anyway. Our specimen may eventually be described as a separate species.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Pl–Rec).

Fissurina laureata (Heron-Allen & Earland 1932)
Pl. 10, Figs 32–33

Lagena laureata HERON-ALLEN & EARLAND 1932, p.382, pl.37, figs 37–40.

Fissurina rugosocarinata ALBANI & YASSINI 1989, p.398, figs 6o–p; YASSINI & JONES 1995, figs 412,416.

Fissurina marginatoperforata (Seguenza 1880). YASSINI & JONES 1995, figs 411,413–415.

DISTINGUISHING FEATURES: Test moderately compressed in cross-section; subovate in side-view. Periphery with one strong, rounded, central keel and two weaker, rounded keels on each side. Ornament of short costae in the peripheral zone and punctae in the middle. Aperture, terminal, long slit with lips.

WORLD GEOGRAPHIC DISTRIBUTION: Southern Ocean (Heron-Allen & Earland 1932).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Fissurina spinosa (Sidebottom 1912)
Pl. 10, Figs 34–35

Lagena fasciata (Egger) var. *spinosa* SIDEBOTTOM 1912, p.402, pl.17, figs 16–17.

Fissurina spinosa (Sidebottom). LOEBLICH & TAPPAN 1994, pl.157, figs 1–11.

DISTINGUISHING FEATURES: Test slightly compressed in cross-section; subovate in side-view. One rounded keel extending right around the periphery, with three aboral spines – one medial and the other two at the sides. Body chamber unornamented. Aperture on produced extension of the keel, terminal, long slit with narrow lips.

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific Ocean (Loeblich & Tappan 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Galwayella* Patterson & Pettis 1986

Test elongate ovate, triangular in section. Smooth with longitudinal carina at test angles. Aperture rounded to triangular, no neck.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION: Rare records from around New Zealand (35–51˚S) at inner shelf to abyssal depths (10–5000 m).

Galwayella trigonomarginata (Parker & Jones, 1865)
Pl. 11, Figs 1–2

Lagena sulcata trigonomarginata PARKER & JONES 1865, p.348, pl.18, fig.1.

Galwayella trigonomarginata (Parker & Jones). JONES 1994, pl.61, fig.12.

DISTINGUISHING FEATURES: Test inflated triangular in cross-section; ovate in side-view. Smooth walls with peripheral keels bordered by wide slightly raised bands; aperture small circular hole with radial grooves extending down the three peripheral angles.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Homalohedra* Patterson & Richardson, 1988

Test circular in end-view, pyriform; ornament of simple longitudinal costae; round, necked aperture. Includes all costate–ornamented forms with a neck, that were formerly included in the genus *Oolina.*

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION: Sporadic occurrences right around New Zealand (33–51˚S) at outer shelf to abyssal depths (100–5000 m).

Homalahedra liratiformis (McCulloch 1977)
Pl. 11, Figs 3–4

Lagena liratiformis McCULLOCH 1977, p.39, pl.53, figs 25,32.

DISTINGUISHING FEATURES: Test circular in cross-section; pyriform flask shape in side-view; broadly rounded aboral end with a small flat basal disc; tapering upwards to a short apical neck. 12–18 strong longitudinal costae extend most of length of test. Prominent smooth, glassy collar at shoulder level; minute, circular aperture on end of a short, thickened neck.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific Ocean (McCulloch, 1977), possibly cosmopolitan but under-recorded.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Laculatina* Patterson & Richardson, 1988

Quadrangular in section. Rounded aperture on short neck.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION: Rare records from east and south-east of the South Island (45–51˚S) at abyssal depths (2000-5000 m).

Laculatina quadrilatera (Earland 1934)
Pl. 11, Figs 5–6
Lagena quadrilatera EARLAND 1934, p.159, pl.7, figs 10–11.

DISTINGUISHING FEATURES: Test small, quadrangular in cross-section; elongate in side view with a bluntly rounded aboral end and tapering to a slender smooth neck at the apertural end. Four peripheral angles with broadly rounded, thickened keels. Sometimes bears a tiny spine at aboral end. Aperture a small round, terminal opening.

WORLD GEOGRAPHIC DISTRIBUTION: Southern Ocean (Earland, 1934).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Lagenosolenia* McCulloch 1977

Test compressed, usually with single peripheral carina; symmetric, slit aperture on end of a neck.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION (Fig. 109): Species of this genus occur throughout the New Zealand region and at all depths from inner shelf to lower abyssal (10–5000 m). Their relative abundance can range up to 2–3% at all depths.

KEY FEATURES OF SOME COMMON NEW ZEALAND SPECIES:

Lagenosolenia confossa: Short apertural neck. Single peripheral keel extends right up neck.

Lagenosolenia falcata: Short apertural neck with large, down-curved, elongate lips surrounding slit aperture; no keel.

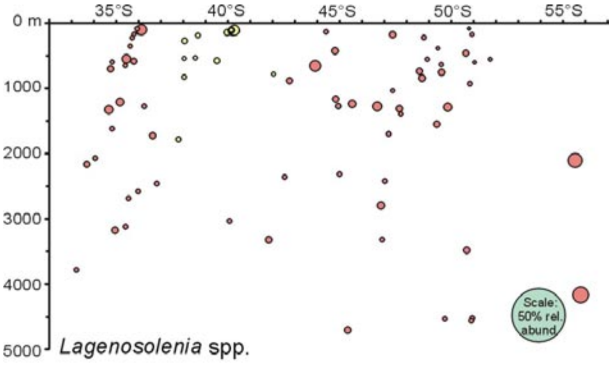


Figure 109. Latitude-depth distribution around NZ of *Lagenosolenia* spp. (red circles are east of NZ, yellow circles are from west of NZ).

Lagenosolenia confossa McCulloch 1977
Pl. 11, Figs 7–8
Lagenosolenia confossa McCULLOCH 1977, pl.64, figs 7–8; Hayward *et al.* 1999, pl.7, figs 27–28.

DISTINGUISHING FEATURES: Test subovate and compressed. Long prominent and compressed neck. A plate-like keel on the shoulder and neck tapers towards aperture. Aperture fissurine with a heavy lip continuous with keel. Wall thick, smooth, transparent and heavily perforated; central area of each face with few perforations.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: A few scattered records from around North, Stewart and Subantarctic Islands.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific Ocean.

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Rare occurrences in fully marine, shelf and bathyal environments.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Lagenosolenia falcata (Chaster 1892)
Pl. 11, Figs 9–10
Lagena falcata CHASTER 1892, p.61, pl.1, fig.7.
Lagenosolenia soulei McCULLOCH 1977, p.49, pl.52, figs 1,4; LOEBLICH & TAPPAN 1994, pl.159, figs 13–14.

DISTINGUISHING FEATURES: Test slightly compressed, rounded in cross-section; body chamber ovate. Periphery broadly rounded, no keel. Body chamber unornamented smooth, slightly tapering to a short, stout neck. Aperture a symmetric slit with elongate phialine lips with a down-turned spine on each end.

REMARKS: The weak radiating costae at the base of the neck are not described on the type material.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Chaster, 1892).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Lagnea* Popescu 1983

Test compressed in end-view; peripheral carina with struts, tubes or reticulations; rounded aperture on a neck.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION: Scattered records from around New Zealand (34–56˚S) at mid shelf to abyssal depths (50–5000 m).

KEY FEATURES OF SOME COMMON NEW ZEALAND SPECIES:

Lagnea honshuensis: Elaborate lagenoid keel with numerous wide tubules opening to the periphery.

Lagnea neosigmoidella: Test sigmoidally twisted in cross-section; wide lagenoid keel with no tubules opening to the periphery.

Lagnea honshuensis (McCulloch 1977)

Pl. 11, Figs 11–12

Lagenosolenia lagenoides honshuensis McCULLOCH 1977, p.64, pl.51, fig.2.

DISTINGUISHING FEATURES: Test compressed in cross-section; ovate flask shape in side view. Whole test surrounded by a fragile, wide, elaborate lagenoid peripheral keel, with numerous tubules along either side, with most opening to the periphery. Keel extends most of way up slender, tubular neck. Aperture a tiny rounded opening with phialine lip on the end of the neck.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific Ocean (McCulloch 1977).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Lagnea neosigmoidella (McCulloch 1977)

Pl. 11, Figs 13–14

Lagenosolenia neosigmoidella McCULLOCH 1977, p.66, pl.51, fig.9.

DISTINGUISHING FEATURES: Test compressed, sigmoid twisted in cross-section; ovate flask shape in side view. Wide, lagenoid peripheral keel, with numerous narrow tubules along either side, with none opening to the periphery. Keel extends most of way up tubular neck. Aperture a tiny rounded terminal opening.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific Ocean (McCulloch 1977).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Oolina* d'Orbigny 1839

Globular to ovate, circular in cross-section. Smooth or with fine longitudinal striae. Aperture round, slightly produced on a short neck, may be radial.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION (Fig. 110): Widespread occurrences right around New Zealand (28–56˚S) at all depths from inner shelf to abyssal (0–5000 m).

KEY FEATURES OF SOME COMMON NEW ZEALAND SPECIES:

Oolina borealis: Ovoid test; thick longitudinal costae (mostly inner shelf, see Hayward *et al.* 1999, pl.8, fig.1).

Oolina emaciata: Elongate test, smooth and unornamented with a short entosolenian tube (rare, see White 1928, pl.29, fig.8).

Oolina felsinea: Test assymetric and elongate; aperture rounded and not central (rare, see Jones 1994, pl.56, fig.4).

Oolina globosa: Globose test, smooth and unornamented (rare, see Yassini & Jones 1995, figs 369–370).

Oolina lineata: Globose test, with faint vertical costae; short aboral spine.

Oolina setosa: Test globose, with several long aboral spines (rare, see Hermelin 1989, pl. 10, fig.6).

***Oolina stelligera*:** Test pyriform with basal collar and short, weak basal costae; conical apertural end with roughened texture.

Oolina tasmanica: Longitudinal costae, coalescing to form reticulate collar (mostly inner shelf, see Hayward *et al.* 1999, pl.8, fig.4).

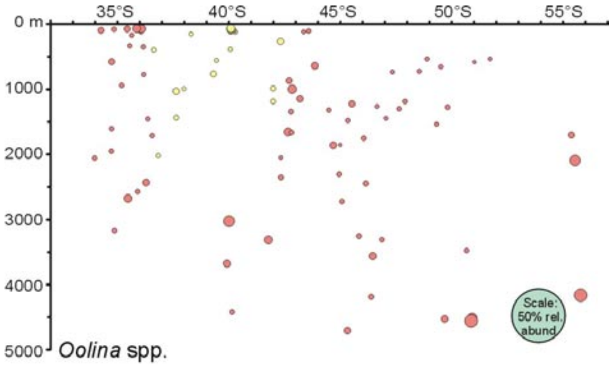


Figure 110. Latitude-depth distribution around NZ of *Oolina* spp. (red circles are east of NZ, yellow circles are from west of NZ).

Oolina lineata **(Williamson 1848)**

Pl. 11, Figs 15–16

Entosolenia lineata WILLIAMSON 1848, p.18, pl.2, fig.18.

Oolina lineata (Williamson). LOEBLICH & TAPPAN 1987, pl.463, figs10–11; YASSINI & JONES 1995, figs 347–348,350–351.

DISTINGUISHING FEATURES: Test small, circular in cross-section, ovate in side view with blunt apical end and tapering aborally to a small spine. Wide circular aperture with a strong, rounded rim.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: More common in Subantarctic New Zealand (47–52˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Williamson 1848).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Oolina stelligera **(Brady 1881)**

Pl. 11, Figs 17–19

Lagena stelligera BRADY 1881b, p.60, pl.57, figs 35–36; UJIIE 1990, pl.5, fig.9.

Cushmanina stelligera (Brady). JONES 1994, pl.57, figs 17,35–36.

DISTINGUISHING FEATURES: Test circular in cross-section; pyriform in side view; widest part slightly below middle of test, tapering to produced apical end, broadly rounded aboral end; often with a narrow circular rim or collar projecting from the aboral end and 8–12 short weak ribs radiating upwards from it and extending over the lower part of the test. Remainder of test smooth, except that the produced apical cone has a rough texture. Tiny terminal circular aperture with a wide star-shaped rim.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Palliolatella* Patterson & Richardson 1987

Test compressed in end-view, with multiple peripheral carina; symmetric, slit aperture on end of a neck and often bearing a low hood.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION (Fig. 111): Species of this genus occur throughout the New Zealand region and at all depths from inner shelf to lower bathyal (10–2000 m), with few records from the abyssal. Highest relative abundances (up to 4%) appear to be at mid–outer shelf depths (50–100 m).

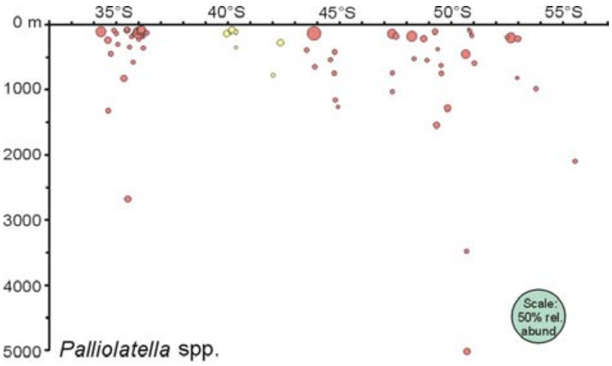


Figure 111. Latitude-depth distribution around NZ of *Palliolatella* spp. (red circles are east of NZ, yellow circles are from west of NZ).

KEY FEATURES OF SOME COMMON NEW ZEALAND SPECIES:

Palliolatella bradyiformis: Three sharp marginal keels, strongest on periphery. Short apertural neck and short slit aperture.

Palliolatella lacunata paucialveolata: Five sharp, marginal keels, strongest on periphery. Short apertural neck, with short oval slit aperture (mostly inner shelf, see Hayward *et al.* 1999, pl.7, figs 31–32).

Palliolatella quadrirevertens: Four marginal keels, none located centrally on periphery. Short apertural neck, with long slit aperture (mostly inner shelf, see Hayward *et al.* 1999, pl.7, figs 29–30).

Palliolatella bradyiformis McCulloch 1977

Pl. 11, Figs 20–21

Lagenosolenia bradyiformis McCULLOCH 1977, p.54, pl.61, fig.14.

DISTINGUISHING FEATURES: Test moderately compressed, biconvex in cross-section; body chamber near circular. Whole test surrounded by three sharp peripheral keels, with the strongest on the periphery. Longest keel extends up to enclose short apertural neck. Aperture a short terminal, symmetric slit with lips.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific Ocean (McCulloch 1977).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Parafissurina* Parr 1947

Test circular–rounded in end-view; asymmetric slit aperture subterminal, protruding with the dorsal margin forming a hood-like extension over the aperture. Entosolenian tube attached to the dorsal wall.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION: Sporadic occurrences right around New Zealand (32–52˚S) at all depths from inner shelf to abyssal (10–5000 m).

Parafissurina lateralis (Cushman 1913)

Pl. 11, Figs 22–23

Lagena lateralis CUSHMAN 1913, p.9, pl.1, fig.1.

Parafissurina lateralis (Cushman 1913). UJIIE 1990, pl.10, fig.1; JONES 1994, pl.56, figs 17–18; LOEBLICH & TAPPAN 1994, pl.164, figs 1–10.

DISTINGUISHING FEATURES: Test oval in cross-section; body chamber elongate–ovate in side-view; periphery rounded throughout. Aperture a curved, subterminal slit on the ventral side of a protruding sharply rounded apex that forms a hood on the dorsal terminus. Wall finely perforate.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Cushman 1913; Loeblich & Tappan 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Pliocene to Recent (Wo–Rec).

GENUS – *Vasicostella* Patterson & Richardson 1987

Test compressed in end-view, with single peripheral carina; aperture rounded opening on a neck.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION: Sporadic records from east of the South Island (44–52˚S) at shelf to bathyal depths (30–2000 m).

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Vasicostella rara: Body chamber smooth with costae at apertural end; keel narrow, unornamented.

Vasicostella squamosoalata: Body chamber with internal reticulate ornament; wide keel with radiate ornament.

Vasicostella rara (McCulloch, 1977)

Pl. 11, Figs 24–25

Lagenosolenia rara McCULLOCH 1977, p.71, pl.52, fig.2.

DISTINGUISHING FEATURES: Test moderately compressed, biconvex in cross-section; body chamber ovate. Whole test surrounded by a peripheral keel, of uniform width around most of the body chamber but increasing gradually to embrace the lower part of a long, tubular, slender neck. Several weak costae radiate outwards from the neck over the upper part of the body chamber. Aperture a tiny rounded opening with phialine lip on the end of the neck.

REMARKS: The weak radiating costae at the base of the neck are not described on the type material.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific Ocean (McCulloch 1977).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Vasicostella squamosoalata (Brady 1881)
Pl. 11, Figs 26–29

Lagena squamosoalata BRADY 1881b, p.61, pl.60, fig.23.

Fissurina squamosoalata (Brady). JONES 1994, pl.60, fig.23.

DISTINGUISHING FEATURES: Test moderately compressed, biconvex in cross-section; body chamber ovate. Body chamber surrounded by a deep groove then a reticulate band, itself surrounded by a wide peripheral keel, of uniform width around most of the body chamber, but increasing gradually to embrace the lower part of a long, tubular, slender neck. The keel itself is ornamented by numerous radiate subdivisions. The body chamber has an internal pentagonal to hexagonal reticulate ornament. On the surface the body chamber and surrounding keel are smooth. Aperture a tiny rounded opening with folded pectinate margin, on the end of the neck.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Brady 1881b).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Ventrostoma* Schnitker, 1970

Test compressed in end-view; aperture flush with test, on ventral side, not on periphery; single carina.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION: Sporadic records from right around New Zealand (35–51˚S) at all depths from inner shelf to abyssal (10–5000 m).

KEY FEATURES OF SOME COMMON NEW ZEALAND SPECIES:
Ventrostoma scaphaeformis: Test elongate ovate in outline with parallel sides; planoconvex in cross-section.
Ventrostoma unguis: Test ovate rounded in outline; biconvex in cross-section.

Ventrostoma scaphaeformis (Parr 1950)
Pl. 11, Figs 30–31

Parafissurina scaphaeformis PARR 1950, p.317, pl.10, figs 1–3.

DISTINGUISHING FEATURES: Test elongate ovate in outline with parallel sides and rounded ends; moderately compressed, plano-convex in cross-section. Surrounded by a wide peripheral carina with rounded edge, slightly twisted up on the convex side. Body chamber elongate ovate. Aperture small rounded opening at junction of body chamber with carina on the convex ventral side.

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific Ocean (Parr 1950).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Pl–Rec).

Ventrostoma unguis (Heron-Allen & Earland 1913)
Pl. 11, Figs 32–33

Lagena unguis HERON-ALLEN & EARLAND 1913b, p.86, pl.7, figs 1–3.

DISTINGUISHING FEATURES: Test ovate to rounded sub-rectangular in outline; moderately compressed, asymmetric biconvex in cross-section. Surrounded by a wide peripheral carina of near equal width all the way around, with rounded edge and slightly twisted up on the dorsal side. Body chamber elongate ovate. Apertural slit at junction of body chamber with carina on the ventral side.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Heron-Allen & Earland 1913b).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Wiesnerina* Jones 1984

Test compressed in end-view; aperture flush with periphery; wall ornamented.

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION: Sporadic occurrences off north-east North Island at shelf depths (10–200 m).

KEY FEATURES OF SOME COMMON NEW ZEALAND SPECIES:
Wiesnerina baccata: Test circular with strong rounded peripheral keel and a single circular costa on each face (mostly inner shelf, see Hayward *et al.* 1999, pl.7, fig.15).
Wiesnerina scarabaeus: Test elongate–ovate with four concentric costate rings on each face.

Wiesnerina scarabaeus (Heron-Allen & Earland 1922)
Pl. 11, Fig. 34

Lagena scarabaeus HERON-ALLEN & EARLAND 1922, p.164, pl.6, figs 20–23.

DISTINGUISHING FEATURES: Test elongate–ovate with parallel sides; compressed in cross-section. Surrounded by a wide peripheral keel, with thickened, rounded edge towards the apertural end. Faces of the body chamber are ornamented with four concentric, costate rings, becoming stronger towards periphery; short, weak vertical costae at base of rings. Narrow, flush apertural slit on the periphery.

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Heron-Allen & Earland 1922).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Glandulinidae Reuss 1860

GENUS – *Glandulina* d'Orbigny 1839

Glandulina ovula d'Orbigny 1846
Pl. 12, Figs 1–2

Glandulina ovula D'ORBIGNY 1846, p.29, pl.1, figs 6–7; JONES 1994, pl.61, figs 17–22.

DISTINGUISHING FEATURES: Test elongate ovate, uniserial; circular in cross-section. Microspheric form expanding rapidly from small early chambers; macrospheric form with a large broadly rounded basal end. Earlier chambers strongly overlapped by later chambers; sutures flush; wall smooth, opaque except for a glassy band just below the aperture. Aperture terminal radiate with a short straight entosolenian tube.

REMARKS: A variety of shapes are included under this species by us.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic records from off both coasts of the two main islands (34–45˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to lower abyssal (80–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Pliocene to Recent (Wn–Rec).

GENUS – *Seabrookia* Brady 1890

Seabrookia pellucida Brady 1890
Pl. 12, Figs 3–4

Seabrookia pellucida BRADY 1890, p.568, text-fig.60; LOEBLICH & TAPPAN 1987, pl.470, figs 28–30; LOEBLICH & TAPPAN 1994, pl.170, figs 1–9.

Seabrookia earlandi WRIGHT 1891, p.477, pl.20, figs 6–7; KAWAGATA 1999, fig.3:11; LOBEGEIER & SEN GUPTA 2008, pl.3, figs 6–7.

DISTINGUISHING FEATURES: Test tiny; ovate to pyriform in outline, slightly twisted; compressed, planoconvex in cross-section. Peripheral keel, sometimes fimbriate. Chambers enrolled with 3 chambers in early whorl, later 2; later chambers completely enveloping earlier ones. Wall thin, smooth, glassy, transparent. Aperture terminal slit with a lip and thick entosolenian tube; situated at alternate ends of test.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 112): Sporadic occurrences right around New Zealand (35–54˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Loeblich & Tappan 1987).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 112): Outer shelf to abyssal (100–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Miocene to Recent (Sw–Rec).

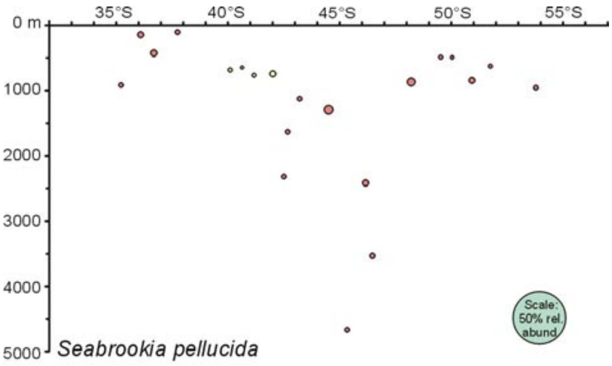


Figure 112. Latitude-depth distribution around NZ of *Seabrookia pellucida* (red circles are east of NZ, yellow circles are from west of NZ).

FAMILY – Lagenidae Reuss 1862

Unilocular without an entosolenian tube.

KEY FEATURES OF COMMON NEW ZEALAND GENERA:

Hyalinonetrion: Test in end-view circular, in side-view elongate or fusiform; unornamented; aperture on a neck.

Lagena: Test in end-view circular, in side-view rounded; aperture on a neck.

Procerolagena: Test in end-view circular, in side-view elongate or fusiform; ornamented; aperture on a neck.

GENUS – *Hyalinonetrion* Patterson & Richardson 1987

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION: Widespread occurrences around New Zealand (32–56˚S) at all depths from inner shelf to abyssal (0–5000 m).

Hyalinonetrion gracillima (Seguenza 1862)
Pl. 12, Figs 5–6

Amphorina gracillima SEGUENZA 1862, p.51, pl.1, fig.37.

Lagena gracillima (Seguenza). BARKER 1960, pl.56, figs 19–22,24–26; AZAZI 1990, pl.2, fig.77; UJIIE 1990, pl.4, fig.14.

Phialinea gracillima (Seguenza). JONES 1984, p.126, pl.5, figs 18–20.

Procerolagena gracillima (Seguenza). JONES 1994, p.62, pl.56, figs 19–22,24–29.

Hyalinonetrion sahulense Paterson & Richardson. LOEBLICH & TAPPAN 1994, p.211, pl.137, figs 13–14.

Procerolagena elongata (Ehrenberg). YASSINI & JONES 1995, figs 271–273.

DISTINGUISHING FEATURES: Test elongate, fusiform, tapering at both ends. Central cylindrical portion is parallel-sided. Slender necks at both ends with small circular aperture with phialine lip (often broken) at one end. Test smooth, unornamented.

REMARKS: Unlike Barker (1960) and Jones (1994) we restrict the definition of *H. gracillima* to the strict shape of the holotype with its fusiform profile and parallel-sided central portion.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994, Loeblich & Tappan 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Lagena* Walker & Jacob 1798

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION (Fig. 113): Species of this genus occur throughout the New Zealand region and at all depths from inner shelf to lower abyssal (10–5000 m). The relative abundance of the genus seldom ranges above 2% at any depth.

KEY FEATURES OF SOME COMMON NEW ZEALAND SPECIES:

Lagena crenata: Decanter-shaped test with widest part at base; strongly crenulate edge around flat base.

Lagena hispida: Globular test, ornamented with small spines (mostly inner shelf, see Hayward *et al.* 1999, pl.7, figs 1–2)

Lagena hispidula**:** Ovate flask-shaped test; roughened texture, but not hispid.

Lagena laevicostatiformis: Elongate, flask-shaped; ornamented with longitudinal costae, strong costae extend up neck (mostly inner shelf, see Hayward *et al.* 1999, pl.7, fig.3)

Lagena oceanica**:** Conical flask-shaped test; short costae around bluntly rounded aboral end.

Lagena peculiariformis**:** Subglobular with flat base; ring of basal spines; ornamented with full-length longitudinal costae; single costa tightly spirals around long slender neck.

Lagena spicata: Subglobular; basal spine; ornamented with longitudinal costae, also extending up neck (mostly inner shelf, see Hayward *et al.* 1999, pl.7, figs 4–5)

Lagena spiratiformis: Subglobular to elongate; ornamented with fine striae; several costae spiral around neck (mostly inner shelf, see Hayward *et al.* 1999, pl.7, figs 6–7)

Lagena tokiokai: Subglobular with flat base; ornamented with short costae; several weak costa spiral around slender neck.

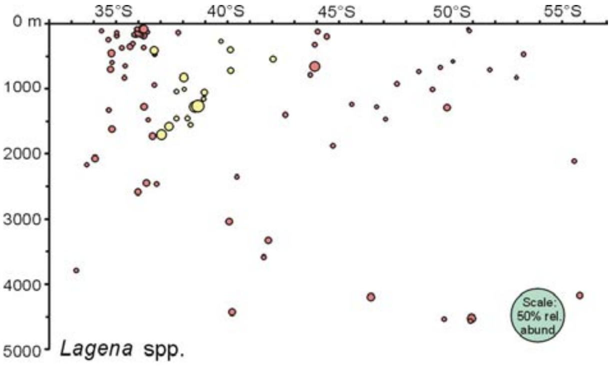


Figure 113. Latitude-depth distribution around NZ of *Lagena* spp. (red circles are east of NZ, yellow circles are from west of NZ).

Lagena crenata Parker & Jones 1865
Pl. 12, Figs 7–10

Lagena crenata PARKER & JONES 1865, p.420, pl.18, fig.4; JONES 1994, pl.57, figs 15,21.

DISTINGUISHING FEATURES: Test circular in cross-section; decanter-shaped in side-view with flat aboral end; widest at base, tapering gently and then more rapidly upwards to a moderately long apertural neck ornamented with costae. Aperture a small round, terminal opening. Test mostly smooth, except for a ring of strongly incised crenulae around the perimeter of the aboral end.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Parker & Jones 1865).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Lagena hispidula Cushman 1913
Pl. 12, Figs 11–12

Lagena hispidula CUSHMAN 1913, p.14, pl.5, figs 2–3; UJIIE 1990, pl.5, fig.3; JONES 1994, pl.56, figs 10–11.

DISTINGUISHING FEATURES: Test circular in cross-section; ovate flask-shape in side view with broadly rounded base. Abruptly tapers above to a long slender apertural neck. Aperture a small round opening. Test with roughened texture to very weakly hispid.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

Lagena oceanica Albani 1974
Pl. 12, Figs 13–14

Lagena oceanica ALBANI 1974, p.37, pl.1, figs 7,10,11.

Pygmaeoseistron oceanicum (Albani). LOEBLICH & TAPPAN 1994, pl.144, figs 4–7.

DISTINGUISHING FEATURES: Test circular in cross-section; flask-shaped with widest part ¼ distance up test, tapering gently to base of long, slender apertural neck; tapers to bluntly flattened aboral end. Test smooth except for short, weak costae around basal portion, projecting as low ring of short spines from base. Aperture a small round opening with low rim.

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Albani 1974; Loeblich & Tappan 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Lagena peculiariformis Albani & Yassini 1989
Pl. 12, Figs 15–16

Lagena peculariformis ALBANI & YASSINI 1989, p.379, figs 2m–n; YASSINI & JONES 1995, figs 334–337,339.

DISTINGUISHING FEATURES: Test circular in cross-section; subglobular in side view, with a flat aboral end. 18–30 slender, longitudinal costae cover test, full test length costae alternate with those that do not extend all the way to the base; projections of longer costae give aboral end a spinose appearance. Aperture a small round opening with low rim on the end of a long slender neck with three narrow spiraling costae all the way up.

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Albani & Yassini 1989).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Lagena tokiokai Uchio 1962
Pl. 12, Figs 17–18

Lagena tokiokai UCHIO 1962, p.387, pl.18, fig.19; LOEBLICH & TAPPAN 1994, pl.140, figs 6–9.

DISTINGUISHING FEATURES: Test circular in cross-section; subglobular to pyriform in side view, with a flat aboral end. 12–15 slender, longitudinal costae extend 1/3 rd to ½ way up test; projections of costae give aboral end a weakly spinose appearance. Aperture a small round opening on the end of a long slender neck with several narrow spiraling costa all the way up.

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Uchio 1962; Loeblich & Tappan 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Procerolagena* Puri 1954

NEW ZEALAND GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION: Widespread occurrences around New Zealand (32–56˚S) at all depths from inner shelf to abyssal (0–5000 m).

KEY FEATURES OF SOME COMMON NEW ZEALAND SPECIES:

Procerolagena distomamargaritifera**:** Test slender fusiform, curved, tapered at both ends, short wavy costae.

Procerolagena meridionalis**:** Test fusiform, with 16–24 longitudinal costae, half extending full length of test.

Procerolagena multilatera: Test fusiform, with 8–12 longitudinal costae extending full length of test.

Procerolagena distomamargaritifera (Parker & Jones 1865)
Pl. 12, Figs 19–20

Lagena sulcata (Walker & Jacob) var. *distomamargaritifera* PARKER & JONES 1865, p.348, pl.18, fig.6.

Procerolagena distomamargaritifera (Rymer Jones 1872). JONES 1994, pl.58, fig.16.

DISTINGUISHING FEATURES: Test elongate, slender, gently curved and tapering at both ends; circular in cross-section. Whole test ornamented with short curved or wavy costae. Aperture a small round opening on the end of a tapered neck with spiral costae.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994, Loeblich & Tappan 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Procerolagena meridionalis (Wiesner 1931)
Pl. 12, Figs 21–24

Lagena gracilis Williamson var. *meridionalis* WIESNER 1931, p.117, pl.18, fig.211.

Lagena meridionalis Wiesner. JONES 1994, pl.58, fig.19.

Procerolagena meridionalis (Wiesner). LOEBLICH & TAPPAN 1994, pl.143, figs 7–11.

Lagena gracilis Williamson. BRADY 1884, pl.58, fig.19.

DISTINGUISHING FEATURES: Test fusiform; circular in cross-section. Aboral end bluntly rounded, usually without an apical spine. 8–12 strong costae extend the entire test length, alternating with a second set of slightly weaker costae that extend 1/2 to ¾ length of test. Apertural end is gently tapered from middle of test to a short, smooth, narrow neck with a small round aperture.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994, Loeblich & Tappan 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Procerolagena multilatera **(**McCulloch 1977)
Pl. 12, Figs 25–26

Lagena gracilis Williamson. BARKER 1960, pl.58, figs 2,3,7–8,22–24; THOMAS *et al.* 1990, pl.5, fig.3.

Lagena multilatera McCULLOCH 1977, p.40, pl.50, fig.5; JONES 1994, p.65, pl.58, figs 2–3,7–8,22–24.

Procerolagena multilatera (McCulloch). LOEBLICH & TAPPAN 1994, p.79–80, pl.144, fig.8.

DISTINGUISHING FEATURES: Test elongate, fusiform in side-view, widest slightly below middle of test; tapers to both ends; circular in cross-section. Often with short spine at aboral end. 8–12 costae extend along the entire test length, sometimes quite weak. Apertural end gently tapers with the small circular aperture situated at the end of a long slender neck, sometimes with a small apertural rim.

WORLD GEOGRAPHIC DISTRIBUTION: South Pacific (Jones 1994).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Nodosariidae Ehrenberg 1838

GENUS – *Botuloides* Zheng 1979

Botuloides pauciloculus Zheng 1979
Pl. 12, Figs 27–28

Botuloides pauciloculus Zheng 1979, p.141, pl.9, figs 15–16.

Glandulonodosaria calomorpha (Reuss). JONES 1994, pl.61, figs 23–24.

DISTINGUISHING FEATURES: Test small, elongate, arcuate, uniserial; circular in cross-section. Usually two elongate, sausage-shaped chambers, with parallel sides and broadly rounded ends, both similar diameter and size; chambers usually added at slight angle with depressed horizontal suture between. Aperture a small round terminal opening, sometimes with a short neck. Wall thin, transparent, smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records from off the east coast of the North Island (39–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Bathyal depths (300–1500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Dentalina* Risso 1826

Dentalina cuvieri (d'Orbigny 1826)
Pl. 12, Figs 29–30

Nodosaria (les Dentalines) *cuvieri* D'ORBIGNY 1826, p.255; PARKER, JONES & BRADY 1871, pl.9, fig.57.

Dentalina cuvieri (d'Orbigny). LOEBLICH & TAPPAN 1987, pl.439, fig.19.

Nodosaria (Dentalina) obliqua Linnaeus. CHAPMAN 1906, pl.3, fig.5.

Dentalina vertebralis (Batsch). HEDLEY *et al.* 1965, pl.6, fig.19.

DISTINGUISHING FEATURES: Test long, uniserial, curved, almost parallel-sided in macrospheric forms, or tapering from a small proloculus in microspheric forms; circular in cross-section. Chambers initially wider than high and not inflated, becoming higher and more inflated in adult portions; sutures initially narrow and flush, becoming depressed later. Ornament of 12–16 vertical ribs extending most of the length of the test. Proloculus with a single spine. Aperture terminal radiate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off both coasts of the North and northern South Islands (34–45°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Loeblich & Tappan 1987).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper bathyal (70–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Frondicularia* Defrance 1826

Frondicularia compta Brady 1879
Pl. 12, Figs 31–33

Frondicularia compta BRADY 1879, p.271, pl.8, fig 6; JONES 1994, pl.65, fig.19.

DISTINGUISHING FEATURES: Test elongate, compressed, uniserial, almost parallel-sided, sometimes with a broader early section; flattened rectangular in cross-section with quadrate peripheries. Chambers chevron-shaped, slightly wider than high; sutures limbate. Surface otherwise smooth. Aperture terminal.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare. Recorded only from the Bay of Plenty, off the east coast of the North Island (37°S).

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to uppermost bathyal (100–400 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Pliocene to Recent (Wn–Rec).

GENUS – *Laevidentalina* Loeblich & Tappan 1986

Test elongate, uniserial, arcuate. Aperture terminal, radiate. Test wall smooth.

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Laevidentalina advena: Test moderately stout, gently curved; 7–10 very slightly inflated, rather broad chambers; sutures thin, flush to weakly incised later, slightly oblique.

Laevidentalina badenensis: Test slender; chambers elongate ovate; sutures strongly oblique; aperture on short neck; proloculus elongate, spined.

Laevidentalina elegans: Test long, slender; chambers numerous, low to subquadrate; sutures horizontal, initially flush and glassy, later narrow and incised; aperture often on short neck.

Laevidentalina haueri: Test slender; chambers oval; sutures slightly oblique; no apertural neck.

Laevidentalina inornata: Test slender; chambers few, subquadrate to ovate; sutures horizontal, initially flush, later narrow and incised; no apertural neck.

Laevidentalina sidebottomi: Test short, moderately stout, almost straight; up to 6, slightly inflated, ovate chambers, of near uniform diameter; sutures incised, almost horizontal.

Laevidentalina advena (Cushman 1923)
Pl. 12, Figs 34–35

Nodosaria advena CUSHMAN 1923, p.79, pl.14, fig.12.

Dentalina advena (Cushman). JONES 1994, pl.63, fig.1.

DISTINGUISHING FEATURES: Test moderately stout, gently curved. 7–10 very slightly inflated, rather broad chambers; sutures thin, flush to weakly incised later, slightly oblique. Aperture radiate, produced but no neck.

REMARKS: *L. advena* has broader chambers than *L. elegans* and *L. inornata* and has more oblique, flush sutures than *L. sidebottomi*.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic records from off both coasts of the North and northern South Islands (34–44°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Cushman 1923).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to bathyal (100–2000 m), most commonly at upper bathyal (200–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Laevidentalina badenensis (d'Orbigny 1846)
Pl. 12, Figs 36–39

Dentalina badenensis D'ORBIGNY 1846, p.44, pl.1, figs 48–49; PAPP & SCHMID, 1985, pl.9, figs 3–4.

Dentalina filiformis (d'Orbigny). JONES 1994, pl.63, figs 3–5.

Laevidentalina filiformis (d'Orbigny). YASSINI & JONES 1995, p.99, figs 257,258; HAYWARD *et al.* 1999, pl.6, figs 18–19.

DISTINGUISHING FEATURES: Test long, slender, curved. High, ovate chambers with strongly oblique sutures. Long basal spine. Aperture radiate, terminal on a short neck.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs around all three main islands and the Chatham Islands (34–46˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Sporadic occurrences in low numbers at shelf and upper bathyal depths (20–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Cretaceous to Recent (Mh–Rec).

Laevidentalina elegans (d'Orbigny 1846)
Pl. 12, Figs 40–42

Dentalina elegans D'ORBIGNY 1846, p.45, pl.1, figs 52–56; PAPP & SCHMID, 1985, pl. 10, figs 1–8; pl.13, figs 7–10.

Dentalina subemaciata PARR 1950, p.329, pl.12, fig.1; JONES 1994, pl.62, figs 25–26.

DISTINGUISHING FEATURES: Test long, curved. Early chambers with height about half width, becoming higher in adult portion. Chambers initially flat and parallel-sided, becoming moderately inflated in adult. Sutures transverse. flush and glassy in early portion; becoming more incised and narrow later. Aperture terminal and radiate, often on a short neck.

REMARKS: Distinguished from *L. inornata* by the more slender test and wide glassy sutures in the early portion of the test.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread around all of New Zealand (33–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Widespread in low numbers at shelf to mid bathyal depths (30–1000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

Laevidentalina haueri (Neugeboren, 1856)
Pl. 12, Figs 43–47

Dentalina haueri NEUGEBOREN 1856, p.81, pl.2, fig.12.

Nodosaria neugeboreni SCHWAGER 1866, p.232, pl.6, fig.67.

Nodosaria inornata var. *bradyensis* DERVIEUX 1894, p.610, pl.5, figs 30,31.

Dentalina bradyensis (Dervieux). JONES 1994, pl.62, figs 19–20.

Laevidentalina bradyensis (Dervieux). LOEBLICH & TAPPAN 1994, p.64, pl.114, figs 1–9; JONES, 1994, pl.62, figs 19–20; HAYWARD *et al.* 1999, pl.6, figs 16–17.

Laevidentalina aphelis (Loeblich & Tappan). JONES, 1994, pl.62, figs 21–22.

DISTINGUISHING FEATURES: Oval chambers with slightly oblique sutures. Aperture terminal with radial slits and no neck.

REMARKS: This species is distinguished from *L.badenensis* by its less slender test and less oblique sutures.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread right around New Zealand in low numbers (28–52˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994, Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Deep inner shelf to mid bathyal depths (30–1000 m) with a few deeper possibly displaced records.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Lw–Rec).

Laevidentalina inornata (d'Orbigny 1846)
Pl. 12, Figs 48–52

Dentalina inornata D'ORBIGNY 1846, p.44, pl. 1, figs 50–51; PAPP & SCHMID, 1985, pl.9, figs 5–8.

Dentalina vagina STACHE 1864, p.206, pl.22, fig.34.

Vaginulina vagina (Stache). HORNIBROOK 1971, pl.7, figs 119–124.

Dentalina emaciata Reuss. HEDLEY *et al.* 1965, pl.6, fig.18.

Laevidentalina subemaciata (Parr). HAYWARD *et al.* 1999, pl.6, figs 22–23.

DISTINGUISHING FEATURES: Test relatively short, gently curved, thick-walled. Chambers few (up to 10), subquadrate to ovate; sutures transverse, initially flush, later narrow and slightly incised. Aperture terminal radiate, no neck.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences right around New Zealand (34–50˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1846).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper bathyal (80–600 m) with two, probably displaced single records from greater depths.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Laevidentalina sidebottomi (Cushman 1923)
Pl. 12, Figs 53–56

Dentalina sidebottomi CUSHMAN 1923, p.12, pl.3, fig.4.

Laevidentalina sidebottomi (Cushman). LOEBLICH & TAPPAN 1994, pl.113, figs 13–19.

Nodosaria radicula Linneaus. SIDEBOTTOM 1918, pl.4, figs 1–5.

DISTINGUISHING FEATURES: Test relatively short, moderately broad, almost straight. Chambers few (up to 6), quadrate to ovate, slightly inflated, of near uniform diameter throughout, becoming slightly longer later; sutures horizontal to slightly oblique, narrow and slightly incised. Aperture radiate, no neck. Wall thin, transparent.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: rare records from off both coasts of the North Island

(34–39˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South Pacific (Cushman, 1923).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to upper bathyal (100–400 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Lingulina* d'Orbigny 1826

Lingulina grandis Cushman 1917
Pl. 12, Figs 57–58

Lingulina grandis CUSHMAN 1917, p.656, pl.43, fig.1; PARR 1950, pl.12, fig.3.

DISTINGUISHING FEATURES: Test huge (up to 10 mm), elongate; lenticular in cross-section; periphery acutely rounded to weakly keeled. Chambers uniserial, rectilinear, broad, low (up to 8), somewhat inflated; sutures slightly depressed, curved down towards the peripheries. Aperture a terminal slit. Wall smooth and shining.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records from off the north-east coast of the North Island (34–37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Cushman, 1917).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf (100–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Mucronina* Ehrenberg 1839

Staffia Schubert 1911
Proxifrons Vella 1963

Mucronina* aff. *advena (Cushman 1923)
Pl. 12, Figs 59–61

Frondicularia advena CUSHMAN 1923, p.141, pl.20, figs 1–2.

Plectofrondicularia advena (Cushman). JONES 1994, p.78, pl.66, figs 8–10 (in part, not figs 11–12).

Proxifrons javana (Boomgaart). LOEBLICH & TAPPAN 1994, pl.118, figs 8–10.

Proxifrons advena (Cushman). LOEBLICH & TAPPAN 1987, pl.444, figs 7–9.

DISTINGUISHING FEATURES: Test elongate, narrowly flaring upwards; compressed in cross-section. Early part of test usually inflated, twisted or irregular; later uniserial chevron-shaped chambers. No costae. Aperture terminal radiate.

REMARKS: This material differs from the types of *M. advena* by the irregular, inflated or twisted early part of the test.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records from around New Zealand (38–44˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994; Hayward *et al*. 2007d).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid to lower bathyal (600–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Pleistocene to Recent (Wn–Rec).

GENUS – *Pseudonodosaria* Boomgaart 1949

Pseudonodosaria brevis (d'Orbigny 1846)
Pl. 12, Figs 62–63

Dentalina brevis D'ORBIGNY 1846, pl.2, figs 9–10; PAPP & SCHMID 1985, pl.12, figs 8–11.

Glandulina discreta REUSS 1850, p.366, pl.46, fig.3.

Pseudonodosaria discreta (Reuss 1850). LOEBLICH & TAPPAN 1987, pl.439, figs 6–8; LOEBLICH & TAPPAN 1994, pl.117, figs 1–6.

Pseudoglandulina glanduliniformis (Dervieux). JONES 1994, pl.61, figs 28–31.

DISTINGUISHING FEATURES: Test elongate, cylindrical, uniserial; circular in cross-section. Base tapering or broadly rounded, usually with a basal spine. Early chambers strongly overlapping, final chamber more inflated; sutures incised, horizontal. Aperture strong, terminal, radiate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered records from off both coasts of the North and northern South Islands (34–44˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Loeblich & Tappan 1987).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to lower bathyal (140–1300 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Eocene to Recent (Dm–Rec).

FAMILY – Polymorphinidae d'Orbigny 1839

GENUS – *Francuscia* McCulloch 1981

Francuscia extensa (Cushman 1923)
Pl. 13, Figs 1–2

Polymorphina longicollis BRADY 1881b, p.64 (NOT of Karrer, 1870); BRADY 1884, pl.73, figs 18–19.

Polymorphina extensa CUSHMAN 1923, p.156, pl.41, figs 7–8.

Francuscia extensa (Cushman). JONES 1994, pl.73, figs 18–19.

DISTINGUISHING FEATURES: Test elongate fusiform; initial end acutely rounded or pointed. Initially biserial with last chamber more central. Chambers few, elongate, slightly inflated; sutures narrow, distinct, but not depressed, except for the last. Chamber ornament hispid, particularly on the last chamber. Aperture small round, terminal on slender, long hispid neck. Last chamber sometimes tending fistulose with more than one long necked apertures (pl.13, fig.2).

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records from north-east of the North Island (35–37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Rare, cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper to mid abyssal (2500–3500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Pyrulina* d'Orbigny 1839

KEY FEATURES OF SOME NEW ZEALAND SPECIES:
Pyrulina angusta: Test slender, chambers not inflated.
Pyrulina fusiformis: Test moderately inflated, widest medially; chambers slightly inflated; basal spine.

Pyrulina angusta (Egger 1857)
Pl. 13, Figs 3–4
Polymorphina angusta EGGER 1857, p.290, pl.13, figs 13–15.
Pyrulina angusta (Egger). UJIIE 1990, pl.6, figs 10–11; JONES 1994, pl.72, figs 1–2.

DISTINGUISHING FEATURES: Test slender fusiform, tapering to both ends; circular in cross-section. Base broadly rounded or a weak spine. Chambers elongate slender, later biserial, strongly overlapping; sutures oblique, flush. No ornament. Aperture terminal radiate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records from off the north-east coast of the North Island (35–38˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower bathyal to mid abyssal (1500–3500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Pyrulina fusiformis (Roemer 1838)
Pl. 13, Figs 5–8
Polymorphina (*Globulinen*) *fusiformis* ROEMER 1838, p.386, pl.3, fig.37.
Pyrulina fusiformis (Roemer). UJIIE 1990, pl.6, fig.12; JONES 1994, pl.71, figs 18–19, pl.72, fig.4.

DISTINGUISHING FEATURES: Test fusiform, moderately inflated, width about half height, tapering to both ends. Aboral end acutely rounded with a moderately strong spine. Chambers slightly inflated; sutures oblique, flush. Aperture terminal, radiate, with small circular openings at lower end of filled radial slits only seen in scanning electon microscope photographs. Wall smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrences north-east of the North Island (34–37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper to mid abyssal (2500–3500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Oligocene to Recent (Ld–Rec).

GENUS – *Ramulina* Jones 1875

Ramulina globulifera Brady 1879
Pl. 13, Fig. 9
Ramulina globulifera BRADY 1879b, p.272, pl.8, figs 32–33; JONES 1994, pl.76, figs 22–28.

DISTINGUISHING FEATURES: Spherical to globular chambers, loosely connected by stolon-like necks, 2–6 per chamber. Chambers and stolon surfaces hispid. Usually found as broken pieces.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered records off both coasts of the North and northern South Island (36–44˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper bathyal (80–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

GENUS – *Sigmoidella* Cushman & Ozawa 1928

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:
Sigmoidella elegantissima: Broadly ovate outline; more than 4 chambers visible on at least one side.
Sigmoidella pacifica: Ovate outline; 4 or fewer chambers visible on both sides.

Sigmoidella elegantissima Parker & Jones 1870
Pl. 13, Figs 10–13
Polymorphina elegantissima Parker & Jones in BRADY, PARKER & JONES 1870, p.231, pl.40, fig.15.
Sigmoidella elegantissima (Parker & Jones). CUSHMAN & OZAWA 1930, pl.16, figs 10–11; JONES 1994, pl.72, figs 12–13; LOEBLICH & TAPPAN 1994, pl.148, figs 4–12; YASSINI & JONES 1995, figs 666–667, 670.

DISTINGUISHING FEATURES: Test large, broadly ovate in outline and somewhat compressed. Basal end flat to concave, apertural end tapering; periphery acutely rounded. Chambers elongate and arranged in a dextral sigmoid form, involute with 4 chambers visible on one side and numerous on the other; sutures distinct but not incised. Aperture terminal radiate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Moderately rare off north-east coast of the North Island (32–36˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Cushman & Ozawa 1929; Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Low numbers at shelf depths (20–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Oligocene to Recent (Lwh–Rec).

Sigmoidella pacifica Cushman & Ozawa 1928
Pl. 13, Figs 14–16
Sigmoidella pacifica CUSHMAN & OZAWA 1928, p.19,

pl.2, fig.13; LOEBLICH & TAPPAN 1987, pl.459, figs 5–7.

Sigmoidella kagaensis Cushman & Ozawa 1928. HAYWARD *et al.* 1999, p.118, pl.7, figs 13–14.

DISTINGUISHING FEATURES: Test moderately large, ovate in outline and somewhat compressed. Basal end rounded, apertural end tapering and periphery acutely rounded. Chambers elongate and arranged in a dextral sigmoid form; involute, with 4 chambers visible on one side and three on the other. Sutures distinct but not depressed except on growing edge.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs right around New Zealand (33–53˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Cushman & Ozawa 1928).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Widespread in low numbers at shelf depths (10–200 m) and rare at upper bathyal (200–400 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

FAMILY – Vaginulinidae Reuss 1860

GENUS – *Amphicoryna* Schlumberger 1881

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Amphicoryna georgechapronierei: Bluntly rounded aboral end with spines; longitudinal costae cross sutures; apertural neck annulate.

Amphicoryna hirsuta* f. *hirsuta: Sutures strongly incised, later chambers often well separated by necks; chamber ornament spinose.

Amphicoryna hirsuta* f. *sublineata: Sutures strongly incised, later chambers often well separated by necks; chamber ornament costate with some spines.

Amphicoryna leurodeira: Sutures not strongly incised; test with overlapping chambers; longitudinal costae; apertural neck smooth (rare, see Loeblich &Tappan 1994, pl. 127, figs 19–24).

Amphicoryna scalaris: Sutures incised; longitudinal costae do not cross sutures; apertural neck smooth (rare, see Jones 1994, pl. 65, figs 7–9).

Amphicoryna separans: Sutures incised; test with overlapping early chambers, last often separated by neck; longitudinal costae do not cross sutures; apertural neck hispid or annulate.

Amphicoryna georgechapronierei Yassini & Jones 1995
Pl. 13, Figs 17–18

Amphicoryna georgechapronierei YASSINI & JONES 1995, p.136, figs 696,700; HAYWARD *et al.* 1999, pl.6, figs 38–39.

DISTINGUISHING FEATURES: Largely uniserial test; chambers not strongly overlapping. Aboral end rounded with short spines. Strong longitudinal costae do not terminate at sutures but die out at base of neck. Annular rings around elongate neck.

REMARKS: This species differs from the cosmopolitan *A. scalaris* by its aboral spines and continuous costae over the sutures.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Recorded from right around New Zealand (34–52˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Australasia, but may be more widely distributed and not distinguished from *A. scalaris*.

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Sporadic occurrences at inner shelf to upper bathyal depths (10–600 m), most commonly at inner and mid shelf.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Pliocene to Recent (Wn–Rec).

Amphicoryna hirsuta* f. *hirsuta (d'Orbigny 1826)
Pl. 13, Fig. 19

Nodosaria (Nodosaire) *hirsuta* D'ORBIGNY 1826, p.252, no.7; PARKER, JONES & BRADY 1871, pl.9, fig.45; VÉNEC-PEYRÉ 2005, p.78, pl.1, fig.5.

Amphicoryna hirsuta (d'Orbigny). JONES 1994, pl.63, figs 14–15.

Nodosaria hispida D'ORBIGNY 1846, p.35, pl.1, figs 24,25; LOEBLICH & TAPPAN 1994, pl.116, figs 7–8.

DISTINGUISHING FEATURES: Test large, narrow, elongate; straight to slightly curved. Chambers spherical; later chambers often well separated by necks. Chamber ornament densely spinose. Apertural neck with weak, broken annulae.

REMARKS: Both spinose and costate forms co-occur, suggesting that they are both forms of the same species.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs right around New Zealand (34–53˚S), more commonly north of 44˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1846).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to mid bathyal (80–800 m), most commonly at outer shelf–upper bathyal (150–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Oligocene to Recent (Lwh–Rec).

Amphicoryna hirsuta* f. *sublineata (Brady 1884)
Pl. 13, Fig. 20

Nodosaria hispida d'Orbigny var. *sublineata* BRADY 1884, p.508, pl.63, figs 19–22.

Amphicoryna sublineata (Brady 1884). Jones 1994, pl.63, figs 19–22.

DISTINGUISHING FEATURES: Test large, narrow, elongate; straight to slightly curved. Chambers spherical; later chambers often well separated by necks. Chamber ornament of weak vertical costae and some short spines. Apertural neck with weak, broken annulae.

REMARKS: Both spinose (f. *hirsuta*) and costate (f. *sublineata*) forms co-occur, suggesting that they are both forms of the same species.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare, only recorded from off the west coast of the South Island (43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal (600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Amphicoryna separans (Brady 1884)
Pl. 13, Figs 21–22
Nodosaria scalaris (Batsch) var. *separans* BRADY 1884, p.510, pl.64, figs 16–19.
Amphicoryna separans (Brady). LOEBLICH & TAPPAN 1994, pl.127, figs 1–18; JONES 1994, pl.64, figs 16–19.

DISTINGUISHING FEATURES: Test moderate size, elongate. Early chambers overlapping, sutures incised; last chamber spherical often separated from earlier ones by a neck. Longitudinal costae numerous, not crossing sutures. Apertural neck hispid or weakly annulate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off both coasts of the North and northern South Islands (34–44˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Gabel 1971).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to mid bathyal (100–800 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Pliocene to Recent (Wn–Rec).

GENUS – *Astacolus* Montfort 1808

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:
Astacolus crepidulus: Test compressed; chambers not inflated.
Astacolus insolitus: Test ovate in cross-section; chambers slightly inflated (mostly inner shelf, see Hayward *et al.* 1999, pl.6, fig.30).

Astacolus crepidulus (Fichtel & Moll 1798)
Pl. 13, Figs 23–24; Pl. 14, Figs 1–2
Nautilus crepidulus FICHTEL & MOLL 1798, p.107, pl.19, figs g–i.
Astacolus crepidulus (Fichtel & Moll). HAYWARD *et al.* 1999, pl.6, figs 28–29.

DISTINGUISHING FEATURES: Test elongate, oval, compressed. Initial planispiral coil, later uncoiled with elongate chambers. Chambers not inflated. Wall unornamented. Aperture terminal radiate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences in low numbers right around New Zealand (35–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Nomura 1981, Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: At deep inner shelf to upper bathyal depths (20–400 m), most commonly at inner to mid shelf (20–100 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Miocene to Recent (Sw–Rec).

GENUS – *Hemirobulina* Stache 1864

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:
Hemirobulina angistoma: Test circular in cross-section; chambers higher than wide.
Hemirobulina hydropica: Test ovate in cross-section; chambers wider than high.

Hemirobulina angistoma Stache 1864
Pl. 13, Figs 25–27
Marginulina angistoma STACHE 1864, p.213, pl.22, fig.46; HORNIBROOK 1971, pl.7, figs 109–114.
Marginulina obesa (Cushman). JONES 1994, pl.65, figs 5–6.

DISTINGUISHING FEATURES: Test stout, elongate; circular in cross-section. Early chambers curved but not coiled, later rectilinear. Chambers as high as wide, no ornament. Last chamber tapers to one margin with a large terminal, radiate aperture.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Only recorded off the east coast of northern North Island (33–37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Bernhard *et al.* 2004).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Rare occurrences at outer shelf to upper bathyal depths (100–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Oligocene to Recent (Lwh–Rec).

Hemirobulina hydropica (Hornibrook 1961)
Pl. 13, Figs 28–30
Marginulinopsis hydropica HORNIBROOK 1961, p.43, pl.5, figs 74–75,79–80.

DISTINGUISHING FEATURES: Test stout, elongate; ovate in cross-section. Early chambers curved but not coiled, later rectilinear. Chambers wider than high; no ornament. Last chamber tapers to one margin with a large terminal, radiate aperture.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare, only recorded from off both coasts of northern North Island (34–39˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Hornibrook 1961).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to lower bathyal (100–1300 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Oligocene to Recent (Ld–Rec).

GENUS – *Lenticulina* Lamarck 1804

Robulus de Montfort 1808

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Lenticulina anaglypta: Denticulate flange-like keel; additional flange-like costae parallel periphery; large tubercles centrally; 6–7 chambers per whorl.

Lenticulina antarctica: Test slightly evolute; no umbo; 8–10 chambers per whorl; sutures narrow, curved.

Lenticulina australis: 7–10 chambers in final whorl; umbo present; sutures gently curved; distinct keel.

Lenticulina calcar: Needle-like peripheral spines on glassy keel; almost straight sutures; 5 chambers per whorl.

Lenticulina cultrata: Test large; flange-like keel; no umbo or small translucent area; 6–7 chambers per whorl.

Lenticulina denticulifera: Peripheral keel with short denticular serrations; large umbo; weak costae on early chambers; 7–8 chambers per whorl.

Lenticulina erratica: Test small, uncoiling; 4–6 spherical chambers per whorl (rare, see Hayward *et al*. 1999, pl.6, figs 33–34).

Lenticulina foliata: Strongly sinuous sutures; small umbo; weak keel; 6–8 chambers per whorl.

***Lenticulina formosa*:** Needle-like peripheral spines on glassy keel; sutures curved; 6–8 chambers per whorl.

Lenticulina gibba: Test becoming uncoiled; no umbo; sutures narrow, curved; last chamber extending part width of test; 6–8 chambers per whorl.

Lenticulina limbosa: Flange-like keel; 5–6 chambers per whorl; almost straight sutures; translucent umbonal area.

Lenticulina orbicularis: Test large; flange-like keel; 7–11 chambers per whorl; strongly curved sutures; large clear umbo.

***Lenticulina subgibba**:* Test becoming uncoiled; no umbo; sutures narrow, curved; last chamber extending full width of test; 6–8 chambers per whorl.

Lenticulina submamilligera: Test large; ornamented with large, translucent tubercles around umbo.

Lenticulina suborbicularis: Strongly recurved sutures; strong flange-like keel; broad, raised, translucent umbonal area; 5–6 chambers per whorl.

Lenticulina tasmanica: Weak keel; translucent umbonal area; sutures almost straight; 5–6 chambers per whorl.

KEY TO NZ RECENT *LENTICULINA* SPECIES

1. Aperture a terminal cluster of short, hollow tubes *Neolenticulina variabilis*
   Aperture terminal with radiating slits 2

2. Possess ornament or peripheral spines 3
   Lack ornament or peripheral spines 7

3. Possess ornament on sides of test 4
   No ornament, but possess peripheral spines or denticles 5

4. Large tubercles near umbonal area *L. submamilligera*
   Umbonal tubercles, peripheral costae, and denticular serrated flange-like keel *L. anaglypta*

5. Peripheral keel with one elongate spine per chamber 6
   Peripheral keel with short denticular serrated sections *L. denticulifera*

6. Test with 5 chambers per whorl; sutures almost straight *L. calcar*
   Test with 6–8 chambers per whorl; sutures curved *L. formosa*

7. Peripheral keel absent; chambers spherical *L. erratica*
   Peripheral keel present; chambers compressed 8

8. Peripheral keel glassy, wide and flange-like 9
   Peripheral keel narrow, weak or strong 12

9. Sutures strongly recurved towards periphery 10
   Sutures gently curved to straight 11

10. 7–11 chambers per whorl; large umbo *L. orbicularis*
    5–6 chambers per whorl; large, raised, translucent umbonal area *L. suborbicularis*

11. 6–8 chambers per whorl; sutures gently curved; umbo lacking or small *L. cultrata*
    5–6 chambers per whorl; sutures almost straight; umbo large *L. limbosa*

12. Sutures strongly sinuous *L. foliata*
    Sutures straight or curved, not sinuous 13

13. Umbo lacking 14
    Umbo present 16

14. 8–10 chambers per whorl; slightly evolute *L. antarctica*
    6–8 chambers per whorl; involute, possibly some uncoiling 15

15. Lower part of final chamber extends part width of test *L. gibba*
    Lower part of final chamber extends full width of test *L. subgibba*

16. Umbo large, 7–10 chambers per whorl; chambers moderately narrow *L. australis*
    Umbo translucent, 6 chambers per whorl; chambers subquadrate *L. tasmanica*

Lenticulina anaglypta (Loeblich & Tappan 1987)
Pl. 13, Figs 31–32; Pl. 14, Figs 3–4

Lenticulina costata (Fichtel & Moll). HEDLEY *et al*. 1965, pl.4, fig.14.

Spincterules anaglyptus LOEBLICH & TAPPAN 1987, p.407, pl.449, figs 7–8.

DISTINGUISHING FEATURES: Test large; periphery acutely rounded with denticulate flange-like keel. 6–7 wedge-shaped chambers per whorl; sutures narrow, curved, flush. Surface ornament of additional flange-like costae parallel periphery and large tubercles over umbonal area.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Two occurrences recorded, from off both coasts of northernmost New Zealand (36–37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Both occurrences are at mid shelf depths (50–100 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Lenticulina antarctica Parr 1950
Pl. 14, Figs 5–6
Lenticulina antarctica PARR 1950, p.323, pl.11, fig.11.

DISTINGUISHING FEATURES: Test of moderate to large size; periphery subacute with a weak broad glassy keel. 8–10 chambers in final whorl; later whorls becoming slightly evolute, so that inner ends of chambers of earlier whorl may be visble; no central umbo. Sutures distinct, gently curved, narrow and flush. Lacks surface ornament.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off the east coast of the full length of New Zealand and in Cook Strait (35–51˚S), but not recorded to the west so far.

WORLD GEOGRAPHIC DISTRIBUTION: Common and widespread around the Southern Ocean (Parr, 1950).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Inner shelf to mid bathyal (20–800 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Lenticulina australis Parr 1950
Pl. 13, Figs 33–34; Pl. 14, Figs 7–8
Lenticulina (Robulus) australis PARR 1950, p.322, pl.11, figs 7,8.
Lenticulina australis Parr 1950. HAYWARD *et al.* 1999, pl.6, figs 31–32.

DISTINGUISHING FEATURES: Test of moderate size; periphery acutely rounded with a narrow keel. 7–10 chambers in final whorl; chambers moderately narrow. Sutures distinct, gently curved, limbate and flush. Large umbilical region flush and often transparent; proloculus clearly visible in juveniles.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread in low numbers throughout the New Zealand region (28–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Also recorded from Australia (Parr 1950, Yassini & Jones 1995).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Shelf and bathyal depths (20–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Lw–Rec).

Lenticulina calcar (Linnaeus 1758)
Pl. 14, Figs 9–10; Pl. 15, Figs 1–2
Nautilus calcar LINNAEUS 1758, p.709.
Lenticulina calcar (Linnaeus). HORNIBROOK *et al.* 1989, fig.23:7; LOEBLICH & TAPPAN 1994, pl.120, figs 1–8; JONES 1994, pl.70, figs 9–12; LOBEGEIER & SEN GUPTA 2008, pl.2, fig.8.

DISTINGUISHING FEATURES: Test moderately small; moderately inflated profile. Periphery subacute with glassy keel bearing long needle-like spines, often broken. 5 chambers per whorl; chambers triangular in outline; sutures almost straight. Translucent umbonal area.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread around New Zealand (36–51˚S), most commonly off the west coast.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to mid bathyal (100–1000 m), most commonly at upper bathyal depths (200–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Pl–Rec).

Lenticulina cultrata Montfort 1808
Pl. 14, Figs 11–12
Robulus cultratus MONTFORT 1808, p.215.
Lenticulina cultrata (Montfort). HEDLEY *et al.* 1965, pl.4, fig.15; RÖGL & HANSEN 1984, p.57, pl.16, figs 2,4 (lectotype); LOEBLICH & TAPPAN 1987, pl.446, figs 9–10; YASSINI & JONES 1994, figs 701–702.

DISTINGUISHING FEATURES: Test large, lenticular. Periphery acute, with wide, flange-like keel. 6–7 chambers per whorl; sutures slightly curved. No umbo, but may be a small translucent central area.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered locations right around New Zealand (34–50˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Sousa *et al.* 2006).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to mid bathyal (80–1000 m), most commonly at outer shelf to upper bathyal depths (100–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

Lenticulina denticulifera (Cushman 1913)
Pl. 14, Figs 13–14
Cristellaria denticulifera CUSHMAN 1913, p.75, pl.37, fig.1.
Cristellaria cultrata (Montfort). BRADY 1884, pl.70, figs 7–8.
Lenticulina denticulifera (Montfort). JONES 1994, pl. 70, figs 7–8.

DISTINGUISHING FEATURES: Test moderate to large size; periphery acute; strong peripheral keel with short denticular serrations. 7–8 chambers per whorl; sutures gently curved. Weak costae towards periphery on early chambers. Large umbonal area.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Three rare occurrences from off both coasts of the North and northern South Islands (34–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Martin 1988).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper bathyal (50–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Lenticulina foliata (Stache 1865)
Pl. 14, Figs 15–16
Cristellaria (Robulina) foliata STACHE 1865, p.245, pl.23, fig.24.
Robulus foliatus (Stache). HORNIBROOK 1971, pl.9, figs 151–152.
Lenticulina foliata (Stache). HORNIBROOK *et al.* 1989, fig.19:18.

DISTINGUISHING FEATURES: Test moderately small, somewhat inflated; periphery subacute with weak keel. 6–8 chambers per whorl; sutures strongly sinuous. Umbo small and glassy. Radiate aperture may be slightly necked.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread in low numbers off both coasts of the North and northern South Islands (34–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Hornibrook 1971).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to mid bathyal (50–800 m), mostly deeper than 100 m.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Eocene to Recent (Ak–Rec).

Lenticulina formosa (Cushman 1923)
Pl. 14, Figs 17–18; Pl. 15, Figs 3–4
Cristellaria formosa CUSHMAN 1923, p.110, pl.29, fig.1; pl.30, fig.6.
Lenticulina formosa (Cushman). JONES 1994, pl.70, figs 13–14.

DISTINGUISHING FEATURES: Test large; periphery acute with glassy keel bearing one needle-like peripheral spines per chamber. 6–8 chambers per whorl; sutures strongly curved, narrow, slightly raised. Umbo small.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off both coasts of the North and northern South Islands (34–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper bathyal (200–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Lenticulina gibba (d'Orbigny 1839)
Pl. 14, Figs 19–20
Cristellaria gibba D'ORBIGNY 1839a, p.40, pl.7, figs 20–21.
Lenticulina gibba (d'Orbigny). HEDLEY *et al.* 1965, pl.3, fig.11; JONES 1994, pl.69, figs 8–9.

DISTINGUISHING FEATURES: Test small to medium size; periphery subacute with narrow, weak keel. 6–8 chambers per whorl; tightly coiled; lower part of final chamber extends part width of test; sutures narrow, curved. No umbo.

REMARKS: Distinguished from *L. subgibba* by the shape of the final chamber with its lower part extended only part way across the width of the test.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs in low numbers right around New Zealand (34–50˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to lower bathyal (60–2000 m), mostly at outer shelf to upper bathyal depths (150–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Eocene to Recent (Ar–Rec).

Lenticulina limbosa (Reuss 1863)
Pl. 14, Figs 21–22
Cristellaria (Robulina) limbosa REUSS 1863, p.55, pl.6, fig.69.
Lenticulina limbosa (Reuss). YASSINI & JONES 1995, fig.726.

DISTINGUISHING FEATURES: Test moderate size; periphery acute with wide, flange-like keel. 5–6 chambers per whorl; chambers triangular in outline; sutures almost straight. Large, translucent umbonal area.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs in low numbers off both coasts of the North and northern South Islands (34–44˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Reuss 1864).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to lower bathyal (60–1500 m), mostly outer shelf to upper bathyal (100–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Miocene to Recent (Sw–Rec).

Lenticulina orbicularis (d'Orbigny 1826)
Pl. 14, Figs 23–24
Robulina orbicularis D'ORBIGNY 1826, p.288, pl.15, figs 8–9.
Lenticulina orbicularis (d'Orbigny). JONES 1994, pl.69, fig.17.

DISTINGUISHING FEATURES: Test large; periphery subacute with wide flange-like keel. Chambers narrow; 7–11 chambers per whorl; sutures strongly curved. Umbo large translucent.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off the east coast of New Zealand (34–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1826).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to upper bathyal (100–500 m) with one presumably displaced record from much deeper.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

Lenticulina subgibba Parr 1950
Pl. 14, Figs 25–26; Pl. 15, Figs 5–6
Lenticulina subgibba PARR 1950, p.321, pl.11, figs 1,2; HAYWARD *et al.* 1999, pl.6, fig.35.

DISTINGUISHING FEATURES: Test small to moderate size, with a tendency towards uncoiling in the last few chambers of the adult; periphery acute, with a weak, blunt keel. 7–8 chambers per whorl, last chamber occupying almost full width of test; sutures narrow, gently curved. No umbo.

REMARKS: Distinguished from *L. gibba* by the shape of the final chamber with its lower part extended fully across the test.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs right around the New Zealand region in low numbers (34–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Also recorded from around southern Australia (Parr 1950).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Deep inner shelf to lower bathyal depths (30–1500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

Lenticulina submamilligera (Cushman 1917)
Pl. 14, Figs 27–28; Pl. 15, Figs 7–8
Cristellaria mamilligera Karrer. BRADY 1884, pl.70, figs 17–18.
Cristellaria submamilligera CUSHMAN 1917, p.657.
Lenticulina submamilligera (Cushman). LOEBLICH & TAPPAN 1994, pl.120, figs 9–14; JONES 1994, pl.70, figs 17–18.

DISTINGUISHING FEATURES: Test large; periphery subacute, with narrow keel. 8–10 chambers per whorl; sutures curved, limbate. Large umbo; ornament of large, translucent tubercles over umbo and inner ends of chambers.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Only recorded from two localities from off the east coast of the North Island (36–41˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Oliviera-Silva *et al.* 2005).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper bathyal (80–400 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Lenticulina suborbicularis Parr 1950
Pl. 14, Figs 29–30
Lenticulina suborbicularis PARR 1950, p.321, pl.11, figs 5–6; HEDLEY *et al.* 1965, pl.5, fig.16; LOEBLICH & TAPPAN 1994, pl.123, figs 1–9.

DISTINGUISHING FEATURES: Test moderate to large size; periphery acute with strong, flange-like keel. 5–6 narrow chambers per whorl; sutures strongly recurved around umbo. Umbo broad, raised, translucent.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread in low numbers right around New Zealand region (34–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to mid bathyal (50–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Miocene to Recent (Sw–Rec).

Lenticulina tasmanica Parr 1950
Pl. 14, Figs 31–32
Lenticulina tasmanica PARR 1950, pl.11, figs 3–4; HEDLEY *et al.* 1965, pl.5, fig.17.
Lenticulina atlantica BARKER 1960, pl.69, figs 9–12; JONES 1994, pl.69, figs 9–12.

DISTINGUISHING FEATURES: Test moderately large; periphery acutely angled with narrow, weak keel. 5–6 subtriangular chambers per whorl; sutures almost straight. Umbonal area translucent. Radiate aperture large.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off the east coast of New Zealand (34–53˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to mid bathyal (100–800 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Marginulina* d'Orbigny 1826

Test lacks early coiled section; chambers circular in cross-section.

Marginulina striata d'Orbigny 1852
Pl. 15, Figs 9–11
Marginulina striata D'ORBIGNY 1852, p.153; FORNASINI 1908, pl.1, fig.9; LOEBLICH & TAPPAN 1994, pl.131, figs 14–20.

DISTINGUISHING FEATURES: Test stout, elongate; circular in cross-section. Initial chambers curved around but not enrolled, later chambers rectilinear. Chambers subspherical in shape, ornamented with weak vertical costae. Last chamber tapering to an elongate radiate aperture at the dorsal side; aperture with radial crenulate margin.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences from off both coasts of the North Island and northern South Island (34–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1852).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper bathyal (80–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Pliocene to Recent (Wn–Rec).

GENUS – *Marginulinopsis* Silvestri 1904

Test with early coiled section; chambers circular in cross-section.

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:
Marginulinopsis bradyi: Test stout, costate.
Marginulinopsis tenuis: Test slender, smooth.

Marginulinopsis bradyi (Goës, 1894)
Pl. 15, Fig. 12
Nodosarina (*Cristellaria*) *bradyi* GOËS 1894, p.64, pl.11, figs 643–645.
Marginulina costata (Batsch). BRADY 1884, pl.65, figs 11–12.
Marginulinopsis bradyi (Goës). LOEBLICH & TAPPAN 1987, pl.446, figs 20–21.
Vaginulinopsis bradyi (Goës). JONES 1994, pl.65, figs 11–12.

DISTINGUISHING FEATURES: Test stout, elongate; early part of test with a peripheral keel, disappearing in rectilinear section.. Early chambers enrolled, later rectilinear; later chambers circular in cross-section. Ornament of strong costae that cross the weakly incised sutures. Last chamber less ornamented, tapering to a pointed radiate aperture on the dorsal side.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off the east coast of the North Island (36–41˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper–mid bathyal (200–800 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Pliocene to Recent (Wn–Rec).

Marginulinopsis tenuis (Bornemann, 1855)
Pl. 15, Figs 13–14
Marginulina tenuis BORNEMANN 1855, p.326, pl.13, fig.14.
Vaginulinopsis tenuis (Bornemann). JONES 1994, pl.66, figs 21–23.

DISTINGUISHING FEATURES: Test slender, elongate, curved; early periphery acutely rounded. Early chambers compressed, coiled; becoming more inflated and rectilinear; later chambers circular in cross-section. Sutures slightly incised, oblique, straight to slightly curved. Small, round, radiate aperture on end of short stout neck.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrences off both coasts of the North or northern South Island (35–41˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Bornemann 1855).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper bathyal (200–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Neolenticulina* McCulloch 1977

Neolenticulina variabilis (Reuss 1850)
Pl. 14, Figs 33–34, Pl. 15, Figs 15–16
Cristellaria variabilis REUSS 1850, p.369, pl.46, figs 15–16.
Neolenticulina variabilis (Reuss). JONES 1994, pl.68, figs 11–16.
Cristellaria peregrina SCHWAGER 1866, p.245, pl.7, fig.89.
Neolenticulina peregrina (Schwager). HAYWARD *et al.* 1999, pl.6, figs 36–37.

DISTINGUISHING FEATURES: Test ovate, involute; distinct peripheral keel. 4–5 inflated chambers per whorl; chambers rapidly increasing in size with last extending full width of test. Sutures gently curved, weakly incised. Aperture terminal, consisting of cluster of short, hollow tubes projecting above keel.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread in low numbers off both coasts of the North and northern South Island (34–44˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Loeblich & Tappan 1987, Yassini & Jones 1995).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to lower bathyal (50–1500 m), mostly at outer shelf to mid bathyal (100–800 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

GENUS – *Planularia* Defrance 1826

Planularia spinipes (Cushman 1913)
Pl. 15, Figs 17–19
Cristellaria tricarinella Reuss var. *spinipes* CUSHMAN 1913, p.72, pl.33, figs 2a–b.
Planularia australis CHAPMAN 1941, p.158, pl.9, fig.1; JONES 1994, pl.68, figs 3–4; HAYWARD *et al.* 1999, pl.6, figs 40–41.

DISTINGUISHING FEATURES: Test large, ovate, strongly compressed; early stage planispiral, becoming uncoiled. Dorsal periphery thickened and glassy. Sutures flush. Microspheric form with longer, more tightly coiled early stage (Pl. 15, Figs 18–19); megalospheric form with inflated proloculus, shorter planispiral stage and several short spines on aboral periphery (Pl. 15, Fig. 17).

REMARKS: This species is more elongate and has narrower chambers than *C. tricarinella* from the Cretaceious of Europe. The types of *P. spinipes* come from the Recent of Japan and are here considered to be the megalospheric form of the later described *P. australis.*

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences in low numbers from right around New Zealand's three main islands (33–47˚S), but mostly north of 40˚S.

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Cushman 1913, Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper bathyal (60–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Saracenaria* Defrance 1824

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Saracenaria altifrons: Apertural face elongate triangular; margins and periphery subacute, rounded.

Saracenaria italica: Apertural face equilateral triangular; margins and periphery acutely rounded; no spines.

Saracenaria latifrons: Apertural face elongate triangular; margins and periphery sharp and weakly keeled.

Saracenaria spinosa: Apertural face equilateral triangular; margins sharply rounded, periphery keeled, with glassy spines on marginal end of chambers.

Saracenaria altifrons (Parr 1950)

Pl. 15, Figs 20–24

Lenticulina (*Robulus*) *altifrons* PARR 1950, p.323, pl.11, fig.12.

Cristellaria acutauricularis (Fichtel & Moll). BRADY 1884, pl.114, fig.17.

Saracenaria altifrons (Parr). JONES 1994, pl.114, fig.17.

DISTINGUISHING FEATURES: Test small to moderate size; subovate outline; periphery acutely rounded. 6–8 slightly inflated chambers per whorl; tightly coiled with no umbo; later chambers becoming narrow, elongate, flaring. Sutures gently curved, slightly incised. Apertural face elongate triangular, inflated medially.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences in low numbers off both coasts of the North and northern South Island (35–42°S).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Kuhnt *et al.* 1999).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper bathyal (80–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Saracenaria italica Defrance 1824

Pl. 15, Figs 25–27

Saracenaria italica DEFRANCE 1824, p.176; JONES 1994, pl.68, figs 18,20–23.

DISTINGUISHING FEATURES: Test initially planispiral, later chambers flaring, becoming triangular in section and uncoiled rectilinear. Margins acutely rounded; dorsal angle may be weakly keeled. Apertural face approximately equilateral triangle. No spines.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences in low numbers off both coasts of the North and northern South Island (35–42°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Nomura 1981, Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid–shelf to upper bathyal depths (80–800 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Mid Miocene to Recent (Sw–Rec).

Saracenaria latifrons (Brady 1884)

Pl. 15, Figs 28–34

Cristellaria latifrons BRADY 1884, p.544, pl.68, fig.19, pl.113, fig.11.

Saracenaria latifrons (Brady). HAYWARD *et al.* 1999, pl.6, figs 44–45.

DISTINGUISHING FEATURES: Test initially planispiral, later chambers strongly flaring becoming elongate triangular in section. Margins and dorsal angle sharp to carinate. Apertural face elongate triangular, extending most of the length of the test.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences in low numbers off both coasts of the North and northern South Island (34–44°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (e.g. Loeblich & Tappan 1987, pl.448, fig.18, *Saracenaria* sp. from Gulf of Mexico).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper bathyal depths (70–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Pl–Rec).

Saracenaria spinosa Eichenberg 1935

Pl. 16, Figs 1–2

Saracenaria spinosa EICHENBERG 1935, p.10, pl.4, fig.5.

Saracenaria italica Defrance. HAYWARD *et al.* 1999, pl.6, figs 42–43.

DISTINGUISHING FEATURES: Test initially planispiral, later chambers flaring, becoming triangular in section and uncoiling, to rectilinear. Margins sharply rounded; dorsal angle strongly keeled. Apertural face approximately equilateral triangle. Short glassy spines on marginal ends of each chamber.

REMARKS: This species has similar shape to *S. italica* but differs in its smaller more fragile test and in the presence of marginal spines.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records off the east coast of northern North Island (34–41°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Eichenberg 1935).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf (100–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Vaginulina* d'Orbigny 1826

Test lacks early coiled portion; chambers compressed–ovate in cross-section;

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Vaginulina inflata: Test unornamented; sutures incised, chambers inflated; no basal spines.

Vaginulina spinigera: Test unornamented; sutures flush; two stout basal spines.

Vaginulina inflata Parr 1950
Pl. 16, Fig. 3
Vaginulina inflata PARR 1950, p.327, pl.11, figs 21–22.

DISTINGUISHING FEATURES: Test elongate with slight sigmoid curve; slightly compressed ovate in cross-section. Early portion of test weakly curved, rapidly becoming almost straight rectilinear; periphery rounded. Chambers smooth, inflated, wider than high; sutures strongly oblique and weakly curved, incised. Large radiate, pointed aperture, at the dorsal angle of the last chamber.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records from off both coasts of the two main islands of New Zealand (35–46˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Parr 1950).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Deep inner shelf to lower bathyal (30–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Pliocene to Recent (Wn–Rec).

Vaginulina spinigera Brady 1881
Pl. 16, Figs 4–7
Vaginulina spinigera BRADY 1881b, p.63, pl.67, figs 13–14; JONES 1994, pl. 67, figs 13–14.

DISTINGUISHING FEATURES: Test large elongate; compressed ovate in cross-section; early portion of test slightly curved, rapidly becoming almost straight rectilinear; periphery rounded. Chambers smooth, wider than high; sutures slightly oblique and weakly curved, almost flush with test. Two long, stout spines on the prolocular end project out with an angle of 60–100 degrees between them, but remain within the compressed plane of the test. Aperture a radiate point at the dorsal angle of the last chamber.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records from off both coasts of the South Island (42–44˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal (600–700 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Pliocene to Recent (Wn–Rec).

GENUS – *Vaginulinopsis* Silvestri 1904

Test with early coiled chambers; later chambers compressed in cross-section.

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Vaginulinopsis gnamptina: Teast broad arcuate, unornamented; slit aperture on a flange.

Vaginulinopsis tasmanica: Test stout, slightly curved; chambers inflated, unornamented; sutures depressed; radiate aperture on dorsal angle.

Vaginulinopsis gnamptina Loeblich & Tappan, 1994
Pl. 16, Figs 8–11
Vaginulinopsis gnamptina LOEBLICH & TAPPAN 1994, p.74, pl.132, figs 11–12.

DISTINGUISHING FEATURES: Test elongate, broad and arcuate; compressed ovate in cross-section. Early portion consists of a coil of about 6 chambers with acutely rounded periphery, later becoming uncoiled. Chambers increasing in breadth and partly overlapping previous chambers; sutures slightly curved to sinuate, moderately depressed, unornamented. Aperture long slit, terminal, on a protruded flange at the dorsal angle of the last chamber.

REMARKS: The slit aperture along the perihery of a protruding flange suggests that a new genus may need to be erected to accommodate this species. Loeblich & Tappan's (1994, figs 11–12) holotype clearly has this flange slit aperture, but the illustrated paratypes (figs 13–16) do not and may be a separate species.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs in moderate numbers in several localities off the east coast of the northern North Island (34–38˚S).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to upper bathyal (100–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Pliocene to Recent (Wn–Rec).

Vaginulinopsis tasmanica Parr 1950
Pl. 16, Figs 12–15
Vaginulinopsis tasmanica PARR 1950, p.324, pl.11, figs 13–14; JONES 1994, pl.67, fig.7.

DISTINGUISHING FEATURES: Test stout, elongate; compressed ovate in cross-section. Early few chambers of microspheric forms form involute coil, macrospheric forms have only one or two coiled chambers after the large proloculus, before becoming rectilinear. Later chambers, inflated, unornamented, about 1.5 times wide than high; sutures moderately depressed, strongly oblique, straight to weakly curved. Aperture pointed radiate at dorsal angle.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off both coasts of the North and northern South Islands (34–42˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Wollenburg *et al.* 2001).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to mid bathyal (70–800 m), most commonly shallower than 200 m.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Pliocene to Recent (Wn–Rec).

ORDER – Robertinida Mikhalevich 1980

FAMILY – Epistominidae Wedekind

GENUS – *Hoeglundina* Brotzen 1948

Hoeglundina elegans (d'Orbigny 1826)
Pl. 16, Figs 16–21
Rotalia (Turbulina) elegans D'ORBIGNY 1826, p.276, no.54.
Hoeglundina elegans (d'Orbigny). HAYWARD *et al.* 1999, pl.8, figs 5–7; KAWAGATA 1999, fig.4:1; LOBEGEIER & SEN GUPTA 2008, pl.2, figs 6a–b.

DISTINGUISHING FEATURES: Test trochospiral, biconvex. 8–9 chambers in adult whorl. Final chamber with flat internal partition attached to apertural lip. Aperture a slit on umbilical side near and parallel to the periphery. Earlier apertures closed by opaque shell. Wall radial, aragonitic, glossy and smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 114): Widespread in deeper samples around the North and South Islands (34–53˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Murray 1991, Yassini & Jones 1995).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 114): Widespread at mid shelf to upper abyssal depths (60–3000 m) with a few sporadic occurrences at deep inner shelf depths.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Mid Eocene to Recent (Ab–Rec).

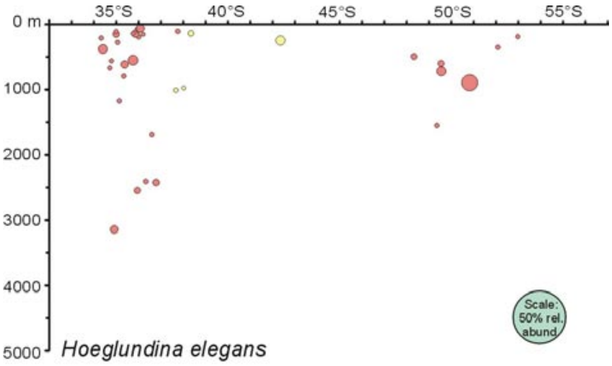


Figure 114. Latitude-depth distribution around NZ of *Hoeglundina elegans* (red circles are east of NZ, yellow circles are west of NZ).

GENUS – *Robertinoides* Höglund 1947

Robertinoides oceanicus (Cushman & Parker 1947)
Pl. 16, Figs 22–24
Robertina oceanica CUSHMAN & PARKER 1947, p.75, pl.28, fig.18.
Robertinoides oceanicus (Cushman & Parker). JONES 1994, pl.50, fig 19; LOEBLICH & TAPPAN 1994, pl.176, figs 4–8.

DISTINGUISHING FEATURES: Test high dextral trochospire. Chambers subglobose, somewhat inflated; sutures slightly incised. Aperture of two slit-like openings, one interiomarginal and the other directed up into the apertural face. Wall radial, aragonitic, glossy and smooth.

REMARKS: Cushman and Parker's (1947) holotype came from 150 m water depth off the North Cape of New Zealand.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare off the east coast of both islands (32–45˚S).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Jones 1994, Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Rare at outer shelf to upper bathyal depths (100–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Mid Eocene to Recent (Ab–Rec).

ORDER – Buliminida Fursenko 1958

FAMILY – Bolivinidae Glaessner 1937

GENUS – *Bolivina* d'Orbigny 1839

Brizalina Costa 1856, p.296.

REMARKS: We adopt the generic description of Sgarrella (1992), where *Brizalina* is a junior synonym of *Bolivina*, not a separate genus as in Loeblich and Tappan (1987).

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:
Bolivina alata: Test broad; periphery keeled with spines; chambers subquadrate, sutures recurved.
Bolivina cacozela: Test elongate, periphery acutely angled. Chambers numerous, wider than high. Sutures straight to slightly curved.
Bolivina compacta: Test moderately small; chambers inflated. Wall coarsely perforate.
Bolivina earlandi: Test moderately large, narrow, elongate, slightly compressed. Chambers higher than wide. Wall finely perforate.
Bolivina glutinata: Test compressed, triangular, medium to large size; strongly pitted ornament. Sutures indistinct (mostly inner shelf, Hayward *et al.* 1999, pl.8, fig.16).
Bolivina neocompacta: Test elongate; chambers slightly inflated; periphery rounded, sutures slightly depressed. Wall glossy and coarsely perforate (mostly inner shelf, Hayward *et al.* 1999, pl.8, figs 12–13).
Bolivina pseudolobata: Rounded inflated chambers with lobular periphery; granular to weakly spinose or weakly costate lower portion of early chambers.
Bolivina pseudoplicata: Pronounced sutural excavations and double row of raised processes down the centre of the test (mostly inner shelf, Hayward *et al.* 1999, pl.8, figs 14–15).
Bolivina pusilla: Compressed test, moderately broad;

with fine parallel ribs over more than half length.

Bolivina pygmaea: Test small; sutures straight; short spines on periphery.

Bolivina robusta: Test triangular, large. Retral processes cross sutures; often with prolocular spine.

Bolivina seminuda: Test narrow, only slightly compressed. Chambers squat; sutures almost straight; coarsely perforate band across lower half of chambers.

Bolivina spathulata: Test compressed, periphery acutely angled. Sutures curved. Wall smooth and finely perforate.

Bolivina striatula: Compressed test, moderately slender; with fine parallel ribs on lower half (mostly inner shelf, Hayward *et al.* 1999, pl.8, fig.21).

Bolivina variabilis: Slowly expanding test with finely reticulate surface ornament.

Pseudobrizalina lobata: Chambers short, inflated, ornamented with a single broad horizontal rib. Sutures excavated (see p.201).

KEY TO NZ RECENT *BOLIVINA* SPECIES

1. Test ornamented 2
Test smooth, unornamented 9

2. Chambers ornamented with vertical ribs 3
Chambers ornamented with spines, oblique or reticulate ribs 4

3. Parallel ribs over lower half of test *B. striatula*
Fine parallel ribs over more than half of test *B. pusilla*

4. Periphery smooth; strongly pitted surface 5
Periphery lobular; strongly raised ornament 6

5. Periphery acute; prolocular spine; weakly rounded sutural ribs *B. robusta*
Periphery square profile; no prolocular spine; coarsely pitted surface *B. glutinata*

6. Reticulate ornament extends over full test 7
Oblique costae or spines over part or all of test 8

7. Slowly expanding test, with finely reticulate ornament *B. variabilis*
Subtriangular test, double row of processes down middle of test *B. pseudoplicata*

8. Oblique costa on each chamber; chambers not inflated *Pseudobrizalina lobata*
Short spines or short costae over some chambers; chambers rounded, inflated *B. pseudolobata*

9. Periphery with spines at end of each chamber; chamber surface unornamented 10
Periphery lacks spines 11

10. Test large; chambers subquadrate; sutures curved *B. alata*
Test small; chambers elongate; sutures straight *B. pygmaea*

11. Periphery acutely angled; chambers numerous 12
Periphery rounded 13

12. Test narrow; sutures straight or gently curved; weakly carinate periphery *B. cacozela*
Test broader; sutures strongly curved down towards periphery; distinctly carinate periphery *B. spathulata*

13. Test wall finely perforate, thin; chambers flat, periphery smooth *B. earlandi*
Test wall coarsely perforate; chambers inflated, periphery lobulate 14

14. Test wall coarsely perforate in band across lower half of chambers *B. seminuda*
Test wall coarsely perforate right across chambers 15

15. Elongate, slowly expanding test *B. neocompacta*
Short, subtriangular, rapidly expanding test with strongly inflated final chambers *B. compacta*

Bolivina alata (Seguenza 1862)
Pl. 16, Figs 25–26

Vulvulina alata SEGUENZA 1862, p.115, pl.2, fig.5.
Brizalina alata (Seguenza). JONES 1994, pl.53, figs 2–4; YASSINI & JONES 1995, figs 516–517.

DISTINGUISHING FEATURES: Test moderately large, broad and leaf-like in outline; compressed lenticular in cross-section; periphery keeled with spines. Chambers slightly inflated, subquadrate in outline; sutures recurved, depressed. Wall coarsely perforate, except for imperforate keels. Aperture terminal, lipped, with toothplate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic rare records from off both coasts of New Zealand (37–45˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Seguenza 1862).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to lower bathyal (100–1200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Lw–Rec).

Bolivina cacozela Vella 1957
Pl. 16, Figs 27–28

Bolivina cacozela VELLA 1957, p.33, pl.8, figs 162,163; HAYWARD *et al.* 1999, pl.8, figs 8–9; HAYWARD *et al.* 2001, figs 14L–M.

DISTINGUISHING FEATURES: Test small to medium size, elongate; subovate in cross-section; periphery acutely angled, sometimes weakly keeled on last few chambers. Chambers numerous, wider than high; sutures distinct and slightly curved, may be depressed towards the apertural end in the adult. Aperture subovate with a thick lip and internal toothplate. Wall smooth and finely perforate.

REMARKS: Distinguished from *B. spathulata* by a less carinate periphery and less curved sutures.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 115): Widespread throughout most of the New Zealand region, becoming rare to absent in the Subantarctic south of 50˚S.

WORLD GEOGRAPHIC DISTRIBUTION: No known records beyond New Zealand.

NEW ZEALAND BATHYMETRIC DISTRIBUTION

(Fig. 115): Widespread in low to moderate numbers in sheltered inner shelf to mid bathyal depths (shallower than 1000 m) with rarer occurrences at lower bathyal and abyssal depths. Greatest relative abundances (5–15%) are at mid shelf depths.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Pliocene to Recent (Wo–Rec).

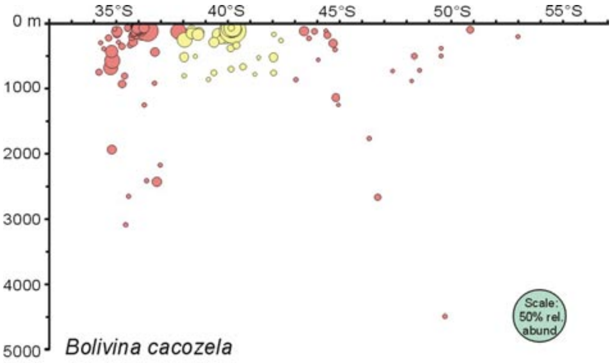


Figure 115. Latitude-depth distribution around NZ of *Bolivina cacozela* (red circles are east of NZ, yellow circles are west of NZ).

Bolivina compacta Sidebottom 1905

Pl. 16, Figs 29–30

Bolivina robusta var. *compacta* SIDEBOTTOM 1905, p.15, pl.15, fig.7.

Bolivina compacta Sidebottom. HEDLEY *et al.* 1967, p.30, pl.9, fig.3; HAYWARD *et al.* 1999, pl.8, figs 10–11.

DISTINGUISHING FEATURES: Test small to moderate size, subtriangular in outline due to expansion of later chambers; ovate in cross-section; periphery broadly rounded. Chambers subovate, wider than high; sutures almost straight, weakly depressed. Aperture subquadrate with a low, thickened lip and internal toothplate. Wall coarsely perforate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread in moderately low numbers (occasionally up to 15% of foraminifera at 2–5 m depth) around the three main islands of New Zealand (33–47˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Nomura 1981, Murray 1991).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Occurs at inner shelf to upper abyssal depths (0–2500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Bolivina earlandi Parr 1950

Pl. 16, Figs 31–33

Bolivina earlandi PARR 1950, p.339, pl.12, figs 16a–b.

DISTINGUISHING FEATURES: Test moderately large, narrow elongate in outline; ovate in cross-section; periphery broadly rounded. Chambers subovate, higher than wide particularly in adult; sutures oblique, slightly curved, weakly depressed. Aperture a narrow loop. Wall thin, translucent, finely perforate throughout.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off south-east New Zealand (43–53˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Southern Ocean (Parr 1950).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Occurs at inner shelf to lower bathyal depths (0–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Bolivina pseudolobata Yassini & Jones 1995

Pl. 16, Figs 34–36

Bolivina pseudolobata YASSINI & JONES 1995, p.130, fig.555.

Bolivina spinescens Cushman. HAYWARD *et al.* 1999, pl.8, figs 18–20

Bolivina subspinescens Cushman. KAWAGATA 1999, fig.4:5.

DISTINGUISHING FEATURES: Test small to medium size, elongate slightly tapered; ovate in cross-section with broadly rounded peripheries. Chambers inflated, subglobular; sutures depressed and almost straight. Lower half of chambers covered in small, short, fat spines, sometimes coalescing to form a weak, wavy subhorizontal costa; upper parts of adult chambers non-porous and translucent. Aperture wide, subovate, subterminal with one side sutural.

REMARKS: Our specimens fit the description of *Bolivina spinescens* yet the figured type specimen appears to be in conflict with the description of wall characters and ornamentation.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 116): Widespread right around New Zealand between 34 and 54˚S.

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Yassini & Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 116): Widespread occurrences in low to moderate numbers from deep inner shelf to upper abyssal depths (30–3000 m). Highest relative abundances (4–10%) are mostly at mid shelf to mid bathyal depths (50–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Pl–Rec).

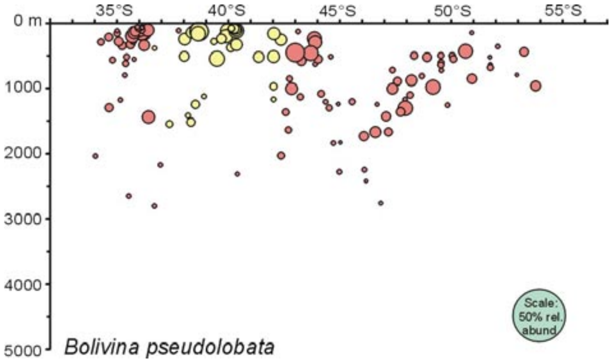


Figure 116. Latitude-depth distribution around NZ of *Bolivina pseudolobata* (red circles are east of NZ, yellow circles are west of NZ).

Bolivina pusilla Schwager 1866

Pl. 16, Figs 37–38

Bolivina pusilla SCHWAGER 1866, p.254, pl.7, fig.101; KURIHARA & KENNETT 1986, pl.2, figs 7–8; UJIIE 1995, pl.4, fig.4; KAWAGATA 1999, fig.4:2.

DISTINGUISHING FEATURES: Test small to medium size, elongate, tapered; moderately compressed; periphery broadly rounded. Chambers elongate, slightly curved; sutures very weakly depressed. Ornament of 8–12 strong, narrow costae continuous over all chambers on each side. Prolocular spine often present. Aperture subterminal, ovate. Wall finely perforate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 117): Moderately widespread off both coasts of mainland New Zealand, north of 47˚S, with no Subantarctic records.

WORLD GEOGRAPHIC DISTRIBUTION: Indo-Pacific (Schwager 1866).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 117): Most records are from lower bathyal and upper abyssal depths (1400–2900 m) with two rare specimens at mid bathyal and mid abyssal depths.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

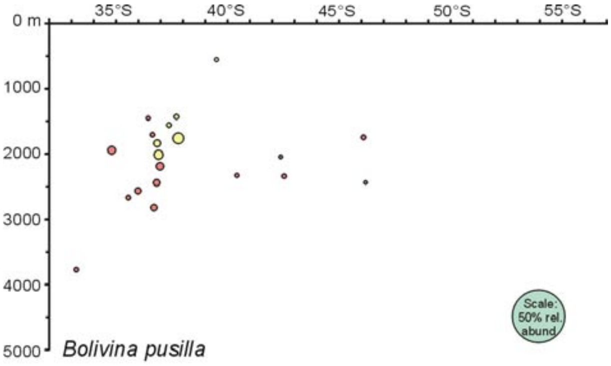


Figure 117. Latitude-depth distribution around NZ of *Bolivina pusilla* (red circles are east of NZ, yellow circles are west of NZ).

Bolivina pygmaea (Brady 1881)

Pl. 16, Figs 39–40

Bulimina (Bolivina) pygmaea BRADY 1881b, p.57.

Bolivina pygmaea (Brady). BRADY 1884, pl.53, figs 5–6; CHAPMAN 1909, p.114, fig.11.

Brizalina pygmaea (Brady). JONES 1994, pl.53, figs 5–6.

DISTINGUISHING FEATURES: Test small, moderately compressed; elongate triangular outline; periphery acutely rounded, with rod-shaped spine at end of each chamber. Chambers elongate, wider than high; sutures straight to slightly curved, flush. Aperture elongate ovate, subterminal. Wall roughened, very slightly perforate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered records from right around New Zealand (36–50˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Rasmussen *et al.* 2002).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to upper abyssal (150–2200 m), mostly at mid–lower bathyal depths (500–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

Bolivina robusta Brady 1881

Pl. 16, Figs 41–42

Bolivina robusta BRADY 1881b, p.57; HEDLEY *et al.* 1965, pl.6, fig.22; JONES 1994, pl.53, figs 7–9; HAYWARD *et al.* 1999, pl.8, fig.16; KAWAGATA 1999, fig.4:3; HAYWARD *et al.* 2001, figs 14P–Q; HAYWARD *et al.* 2007b, pl.1, fig.4.

DISTINGUISHING FEATURES: Test moderately large, moderately compressed; roughly triangular in outline; periphery smooth, acutely angled, not keeled. Strong prolocular spine common. Chambers elongate; sutures strongly recurved, very slightly depressed; weakly rounded sutural ribs. Aperture ovate, terminal surrounded by an imperforate rim; toothplate visible. Wall glassy with coarse pores.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 118): Widespread off both coasts of New Zealand between 33 and 54˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Widespread in the West Pacific (Nomura 1981, Murray 1991, Jones 1994, Yassini & Jones 1995).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 118): The bathymetric range is largely confined between mid shelf and upper abyssal depths (50–3000 m), with the greatest relative abundances (5–50%) at upper and mid bathyal (200–700 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Pliocene to Recent (Wm–Rec).

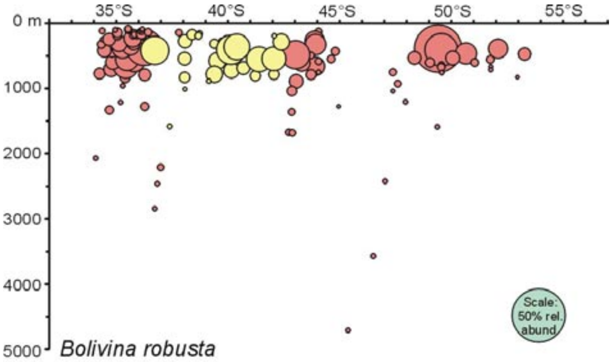


Figure 118. Latitude-depth distribution around NZ of *Bolivina robusta* (red circles are east of NZ, yellow circles are west of NZ).

Bolivina seminuda Cushman, 1911

Pl. 17, Figs 1–3

Bolivina seminuda CUSHMAN 1911, p.34, fig.55; PARR 1950, pl.12, fig.17; KAWAGATA 1999, fig.4:4; HAYWARD *et al.* 2001, figs 14R–S.

Bolivina subspinescens Cushman. YASSINI & JONES 1995, figs 618–619.

DISTINGUISHING FEATURES: Test small to medium size, narrow elongate; slightly compressed with inflated ovate cross-section. Chambers squat or subquadrate, subglobular; sutures almost straight, slightly incised. Chambers non-perforate on the upper third to half, with moderately coarse perforate band across lower half of each. Aperture narrow subterminal with toothplate visible.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 119): This species has numerous occurrences throughout the New Zealand region.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Cushman 1911).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 119): This species has relatively even relative abundances throughout its wide depth range from mid shelf to lower abyssal (50–5000 m). Slightly higher relative abundances (5–10%) occur at abyssal depths (2000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

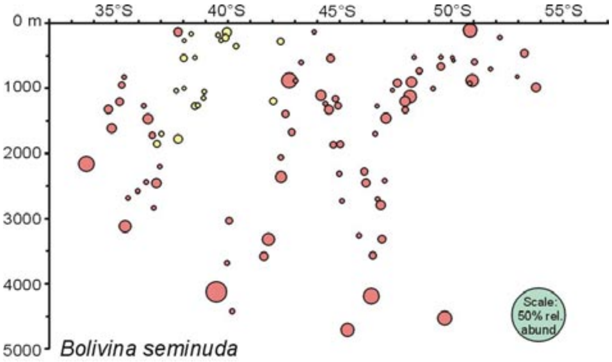


Figure 119. Latitude-depth distribution around NZ of *Bolivina seminuda* (red circles are east of NZ, yellow circles are west of NZ).

Bolivina spathulata (Williamson 1858)
Pl. 17, Figs 4–5

Textularia variabilis var. *spathulata* WILLIAMSON 1858, p.76, pl.6, figs 164,165.

Bolivina numerosa VELLA 1957, p.33, pl.8, figs 160,161.

Bolivina spathulata (Williamson). HAYWARD *et al.* 1999, pl.8, fig.17.

DISTINGUISHING FEATURES: Test moderate size, broadly elongate to leaflike; compressed with an acutely-angled periphery. Chambers wider than high, comma-shaped; sutures curved, thick limbate, thinning towards the periphery. Wall smooth and finely perforate, except over the imperforate, limbate sutures.

REMARKS: See *B. cacozela*.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread occurrences right around New Zealand (34–53˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Murray 1991).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Moderate to low numbers (up to 5% of foraminifera) at inner shelf to upper bathyal depths (0–600 m), with a few deeper records probably being displaced.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Mid Miocene to Recent (Sl–Rec).

Bolivina variabilis (Williamson 1858)
Pl. 17, Figs 6–10

Textularia variabilis WILLIAMSON 1858, p.76, pl.6, figs 162–163.

Bolivina variabilis (Williamson). UJIIE 1995, pl.4, fig.5; LOEBLICH & TAPPAN 1994, pl.216, figs 7–15.

Bolivina subexcavata CUSHMAN & WICKENDEN 1929, p.9, pl.4, figs 4a,b; HAYWARD *et al.* 1999, pl.8, fig.22; HAYWARD *et al.* 2001, figs 14T–U.

Bolivina decussata (Brady). UJIIE 1995, pl.4, fig.1.

DISTINGUISHING FEATURES: Narrow, elongate, slowly expanding test; periphery broadly rounded. Distinct medial channel often present on either side. Sutures indistinct although chambering clear. Wall rough, finely reticulate costa on surface.

REMARKS: See *B. pseudoplicata*.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 120): Widespread off both coasts of New Zealand, north of 51˚S; only extending south into the Subantarctic at shelf depths around Auckland Island.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Nomura 1981, Culver & Buzas 1981, 1986).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 120): Widespread and common (up to 10% of foraminifera) in sheltered to exposed, fully marine depths, from inner shelf down to uppermost abyssal (0–2500 m). The deepest occurrences appear to shallow southwards between 45 and 51˚S. Two rare deeper water records may be displaced specimens.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Oligocene to Recent (Ld–Rec).

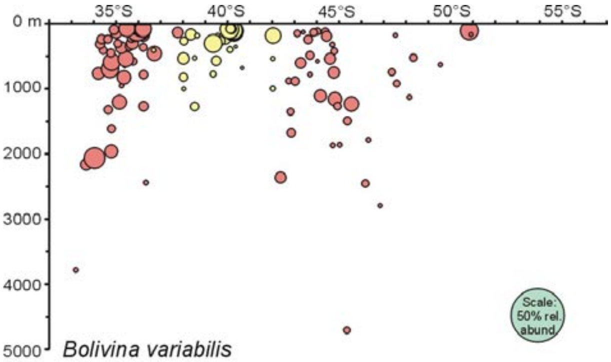


Figure 120. Latitude-depth distribution around NZ of *Bolivina variabilis* (red circles are east of NZ, yellow circles are west of NZ).

FAMILY – Bolivinitidae

GENUS – *Abditodentrix* Patterson 1985

Abditodentrix pseudothalmanni (Boltovskoy & Guissani de Kahn 1981)
Pl. 17, Figs 11–12
Bolivinita pseudothalmanni BOLTOVSKOY & GUISSANI DE KAHN 1981, p.44.
Abditodentrix pseudothalmanni (Boltovskoy & Guissani de Kahn). LOEBLICH & TAPPAN 1987, pl.554, figs 1–5; LOEBLICH & TAPPAN 1994, pl.218, figs 1–2; UJIIÉ 1995, pl.4, figs 7a,b; KAWAGATA 1999, fig.4: 6; HAYWARD *et al.* 2001, figs 14J–K; HAYWARD *et al.* 2002, pl.1, figs 3–4; HAYWARD *et al.* 2003, fig.4D; HAYWARD *et al.* 2007b, pl.1, fig.2; LOBEGEIER & SEN GUPTA 2008, pl.1, fig.1.

DISTINGUISHING FEATURES: Test elongate, biserial; rectangular cross-section with flat sides and truncate edges. Sutures laterally constricted resulting in serrate peripheries. Surface strongly ornamented with reticulate costae. Aperture terminal with small lip and internal folded toothplate on one side.

REMARKS: Distinguished from species of *Bolivina* by its rectangular cross-section and from *Bolivinita* by its reticulate ornament.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 121): Common and widespread throughout the New Zealand region, from 33 to 56˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Boltovskoy & Guissani de Kahn 1981).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 121): Occurs at all depths from mid shelf to lower abyssal (80–5000 m) but with its peak relative abundances (20–40%) at bathyal depths (400–1500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

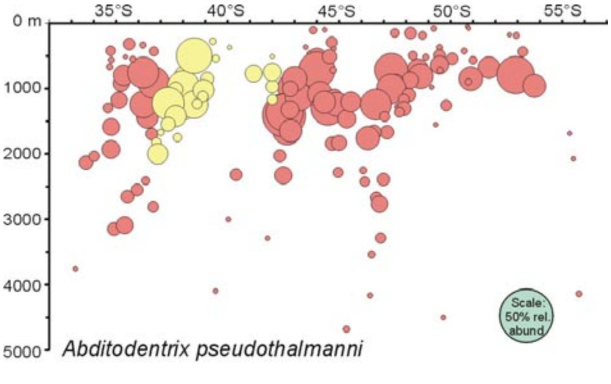


Figure 121. Latitude-depth distribution around New Zealand of *Abditodentrix pseudothalmanni* (red circles are east of NZ, yellow circles are west of NZ).

GENUS – *Bolivinita* Cushman 1927

Bolivinita quadrilatera (Schwager 1866)
Pl. 17, Figs 13–16
Textilaria quadrilatera SCHWAGER 1866, p.253, pl.7, fig.103.
Bolivinita quadrilatera (Schwager). JONES 1994, pl.42, figs 8–12; LOEBLICH & TAPPAN 1987, pl.554, figs 6–10; LOEBLICH & TAPPAN 1994, pl.219, figs 7–12; YASSINI & JONES 1995, figs 547–548.

DISTINGUISHING FEATURES: Test elongate, biserial; rectangular cross-section with flat to concave sides and truncate peripheral edges. Four peripheral angles carinate. Surface smooth apart from small pores. Aperture terminal elliptical with folded internal tooth plate on one side.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered records off both coasts of the main islands (37–47˚S), mostly off the east coast of the South Island.

WORLD GEOGRAPHIC DISTRIBUTION: Indo-Pacific (Schwager 1866).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper bathyal to upper abyssal (400–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

FAMILY – Buliminidae Jones 1875

GENUS – *Bulimina* d'Orbigny 1826

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:
Bulimina elongata: Test moderately inflated; chambers evenly rounded; no ornament (mostly inner shelf, see Hayward *et al.* 1999, pl.9, figs 6–7).
Bulimina exilis: Test slender, elongate; no ornament (rare, see Vella 1957, pl.8, figs 164–165).
Bulimina marginata* f. *acaenapeza: Evenly rounded chamber margins; numerous strong, long spines, mostly over lower half of test.
Bulimina marginata* f. *acanthia: Lower chamber margins sharply undercut; chamber margins crenate or thickened, no spines.
Bulimina marginata* f. *aculeata: Evenly rounded chamber margins; short spines mostly on lower third of chambers and apical end.
Bulimina marginata* f. *marginata: Lower chamber margins sharply undercut; densely spinose chamber margins and apical end.
Bulimina striata: Lower chamber margins undercut; longitudinal costae on each chamber, sometimes with spinose ends, never extend across sutures.
***Bulimina subornata*:** Test elongate–ovate; early chambers with weak costae, later smooth; prolocular spine (rare, see Jones 1994, pl. 51, fig. 6).
Bulimina truncana: Strong longitudinal costae extend most of length of test, extend across sutures.

KEY TO NZ RECENT *BULIMINA* SPECIES:
1. Test unornamented (sometimes a prolocular spine) 2
Test ornameneted with costate or spines 4

2. Test slender, elongate *B. exilis*
Test moderately inflated 3

3. Chambers evenly rounded *B. elongata*
Chambers sharply undercut, often with
crenate chamber margin *B. marginata* f. *acanthia*

4. Test with longitudinal costae 5
Test with spines on chambers 7

5. Longitudinal costae confined to early
chambers; prolocular spine *B. subornata*
Longitudinal costae on all chambers 6

6. Costae extend across sutures and most of
length of test *B. truncana*
Costae separate on each chamber, do not cross sutures,
often spined *B. striata*

7. Chambers sharply undercut 8
Chambers evenly rounded 9

8. Chambers lack spines; chamber margin often
densely crenate *B. marginata* f. *acanthia*
Chamber margins and proloculus covered in
numerous short spines *B. marginata* f. *marginata*

9. Chambers covered in numerous short spines
B. marginata f. *aculeata*
Chambers covered in very long spines, especially
lower half of test *B. marginata* f. *acaenapeza*

Bulimina marginata* f. *acaenapeza Loeblich & Tappan 1994
Pl. 17, Figs 17–18

Bulimina acaenapeza LOEBLICH & TAPPAN 1994, p.123, pl.243, figs 1–6.

Bulimina aculeata d'Orbigny. JONES 1994, pl.51, figs 7–9; LOBEGEIER & SEN GUPTA 2008, pl.1, fig.9.

Bulimina marginata f. *acaenapeza* Loeblich & Tappan. HAYWARD *et al.* 2001, figs 14X–Y.

DISTINGUISHING FEATURES: Test variable in shape, with a relatively large length:width ratio. Chambers inflated with evenly rounded margins. Ornament of variable strong, long spines mostly on lower half of test, but occasionally also on last chamber.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records off both coasts of North and northern South Island (36–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper abyssal (2000–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Bulimina marginata* f. *acanthia Costa 1856
Pl. 17, Fig. 19

Bulimina acanthia COSTA 1856, p.335, pl.13, figs 35–36.

Bulimina marginata d'Orbigny. JONES 1994, pl.51, figs 3–4.

Bulimina marginata f. *acanthia* Costa. HAYWARD *et al.* 1999, pl.9, figs 16–17.

DISTINGUISHING FEATURES: Test variable in size and shape, showing variation in length:width ratio. Chambers moderately inflated with lower margin undercut. This margin is fringed by a keel which may or may not be weakly crenulated. Spines are absent or extremely reduced.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences from right around New Zealand (34–51˚S), but mostly north of 44˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Low numbers at deep inner shelf to mid bathyal depths (30–800 m), mostly shallower than 400 m.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Pleistocene to Recent (Wc–Rec).

Bulimina marginata* f. *aculeata d'Orbigny 1826
Pl. 17, Figs 20–22

Bulimina aculeata D'ORBIGNY 1826, p.7; KAWAGATA 1999, fig.5:6.

Bulimina marginata f. *aculeata* d'Orbigny. HAYWARD *et al.* 1999, pl.9, figs 10–12; HAYWARD *et al.* 2001, figs 14Z,AA; HAYWARD *et al.* 2002, pl.1, figs 5–6; HAYWARD *et al.* 2003, fig.4E; HAYWARD *et al.* 2007b, pl.1, fig.3.

DISTINGUISHING FEATURES: Test variable in shape, with a relatively large length:width ratio. Chambers inflated with evenly rounded margins. Ornament of variable short spines mostly on lower third of chambers and apical end.

REMARKS: In the past this form has often been confused with the deeper water, long-spined form (identified as *B. aculeata* by Barker (1960) and Jones (1994)) that has recently been described as a new species, *B. acaenapeza*, by Loeblich and Tappan (1994).

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 122): Widespread throughout the New Zealand region.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Murray 1991).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 122): Most specimens occur at upper bathyal to upper abyssal depths (400–3000 m), with rarer records above and below these limits.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tk–Rec).

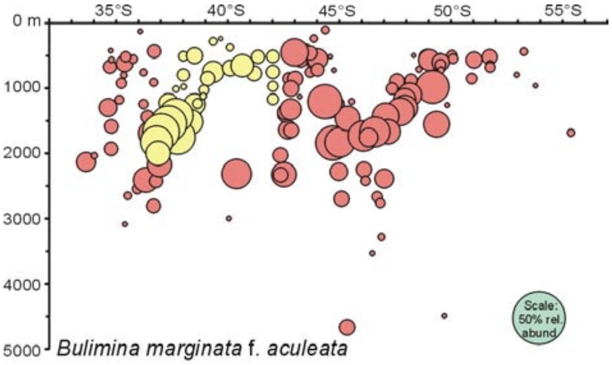


Figure 122. Latitude-depth distribution around NZ of *Bulimina marginata* f. *aculeata* (red circles are east of NZ, yellow circles are west of NZ).

Bulimina marginata* f. *marginata d'Orbigny 1826

Pl. 17, Figs 23–24

Bulimina marginata D'ORBIGNY 1826, p.269, no.4, pl.12, figs 10–12.

Bulimina marginata f. *marginata* d'Orbigny. HAYWARD *et al*. 1999, pl.9, figs 13–15; HAYWARD *et al.* 2001, fig.14BB; HAYWARD *et al.* 2002, pl.1, figs 7–8; HAYWARD *et al.* 2003, fig.4F.

Bulimina submarginata PARR 1950, p.336–337, pl.12, fig.13.

DISTINGUISHING FEATURES: Test variable in size and shape. Test shows variation in length:width ratio from 1–2. Chamber margins are distinctly undercut, generally sharply so. This margin is fringed by a keel with numerous small spines. An apical spine may or may not be present.

REMARKS: In the past this species has in New Zealand been called either *B. marginata* or *B. submarginata*. Jorissen's (1988) studies of *Bulimina marginata* in its type area, the Adriatic Sea, resulted in the recognition of one highly variable species with three forms – f. *marginata*, f. *aculeata* and f. *denudata*. There they have distinctive, though overlapping ecologic ranges. In this study we recognise the first two forms, and two additional forms, one spineless (f. *acanthia*) and one with long spines (f. *acaenapeza*).

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 123): Widespread throughout the New Zealand region (34–54°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Murray 1991).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 123): The most abundant *Bulimina* in fine sediment at shelf and bathyal depths (0–2000 m) around New Zealand. In this study it occurs in its greatest relative abundances (10–30%) at mid shelf–mid bathyal depths (50–900 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Pliocene to Recent (Wo–Rec).

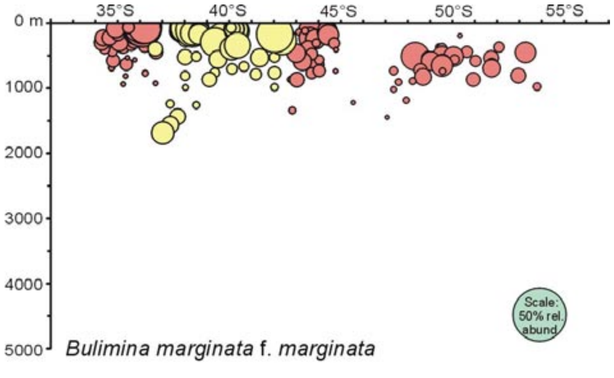


Figure 123. Latitude-depth distribution around NZ of *Bulimina marginata* f. *marginata* (red circles are from east of NZ, yellow circles are from west of NZ).

Bulimina striata d'Orbigny 1843

Pl. 17, Figs 25–27

Bulimina striata D'ORBIGNY 1826, pl.18, fig.2 (nomen nudum).

Bulimina costata D'ORBIGNY 1826, pl.18, fig.1 (nomen nudum).

Bulimina striata D'ORBIGNY in GUÉRIN-MÉNEVILLE 1843, p.9, pl.2, fig.16; KURIHARA & KENNETT 1986, pl.2, fig.13; UJIIE 1990, pl.12, figs 9–10; LOEBLICH & TAPPAN, 1994, pl.242, figs 8–14; VÉNEC-PEYRÉ 2005, p.157, pl.18, fig.2.

Bulimina costata D'ORBIGNY 1852, p.194; VÉNEC-PEYRÉ 2005, p.157, pl.18, fig.1.

Bulimina inflata mexicana CUSHMAN 1922, p.95, pl.21, fig.2.

Bulimina mexicana Cushman. VAN MORKHOVEN *et al.* 1986, p.59–62, pl.19, figs 1–4; JONES 1994, pl.51, figs 10–13; LOBEGEIER & SEN GUPTA. 2008, pl.1, fig.12.

Bulimina striata mexicana Cushman. YASSINI & JONES 1995, figs 552–553.

Bulimina australis VELLA 1957, p.32, pl.8, figs 168–169.

DISTINGUISHING FEATURES: Shell length 1 to 2 times the width. Chambers inflated with undercut and overhanging lower margins. Costae extend around lower half of each chamber and overhang preceeding chambers as spinose projections.

REMARKS: Populations have costae of variable strength with or without spinose ends. Examination of topotypes from Rimini Beach, Italy, show this species to be indistinguishable from *B. mexicana*. Vénec-Peyré (2005) showed that *B. striata* is the senior synonym out of d'Orbigny's two original 1826 species.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 124): Numerous occurrences off both the east and west coasts of mainland New Zealand, but not extending south of 50°S into the Subantarctic.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1826).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 124): Ranges from outer shelf to upper abyssal (100–3000 m), with greatest relative abundances (up to 5%) in the bathyal zone (200–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Eocene to Recent (Ab–Rec).

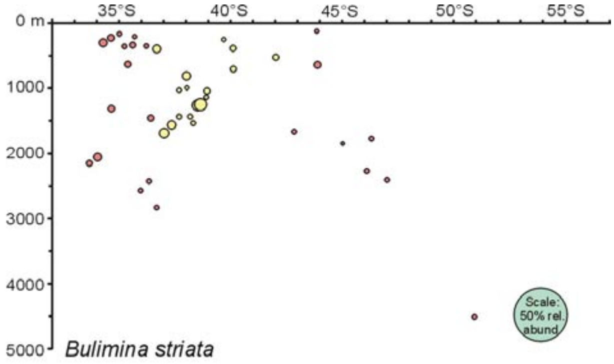


Figure 124. Latitude-depth distribution around NZ of *Bulimina striata* (red circles are from east of NZ, yellow circles are from west of NZ).

Bulimina truncana Gümbel 1868
Pl. 17, Figs 28–29

Bulimina truncana GÜMBEL 1868, p.644, pl.2, figs 77a,b; HAYWARD & BUZAS 1979, p.45, pl.7, figs 87,88; BOERSMA 1986, pl.5, figs 2–5; UJIIE 1995, pl.6, fig.5; KAWAGATA 1999, fig.5:7; HAYWARD *et al.* 2001, figs 14DD–EE; HAYWARD *et al.* 2002, pl.1, figs 9–10; HAYWARD *et al.* 2003, fig.4G.

Bulimina rostrata BRADY 1884, p.408, pl.51, figs 14–15; KURIHARA & KENNETT 1986, pl.2, figs 12–13; JONES 1994, pl.51, figs 14–15.

Bulimina alazanensis CUSHMAN 1927a, p. 161, pl.25, fig.4; YASSINI & JONES 1995, figs 558–560; LOBEGEIER & SEN GUPTA 2008, pl.1, fig.10.

Bulimina bremneri FINLAY 1940, p.455, pl.64, figs 84–86.

Bulimina n.sp. BARKER 1960, pl.51, figs 18–19; JONES 1994, pl.51, figs 18–19.

DISTINGUISHING FEATURES: Test 1.5 to 2 times long as wide. Sutures between chambers not depressed. About 12 crisp costae extend most of length of test and are uninterrupted by sutures.

REMARKS: Study of types and topotypic suites of *Bulimina alazanensis*, *B. bremneri*, *B. rostrata* and *B. truncana* suggests that all belong to one species. There is considerable variability in test inflation.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 125): Widespread occurrences off both coasts of northern and central New Zealand, north of 44˚S, with rarer occurrences extending south into the Subantarctic zone (56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Gümbel 1868).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 125): Largely confined between upper bathyal and mid abyssal depth range (400–3500 m) with greatest relative abundances (5–25%) mid to lower bathyal (700–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Lw–Rec).

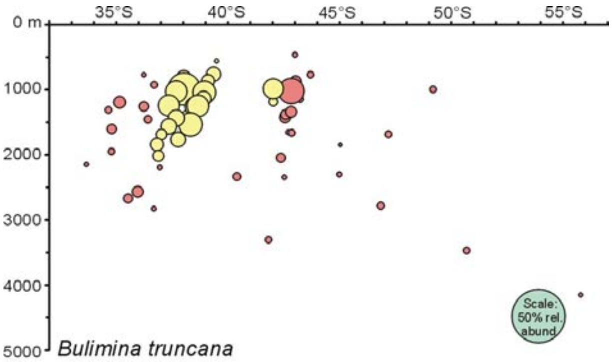


Figure 125. Latitude-depth distribution around NZ of *Bulimina truncana* (red circles are from east of NZ, yellow circles are from west of NZ).

GENUS – *Globobulimina* Cushman 1927

KEY FEATURES:

Globobulimina pacifica: Test small; walls thin, transparent; three elongate chambers almost fully enclose test.

Globobulimina turgida: Moderate to large size, thick-walled, early portion of test usually protruding as rounded or sharp cone.

Globobulimina pacifica Cushman 1927
Pl. 17, Figs 30–32

Globobulimina pacifica CUSHMAN 1927b, pl.14, fig.12; JONES 1994, pl.50, figs 7–10.

Globulimina turgida (Bailey). HEDLEY *et al.* 1965, pl.7, fig.26.

DISTINGUISHING FEATURES: Test small, elongate ovate, triserial with a circular cross-section. Chambers elongate, strongly overlapping so that all the early whorls are encapsulated within the last; sutures slightly depressed. Aperture elongate, loop-shaped, with gently overturned lip; toothplate. Wall thin, transparent, finely perforate, smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences in low numbers off both coasts of central New Zealand (38–44˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to upper abyssal (150–2500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Oligocene to Recent (Ld–Rec).

Globobulimina turgida (Bailey 1851)
Pl. 17, Figs 33–34

Bulimina turgida BAILEY 1851, p.12, pls.28–31.

Globobulimina turgida (Bailey). HAYWARD *et al.* 1999, pl.9, figs 20–21.

DISTINGUISHING FEATURES: Test large, inflated ovate, triserial with a circular cross-section. Chambers inflated and overlapping, but with first few whorls protruding at the apex; sutures slightly depressed. Often with several short spines on the apex. Aperture elongate, loop-shaped, with gently overturned lip; toothplate. Wall moderately thick, finely perforate, smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences in low numbers off both coasts of the North Island (36–40˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Bailey 1851).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper abyssal depths (70–2500 m), with greatest abundances at outer shelf and upper bathyal depths (100–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Oligocene to Recent (Ld–Rec).

GENUS – *Praeglobobulimina* Hofker 1951

KEY FEATURES:

Praeglobobulimina pupoides: Ovate to pear-shaped test, greatest width above middle of test; chambers subglobular, no spines.

Praeglobobulimina spinescens: Pear-shaped test, with strongly overlapping elongate chambers; short spines on early chambers.

Praeglobobulimina pupoides (d'Orbigny 1846)

Pl. 17, Figs 35–36

Bulimina pupoides D'ORBIGNY 1846, p.185, pl.11, figs 11,12; PAPP & SCHMID, 1985, p.69.

Praeglobobulimina pupoides (d'Orbigny). JONES 1994, pl.50, figs 14–15.

Protoglobobulimina pupoides (d'Orbigny). LOEBLICH & TAPPAN 1994, pl.244, figs 8–10.

Bulimina ovata D'ORBIGNY 1846, pl.11, figs 13–14; PAPP & SCHMID, 1985, p.69.

Praeglobobulimina ovata (d'Orbigny). JONES 1994, pl.50, fig.13.

DISTINGUISHING FEATURES: Test moderately large, pear-shaped to ovoid with greatest width above middle of test; triserial with a circular cross-section. Chambers inflated and slightly overlapping, but with all early whorls visible; sutures slightly depressed. Aperture elongate, loop-shaped, with gently overturned lip; toothplate. Wall finely perforate, smooth.

DISCUSSION: We follow Papp and Schmid (1985) in considering *B. ovata* to be a junior synonym of *B. pupoides*, but not both as junior synonyms of *B. pyrula* d'Orbigny 1846, as they suggest.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs off both coasts of the North Island, but mostly off the east coast (33–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1846).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper abyssal (60–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Miocene to Recent (Sw–Rec).

Praeglobobulimina spinescens (Brady 1884)

Pl. 17, Figs 37–38

Bulimina pyrula var. *spinescens* BRADY 1884, pl.50, figs 11–12.

Praeglobobulimina spinescens (Brady). LOEBLICH & TAPPAN 1987, pl.571, figs 13–16; JONES 1994, pl.50, figs 11–12.

DISTINGUISHING FEATURES: Test moderately large, pear-shaped, with greatest width always below the middle of the test; triserial with a circular cross-section. Chambers inflated and strongly overlapping, but with the lower parts of all early whorls visible; sutures slightly depressed. Aperture elongate, loop-shaped, with gently overturned lip; toothplate. Wall finely perforate, smooth, with characteristic, extremely short spines on early chambers.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Moderate numbers recorded from off the east coast of northern North Island (34–38˚S).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper bathyal (80–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

FAMILY – Cassidulinidae d'Orbigny 1839

GENUS – *Cassidulina* d'Orbigny 1826

KEY FEATURES OF NEW ZEALAND SPECIES:

Cassidulina angulosa: Compressed, chambers inflated, periphery strongly lobulate, somewhat keeled (rare, see Loeblich & Tappan 1994, pl.221, figs 1–4).

Cassidulina carinata: Test lenticular, keeled; aperture elongate, with broad apertural flap.

Cassidulina reniforme: Test small; periphery acutely rounded; narrow apertural flap.

Cassidulina spiniferiformis: Test lenticular; periphery acute, lobulate, weakly keeled and strongly spinose.

Cassidulina carinata Silvestri 1896

Pl. 17, Figs 39–41

Cassidulina laevigata var. *carinata* SILVESTRI 1896, p.104, pl.II, figs 10a–c.

Cassidulina carinata Silvestri. HAYWARD *et al.* 1999, pl.8, figs 23–24; KAWAGATA 1999, fig.4:7; HAYWARD *et al.* 2001, fig.14FF; HAYWARD *et al.* 2003, fig.4H; HAYWARD *et al.* 2007b, pl.1, fig.5; LOBEGEIER & SUN GUPTA 2008, pl.1, fig.13.

Cassidulina laevigata d'Orbigny. HAYWARD *et al.* 1999, pl.8, fig.25.

DISTINGUISHING FEATURES: Test compressed, biconvex; with 4 pairs of chambers per whorl. Peripheral keel always present, varies from a slight thickening of the already acute peripheral margin to a distinct keel with a serrated edge. Aperture an elongate, narrow slit paralleling the margin, with a broad apertural flap. Test smooth and translucent.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 126): Abundant right around New Zealand region (33–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Murray 1991).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 126): Occurs at all depths from inner shelf to lower abyssal (0–5000 m), but its greatest relative abundance (20–60%) occurs at shelf and bathyal depths (20–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Oligocene to Recent (Ld–Rec).

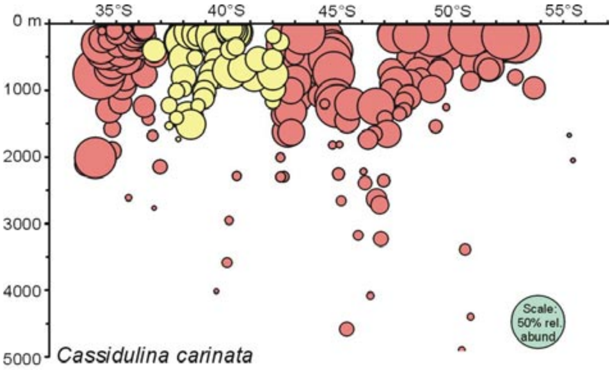


Figure 126. Latitude-depth distribution around NZ of *Cassidulina carinata* (red circles are from east of NZ, yellow circles are from west of NZ).

Cassidulina reniforme Nørvang 1945
Pl. 18, Figs 1–3

Cassidulina reniforme NØRVANG 1945, p.41, figs 6e–h; SERJUP & GUILBAULT 1980, p.79, figs 2F–K; NOMURA 1999, p.43, fig.18, 18a–c, 19a–c, 30–33.

Cassidulina islandica var. *norvangi* THALMANN in Phleger 1952, p.83, footnote 1.

Cassidulina norvangi Thalmann. NOMURA 1983b, figs 45–46, pl.4, figs 12a–c, 13; OKI 1989, pl.19, figs 1a–f; UJIIE 1995, pl.4, fig.10; HAYWARD *et al.* 2001, fig.14GG; HAYWARD *et al.* 2003, fig.4I.

DISTINGUISHING FEATURES: Test small; side view nearly circular, profile compressed; periphery acutely rounded. Chambers not inflated; sutures distinct, flush. Aperture an angled, curved slit, with a projecting relatively narrow apertural flap.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 127): Occurs around all of mainland New Zealand, but does not appear to extend south of 47˚S into the Subantarctic.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Phleger 1952, Nomura 1983b).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 127): Ranges from mid shelf to mid abyssal (50–4000 m), with its greatest relative abundance (10–30%) at outer shelf to uppermost bathyal (100–2500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

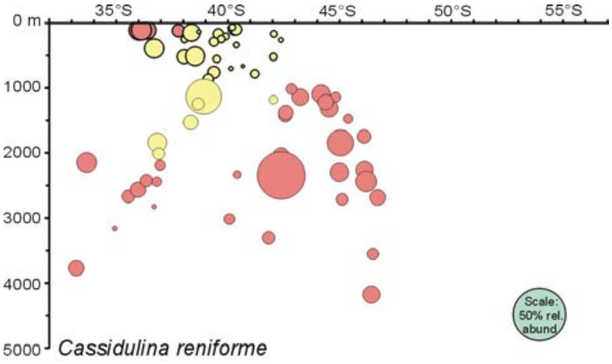


Figure 127. Latitude-depth distribution around NZ of *Cassidulina reniforme* (red circles are from east of NZ, yellow circles are from west of NZ).

Cassidulina spiniferiformis McCulloch 1977
Pl. 18, Figs 4–5

Cassidulina (?) *spiniferiformis* McCULLOCH 1977, p.394, pl.164, figs 9a–b.

DISTINGUISHING FEATURES: Test lenticular; periphery acute, weakly keeled, strongly spinose, lobulate. Apertural slit short, more angled than curved.

COMMENT: McCulloch (1977) distinguishes this species from the similar Eocene species, *C. spinifera* Cushman and Jarvis (1929), on the basis of their apertural faces and apertures.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs in deep water off the east coast of New Zealand (31–53˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (McCulloch 1977).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower abyssal (4000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Ehrenbergina* Reuss 1850

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Ehrenbergina aspinosa: Test small; dorsal sutures raised.

Ehrenbergina carinata: Ventral keel prominent, spinose, but not furrowed; dorsal surface flat.

Ehrenbergina* aff. *crassitrigona: Test thick with rugose sculpture (rare, see Nomura 1999, fig.29).

Ehrenbergina glabra: Test smooth, with high rounded ventral side; chambers bulbous.

Ehrenbergina hystrix: Early chambers on ventral surface heavily spinose; dorsal surface with cristate ridges.

Ehrenbergina mestayeri: Test broad, moderately compressed; dorsal surface smooth and convex.

Ehrenbergina trigona: Ventral keel prominent, spinose and furrowed; dorsal surface flat.

Ehrenbergina aspinosa Parr 1950
Pl. 18, Figs 6–8

Ehrenbergina pacifica var. *aspinosa* PARR 1950, p.345, pl.2, figs 1–2.

Ehrenbergina aspinosa Parr. EADE 1967b, fig.7 (4–6), fig.8 (1–2).

DISTINGUISHING FEATURES: Characterised by its small size (Eade 1967b), with small delicate spines (often broken) at the periphery. Sutures raised dorsally; strongly raised central ventral area with a central groove. Chambers on ventral side raised in a sharp ridge.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 128): Largely restricted in occurrence to off north-east North Island (34–37˚S) with one specimen further south off the west coast.

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Eade 1967b).

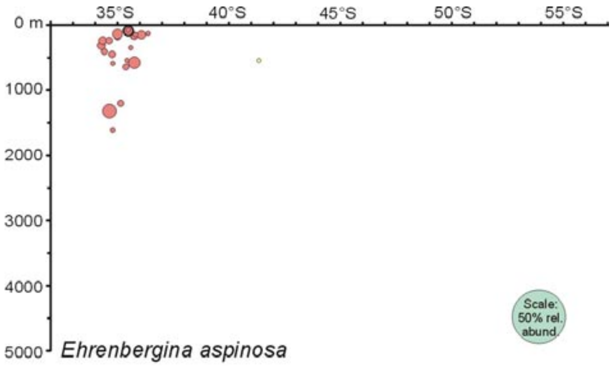


Figure 128. Latitude-depth distribution around NZ of *Ehrenbergina aspinosa* (red circles are from east of NZ, yellow circle is from west of NZ).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 128): Ranges between mid shelf and lower bathyal (100–1400 m), with most frequent occurrences at outer shelf and upper bathyal (100–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tk–Rec).

Ehrenbergina carinata Eade 1967

Pl. 18, Figs 9–11

Ehrenbergina carinata EADE 1967b, p.448, fig.8 (9), fig.9 (1–4); NOMURA 1983b, pl.5, figs 5–6.

DISTINGUISHING FEATURES: Test small and triangular when viewed dorsally and in profile. Dorsal side almost flat and slightly convex in the direction of growth especially in juveniles. Ventral side of test raised into a central keel with spines, usually one per chamber. Chambers not inflated in early stages of growth, later slightly inflated, up to about 21 in number. Peripheral keel well developed with a large spine developed at the base of each chamber. Test between central and peripheral keel flat to slightly concave with flush sutures in juvenile later slightly depressed. Apertural face broad, flat, non-perforate around aperture; aperture narrow, elongate slit extending from margin with previous chamber into the apertural face.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 129): Occurs between 36 and 56˚S off the east coast of New Zealand, but mostly confined to south of the Subtropical Front, south of 44˚S.

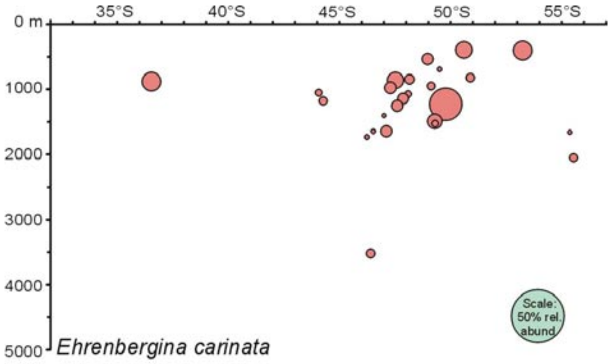


Figure 129. Latitude-depth distribution around NZ of *Ehrenbergina carinata* (red circles are from east of NZ).

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Eade 1967b).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 129): All but one record in our study is at bathyal depths (400–2000 m). Eade (1967b) recorded it from 900–2,700 m.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tk–Rec).

Ehrenbergina glabra Heron-Allen & Earland 1922

Pl. 18, Figs 12–14

Ehrenbergina hystrix Brady var. *glabra* HERON-ALLEN & EARLAND 1922, p.140, pl.5, figs 1–6, 11.

Ehrenbergina glabra Heron-Allen and Earland. CHAPMAN & PARR 1937, p.84; PARR 1950, p.344; HAYWARD *et al.* 2007b, pl.1, figs 6–7.

DISTINGUISHING FEATURES: Test moderately large, broad, planoconvex in cross section. Dorsal side smooth, flat; ventral side smooth, strongly convex, sutures indistinct. No keel developed but each chamber has a short peripheral spine. Apertural face broad, flat, with grooves around aperture. Aperture arcuate, lipped, usually extending from margin with previous chamber well into the apertural face. Finely perforate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 130): Confined to the Subantarctic region, south-east of New Zealand, south of 46˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Southern Ocean (Heron-Allen & Earland 1922; Parr 1950).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 130): Bathyal–abyssal range, with zone of highest relative abundance (10–30%) restricted to the bathyal (400–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

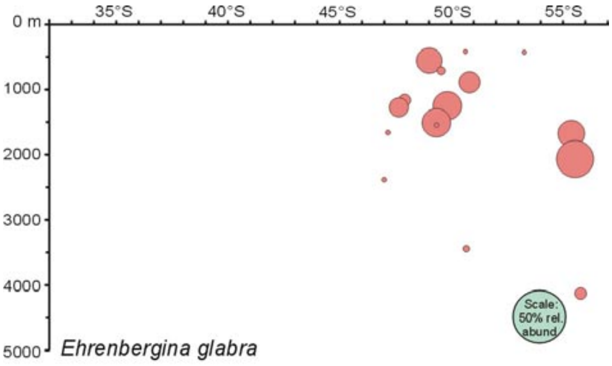


Figure 130. Latitude-depth distribution around NZ of *Ehrenbergina glabra* (red circles are from east of NZ).

Ehrenbergina hystrix Brady 1881

Pl. 18, Figs 15–18

Ehrenbergina hystrix BRADY 1881b, p.60; JONES 1994, p.61, pl.55, figs 8–11.

DISTINGUISHING FEATURES: Test moderately large, broad, unequally biconvex; peripheral keel well developed. Dorsal side slightly convex with the early

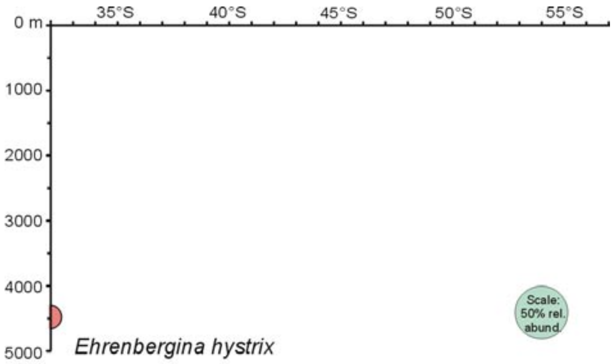


Figure 131. Latitude-depth distribution around NZ of *Ehrenbergina hystrix* (red circle is from east of NZ).

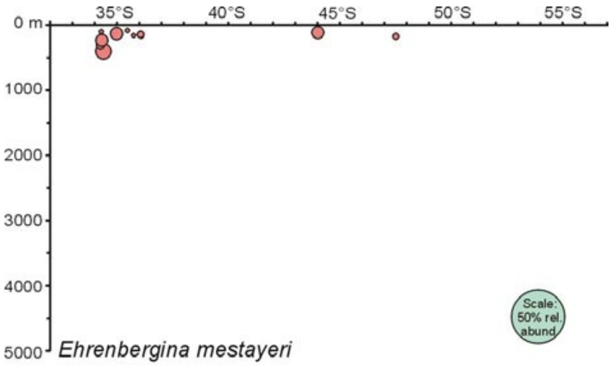


Figure 132. Latitude-depth distribution around NZ of *Ehrenbergina mestayeri* (red circles are from east of NZ).

chambers having cristate ridges or spinose sculpture. Ventral side strongly convex with the early chambers having spinose sculpture on weak irregular ridges. Chambers not inflated in early stages of growth, later inflated. Apertural face broad, flat, with grooves around aperture. Aperture variable, lipped, usually a short, elongate slit extending from margin with previous chamber into the apertural face.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 131): Only known from the subtropical north of New Zealand (32˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific.

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 131): Only recorded from the lower abyssal on the side of the Kermadec Trench (4500 m) with a relative abundance of 12%.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Ehrenbergina mestayeri Cushman 1922
Pl. 19, Figs 1–3
Ehrenbergina mestayeri CUSHMAN 1922, p.135; HAYWARD *et al*. 1999, pl.8, figs 26–27.

DISTINGUISHING FEATURES: Test small and roughly triangular, with broadly curved apertural end; peripheral margin serrate. Dorsal surface convex and smooth with sutures flush but distinct. Ventral surface with raised medial area extending from initial end and broadening towards apertural end. Apertural face with grooves; aperture an elongate curved slit.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 132): Sparse records from east of New Zealand between 34 and 48˚S. Not known from west of New Zealand.

WORLD GEOGRAPHIC DISTRIBUTION: Apparently endemic to the New Zealand region (Cushman 1922).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 132): Sporadic occurrences in low numbers (up to 6%) in fully marine, deep inner shelf to uppermost bathyal depths (30–400 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Pliocene to Recent (Wo–Rec).

Ehrenbergina trigona Goës 1896
Pl. 19, Figs 4–6
Ehrenbergina serrata Reuss var. *trigona* GOËS 1896, p.49.
Ehrenbergina trigona Goës. EADE 1967b, fig.8(8).

DISTINGUISHING FEATURES: Test small and triangular viewed dorsally and in profile. Peripheral keel with a large spine developed at the base of each chamber. Dorsal side almost flat; ventral side raised into a furrowed central keel with small spines on each side, usually one per chamber. Test between central and peripheral keels flat to slightly concave with flush sutures in juvenile, later slightly depressed. Apertural face broad, flat, non-perforate around aperture; aperture narrow, elongate slit extending from margin with previous chamber into the apertural face.

REMARKS: Differs from *E. carinata* in having a distinct spined furrow down the ventral keel and smaller peripheral spines.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 133): Sporadic occurrences throughout the New Zealand region (this study, Eade 1967b).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Eade 1967b).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 133): Records from outer shelf to lower abyssal (100–5000 m), with slightly more records from southern deep water.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Pleistocene to Recent (Wc–Rec).

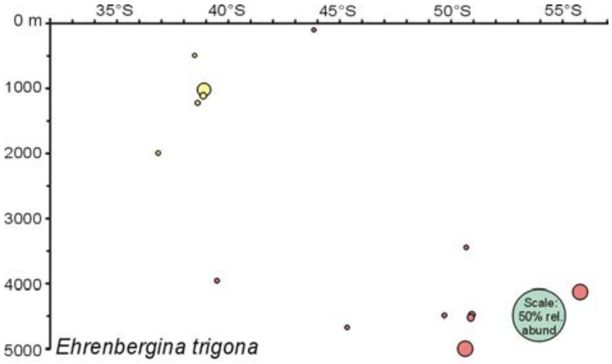


Figure 133. Latitude-depth distribution around NZ of *Ehrenbergina trigona* (red circles are from east of NZ, yellow circles are from west of NZ).

GENUS – *Evolvocassidulina* Eade 1967

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Evolvocassidulina belfordi: Test medium-sized, pyriform; apertural face poorly developed; periphery broadly rounded.

Evolvocassidulina bradyi: Test small, elongate, compressed; aperture loop-shaped; periphery acutely rounded.

Evolvocassidulina orientalis: Test large (adults), compressed, broad, sutures distinct; peripheral keel.

Evolvocassidulina tenuis: Test small, elongate, curved, nearly circular in cross-section (rare, see Eade 1967b, fig.3 (3–4)).

Evolvocassidulina belfordi Nomura 1983

Pl. 19, Figs 7–9

Evolvocassidulina belfordi NOMURA 1983a, p.79, figs 49–50, pl.2, figs 6a–c, pl.20, figs 8–10, 12.

Evolvocassidulina cf. *E. belfordi* Nomura. HAYWARD *et al.* 2001, figs 14HH–II.

DISTINGUISHING FEATURES: Test compressed, medium-sized, pyriform in shape, last two chambers tending to uncoil; apertural end bluntly rounded; periphery broadly rounded. Chambers distinct, not inflated, sutures visible, flush, slightly curved near periphery, but almost straight. Aperture a subterminal, elongate slit, extending upward almost to the top of poorly developed apertural face.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 134): Between 36 and 47°S off both coasts of the North and northern South Islands.

WORLD GEOGRAPHIC DISTRIBUTION: Indo-Pacific (Nomura 1983a).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 134): Between mid shelf and mid abyssal (80–4000 m), with relative abundances always less than 3%.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

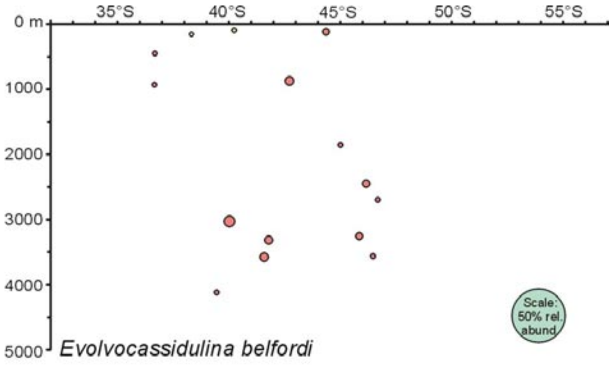


Figure 134. Latitude-depth distribution around NZ of *Evolvocassidulina belfordi* (red circles are from east of NZ, yellow circles are from west of NZ).

Evolvocassidulina bradyi (Norman 1881)

Pl. 19, Figs 10–11

Cassidulina bradyi NORMAN in BRADY 1881b, p.59. BRADY 1884, (part), pl.54, figs 6–9 (not figs 10a–b).

Cassidulinoides bradyi (Norman). JONES 1994, pl.54, figs 6–9.

Evolvocassidulina bradyi (Norman). HAYWARD & BUZAS 1979, pl.14, fig.179; NOMURA 1983b, pl.4, figs 3a–b.

DISTINGUISHING FEATURES: Test small, elongate, reniform; early chambers tightly coiled and later uncoiled; periphery acutely rounded. Sutures distinct, not depressed and slightly curved. Aperture an elongate loop with a fragile cristate tooth extending obliquely upward from the basal suture of the apertural face. Wall thin.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic records off both coasts of both main islands (36–50°S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Brady 1884, Noumura 1983b).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to lower bathyal (100–2000 m), with the one deeper record possibly displaced.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Oligocene to Recent (Lwh–Rec).

Evolvocassidulina orientalis (Cushman 1922)

Pl. 19, Figs 12–13

Cassidulina orientalis CUSHMAN 1922, p.129.

Evolvocassidulina orientalis (Cushman). HAYWARD *et al.* 1999, pl.8, fig.28; HAYWARD *et al.* 2001, figs 14JJ–KK.

DISTINGUISHING FEATURES: Test compressed; initially biserially enrolled with a narrow peripheral keel; later uncoiled and unkeeled. Aperture lipped, loop-shaped and oblique to the basal margin of the apertural face; base of aperture with a significant tooth-like extension of the lip.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 135): Throughout the New Zealand region, including the Subantarctic islands at inner shelf depths, but at greater depths largely restricted to regions north of 45°S off both coasts.

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Eade 1967b, Nomura 1981).

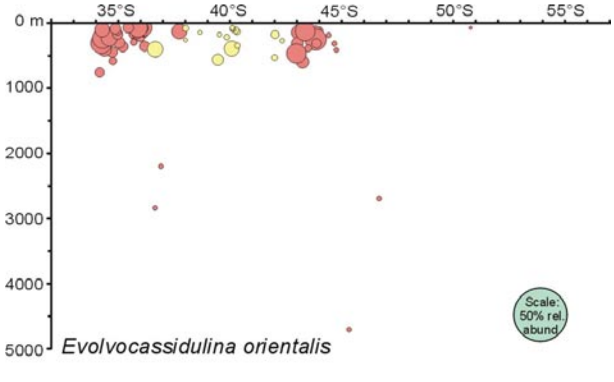


Figure 135. Latitude-depth distribution around NZ of *Evolvocassidulina orientalis* (red circles are from east of NZ, yellow circles are from west of NZ).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 135): Largely restricted to deep inner shelf to upper bathyal depths (30–600 m), with greatest relative abundances (up to 10%) scattered throughout this range. The few rare records at greater depths may be displaced.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Oligocene to Recent (Lwh–Rec).

GENUS – *Favocassidulina* Loeblich & Tappan 1957

Favocassidulina australis Eade 1967
Pl. 19, Figs 14–15
Favocassidulina australis EADE 1967b, p.426, 428–429, fig.2(2–3), fig.3(1–2).

DISTINGUISHING FEATURES: Test robust, lenticular; periphery rounded and lobate in outline. Chambers comma-shaped with strongly inflated head. Four pairs of chambers per whorl. Test ornamented with a finely developed, irregular reticulate pattern. Apertural face peripheral.

REMARKS: Differs from *F. fava* in being lobate and having finer sculpture.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Only recorded from off the east coast of the northern North Island (28–37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Eade 1967b).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal to mid abyssal (500–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Globocassidulina* Voloshinova 1960

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Globocassidulina canalisuturata: Test subglobular; sutures narrow, channelled; L–shaped aperture.

Globocassidulina crassa: Test compressed, last chamber protruding; aperture tripartite with a short areal branch.

Globocassidulina decorata: Test globular; possess network of irregular costae (rare, see Eade 1967b, fig.5(1)).

Globocassidulina elegans: Test almost globular, sutures sunken; upper portions of chambers raised – sometimes almost angular (rare, see Eade 1967b, fig.4(6–7)).

Globocassidulina minuta: Test moderately compressed, small; broad crescentic aperture with flap-like lip.

Globocassidulina producta: Test elongate; aperture almost terminal (rare, see Eade 1967b, fig.4(5)).

Globocassidulina spherica: Test almost spherical; robust, smooth; aperture a simple, elongate, loop-like slit.

Globocassidulina subglobosa: Test large, subglobular, smooth; aperture a simple, elongate, loop-like slit.

Globocassidulina canalisuturata Eade 1967
Pl. 19, Figs 16–18
Globocassidulina canalisuturata EADE 1967b, p.440, fig.3(5–7), fig.5(7–8); HAYWARD *et al.* 1999, pl.8, figs 29–30; HAYWARD *et al.* 2007b, pl.1, fig.8.

DISTINGUISHING FEATURES: Test subglobular and slightly compressed laterally; 5 pairs of chambers in the last whorl. Sutures distinct, limbate, with slot-like depressions in the centre. Aperture L-shaped, lower part along margin with the penultimate chamber.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 136): Widespread around New Zealand (34–54˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Apparently endemic to New Zealand (Eade 1967b).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 136): Deep inner shelf to upper abyssal (30–3000 m), with greatest relative abundances at mid shelf to mid bathyal depths (50–1000 m). The greatest depth of occurrence appears to shallow southwards from 3000 m to 1500 m.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tk–Rec).

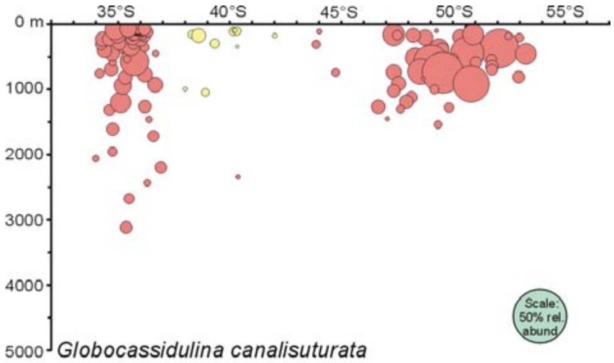


Figure 136. Latitude-depth distribution around NZ of *Globocassidulina canalisuturata* (red circles are from east of NZ, yellow circles are from west of NZ).

Globocassidulina crassa (d'Orbigny 1839)
Pl. 19, Figs 19–21
Cassidulina crassa D'ORBIGNY 1839b, p.56, pl.7, figs 18–20.
Globocassidulina crassa (d'Orbigny). EADE 1967b, fig.4(4); NOUMURA 1983b, p.37–40, text-figs 31–32, pl.3, figs 9a–c, 10a–b; HAYWARD *et al.* 2001, figs 14MM–NN; HAYWARD *et al.* 2007b, pl.1, fig.9.

DISTINGUISHING FEATURES: Test oval to almost circular in side view, moderately compressed in profile; last chamber protruding; periphery broadly rounded, slightly lobulate. Chambers moderately inflated; sutures distinct, notched. Aperture tripartite with a short areal branch.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 137): Appears to be restricted to east and south-east of southern South Island (46–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1839b).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 137): Bathyal and abyssal, with greatest relative abundances (10–15%) in the upper bathyal.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

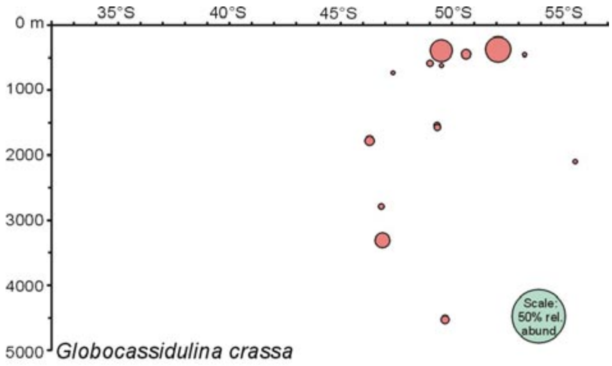


Figure 137. Latitude-depth distribution around NZ of *Globocassidulina crassa* (red circles are from east of NZ).

Globocassidulina minuta (Cushman 1933)

Pl. 19, Figs 22–24

Cassidulina minuta CUSHMAN 1933a, p.92, pl.10, fig.3.

Globocassidulina minuta (Cushman). HAYWARD *et al.* 1999, pl.8, figs 31–32; HAYWARD *et al.* 2001, figs 14OO–PP.

Paracassidulina minuta (Cushman). KAWAGATA 1999, fig.5:5.

DISTINGUISHING FEATURES: Test small, thickness less than height; laterally compressed but inflated chambers give test an inflated appearance. Periphery broadly rounded. Sutures distinct, slightly depressed. Aperture central at the base of the last chamber, crescent-shaped with a strong flap-like lip on the penultimate face. In New Zealand specimens, chambers are more globose than the type (Eade 1967b).

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 138): Occurs right around New Zealand, although less frequently in the Subantarctic, south of 49˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Known from both the North and South Pacific Ocean (Eade 1967b).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 138): From mid shelf to mid abyssal (50–4000 m), with greatest abundance and frequency in the bathyal zone (200–2000 m).

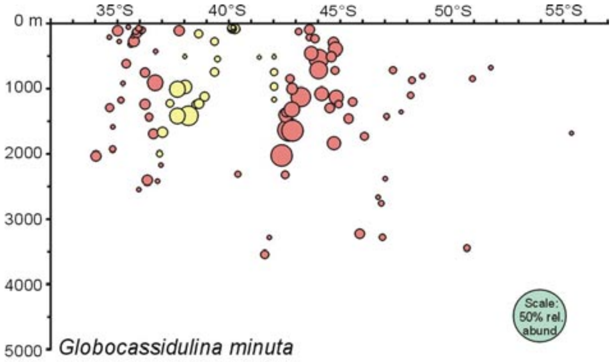


Figure 138. Latitude-depth distribution around NZ of *Globocassidulina minuta* (red circles are from east of NZ, yellow circles are from west of NZ).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Globocassidulina spherica Eade 1967

Pl. 20, Figs 1–3

Globocassidulina spherica EADE 1967b, p.441, fig.7(1–3).

DISTINGUISHING FEATURES: Test robust, smooth, almost spherical; slightly compressed laterally. Chambers not inflated, sutures flush and on last two chambers appear as dark limbate lines; other sutures obscure unless wet. Apertural face low; aperture a narrow, loop-shaped slit extending into the apertural face. Wall thick.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 139): Three widespread sporadic occurrences all off the east coast. Eade (1967b) records it north of New Zealand and abundant off Great Barrier Island between 514–700m.

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Eade 1967).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 139): Mid bathyal to mid abyssal (600–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

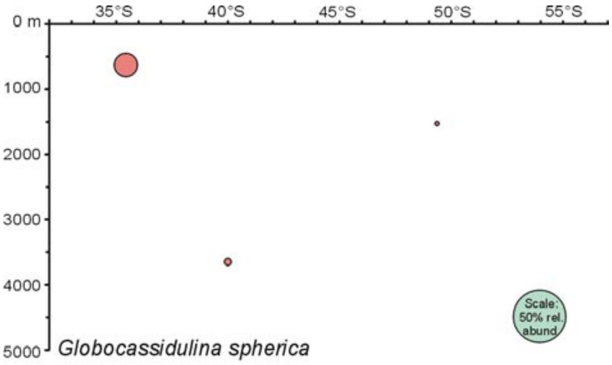


Figure 139. Latitude-depth distribution around NZ of *Globocassidulina spherica* (red circles are from east of NZ).

Globocassidulina subglobosa (Brady 1881)

Pl. 20, Figs 4–6

Cassidulina subglobosa BRADY 1881b, p.60; BRADY 1884, pl.54, figs 17a–c.

Globocassidulina subglobosa (Brady). NOMURA 1983b, fig.16, pl.2, figs 8a–c, pl.13, figs 5–6; KAWAGATA 1999, fig.5:2; JONES 1994, pl.54, figs 17a–c; HAYWARD *et al.* 2001, fig.14QQ; HAYWARD *et al.* 2003, fig.4J; HAYWARD *et al.* 2007b, pl.1, fig.10.

DISTINGUISHING FEATURES: Test large (adults), subglobular, smooth, polished; periphery broadly rounded, not lobulate. Chambers not inflated; sutures distinct on later chambers, flush with surface. Aperture a simple elongate, loop-like slit at the base of the last apertural face.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 140): Widespread right around New Zealand.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 140): Outer shelf to lower abyssal (90–5000 m), with the greatest relative abundances (10–25%) in the lower bathyal and abyssal (deeper than 1000 m). There is a "plume" of shallower occurrences in the Bounty Trough, east of the South Island and to a lesser extent west of the North Island.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Eocene to Recent (Dh–Rec).

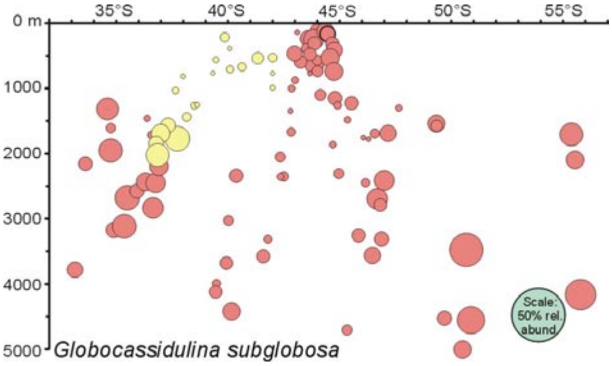


Figure 140. Latitude-depth distribution around NZ of *Globocassidulina subglobosa* (red circles are from east of NZ, yellow circles are from west of NZ).

GENUS – *Paracassidulina* Nomura 1983

Paracassidulina sagamiensis (Asano & Nakamura 1937)
Pl. 20, Figs 7–9
Cassidulina sagamiensis ASANO & NAKAMURA 1937, p.147, pl.14, figs 14a–c; SCOTT *et al.* 2000, figs 2.38–2.39.
Paracassidulina sagamiensis (Asano & Nakamura). NOMURA 1983b, pl.6, figs 1a–c, 2, 3; pl.5, fig.6; pl.24, figs 10–12; pl.25, figs 1–2; HAYWARD *et al.* 2007b, pl.1, figs 11–12.

DISTINGUISHING FEATURES: Test somewhat compressed, nearly circular in side view; periphery rounded, very slightly lobulate. Chambers large, slightly inflated; sutures distinct, slightly depressed. Aperture a long crescentic, elongate slit with a distinct apertural lip.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 141): Restricted to Subantarctic zone (49–54˚S) south-east of New Zealand.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific. Described from the Plio-Pleistocene of Japan (Asano & Nakamura, 1937; Hayward *et al*. 2007b).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 141): Mid–lower bathyal (900–1200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

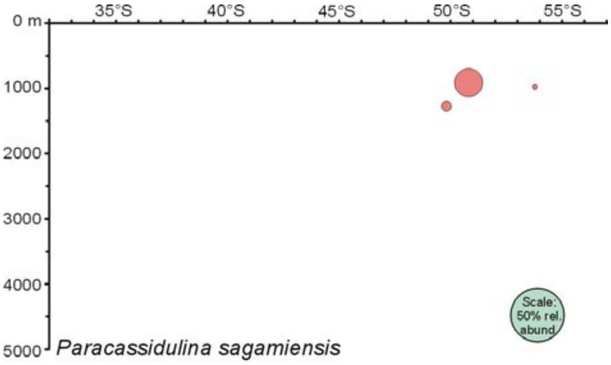


Figure 141. Latitude-depth distribution around NZ of *Paracassidulina sagamiensis* (red circles are from east of NZ).

FAMILY – Caucasinidae Bykova 1959

GENUS – *Francesita* Loeblich & Tappan 1963

Francesita advena (Cushman 1922)
Pl. 20, Figs 10–11
Virgulina? *advena* CUSHMAN 1922, p.120.
Francesita advena (Cushman). LOEBLICH & TAPPAN 1987, pl.581, figs 1–7.

DISTINGUISHING FEATURES: Test medium size, elongate subcylindrical; ovate to subcircular in cross-section. Triserial chamber arrangement becoming biserial; sutures flush to weakly incised. Unornamented. Aperture a distinctive elongate slit with narrow poreless margins; extends from base of last chamber over the top and halfway down the opposite side; one rim projects slightly above the other as a low hood.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off the east coast of the North and northern South Islands (33–45˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Cushman 1922).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Abyssal (2000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Pliocene to Recent (Wm–Rec).

FAMILY – Fursenkoinidae Loeblich & Tappan 1961

GENUS – *Cassidella* Hofker 1951

Cassidella bradyi (Cushman 1922)
Pl. 20, Figs 12-14
Virgulina bradyi CUSHMAN 1922, p.115, pl.24, fig.1.
Fursenkoina bradyi (Cushman). JONES 1994, pl.52, fig.9.

DISTINGUISHING FEATURES: Test narrow, elongate, twisted biserial; ovoid in cross-section. Chambers smooth, becoming more elongate with maturity; sutures slightly depressed. Aperture a narrow slit extending up the face onto the top of the last chamber and with a small hook at the end; low non-porate rim.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 142): Scattered sparse occurrences off both coasts of mainland New Zealand, with one record from the deep Subantarctic.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Cushman 1922).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 142): Wide depth range within the bathyal and abyssal (200–4500 m) with no depths with optimal abundance.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

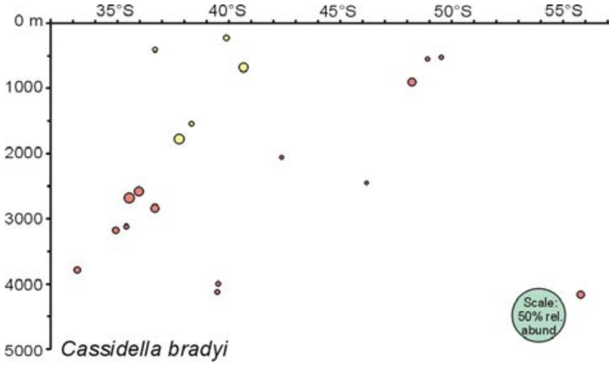


Figure 142. Latitude-depth distribution around NZ of *Cassidella bradyi* (red circles are from east of NZ, yellow circles are from west of NZ).

GENUS – *Fursenkoina* Loeblich & Tappan 1961

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Fursenkoina complanata: Chambers ovate; aperture ovate, hooded; apical spine.

Fursenkoina schreibersiana: Chambers elongate; aperture elongate ovate; no apical spine.

Fursenkoina complanata (Egger 1893)

Pl. 20, Figs 15–16

Virgulina schreibersiana var. *complanata* EGGER 1893, p.202, pl.8, figs 91–92.

Fursenkoina complanata (Egger). JONES 1994, pl.52, figs 1–3; HAYWARD *et al.* 2001, fig.14LL.

DISTINGUISHING FEATURES: Test of small to moderate size; narrow, elongate shape; rounded in cross-section. Chambers moderately inflated, twisted biserial; sutures distinct, depressed. Surface smooth; proloculus with long apical spine. Aperture a prominent, elongate–ovate opening, extending up the face of the final chamber; higher hooded marginal lip around the chamber periphery with a lower lip on the opposite side.

TAXONOMIC REMARKS: The shape of this species is suggestive of the genus *Stainforthia*, but the tooth plate is quite different.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 143): Widespread throughout the New Zealand region (33–54˚S).

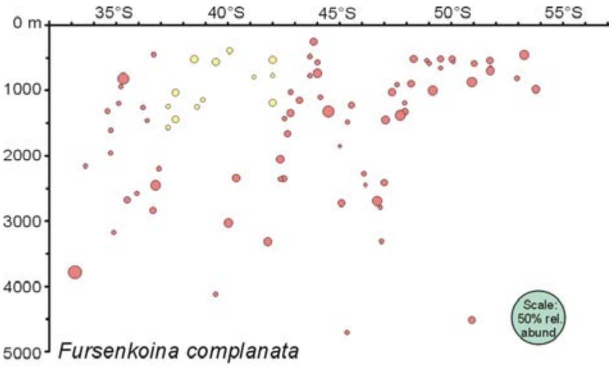


Figure 143. Latitude-depth distribution around NZ of *Fursenkoina complanata* (red circles are from east of NZ, yellow circles are from west of NZ).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 143): Occurs in relatively low numbers with even spread throughout the bathyal and abyssal (200–5000 m), possibly shallowing south of 45˚S into the Subantarctic.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

Fursenkoina schreibersiana (Czjzek 1848)

Pl. 20, Figs 17–19

Virgulina schreibersiana CZJZEK 1848, p.147, pl.13, figs 18–21.

Fursenkoina schreibersiana (Czjzek). HAYWARD *et al.* 1999, pl.9, fig.29.

DISTINGUISHING FEATURES: Test of small to moderate size; narrow elongate shape. Chambers inflated and elongate; sutures distinct and depressed. Aperture a narrow elongate slit, extending from edge of last chamber up to and just over the terminal end of the test. Wall smooth, translucent and finely perforate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Present right around the New Zealand region (35–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Culver & Buzas 1980, 1986, Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Widespread in low numbers at inner shelf to abyssal depths (30–5000 m), mostly shallower than 1000 m.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Latest Eocene to Recent (Ar–Rec).

GENUS – *Rutherfordoides* McCulloch 1981

Rutherfordoides rotundata (Parr 1950)

Pl. 20, Figs 20–23

Virgulina rotundata PARR 1950, p.337, pl.12, fig.14.

Fursenkoina rotundata (Parr). JONES 1994, pl.52, figs 10–11.

DISTINGUISHING FEATURES: Test elongate, subfusiform or slightly rotund; subcircular to ovate in cross-section. Chambers biserial, with slightly twisted axis; broad and low on the dorsal side, but more inflated and overlapping on ventral side; sutures strongly oblique, flush to slightly depressed. Surface smooth; wall glassy and translucent. Aperture an elongate loop extending up face of final chamber.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off both coasts of the two main islands (35–47˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to upper abyssal (150–3000 m), mostly deeper than 400 m.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

FAMILY – Siphogenerinoididae Saidova 1981

GENUS – *Pseudobrizalina* Zweig-Strykowski & Reiss 1976

Pseudobrizalina lobata (Brady 1881)
Pl. 20, Figs 24–25
Bolivina lobata BRADY 1881b, p.58, pl.53, figs 22–23; HAYWARD *et al.* 2001, figs 14N–O.
Pseudobrizalina lobata (Brady). JONES 1994, pl.53, figs 22–23.
Sagrinella lobata (Brady). LOEBLICH & TAPPAN 1987, pl.567, figs 19–21.
Bolivina subspinescens Cushman; HAYWARD *et al.* 2001, figs 14V–W.

DISTINGUISHING FEATURES: Test small, narrow elongate; slightly compressed, ovate in cross-section. Periphery broadly rounded to quadrate, lobular with projecting ends of costae. Early chambers wider than high, later becoming subquadrate; sutures almost straight, excavated; chamber arrangement biserial, tending towards uniserial in adult. Each chamber ornamented with a single broad obliquely-angled rib with one or two backwards-pointing branches; numerous, minute, wavy ridges on the chamber wall. Aperture subterminal elongate slit with a low, thickened lip and internal toothplate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 144): Most records are from off the west coast of central New Zealand with several from the east coast, all within the latitudinal range of 39–47˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 144): Most occurrences are at mid bathyal depths (500–1000 m) with two rare deeper records in the south, that may be displaced.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tk–Rec).

GENUS – *Saidovina* Haman 1984

Saidovina karreriana (Brady 1881)
Pl. 20, Figs 26–28
Bolivina karreriana BRADY 1881b, p.58.
Saidovina karreriana (Brady). HAYWARD *et al.* 1999, pl.9, fig.3.

DISTINGUISHING FEATURES: Elongate, biserial test, tapering at base. Chambers rounded and distinct with depressed sutures. Test covered in numerous longitudinal ribs that are continuous over the sutures. Ribs extend from basal to apertural end. Aperture terminal, large and rounded with a phialine lip.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 145): Occurs at inner shelf depths (10–50 m) right around New Zealand with rare specimens around the southern South Island and Subantarctic islands. At greater depths it occurs off both coasts of the North and northern South Islands, north of 42˚S.

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Nomura 1981, Jones 1994, Yassini & Jones 1995).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 145): Its greatest relative abundances (up to 20%) are in quiet, deep inner shelf waters (20–40 m depth) inside or at the entrance to deep inlets. Its bathymetric range extends down to the upper bathyal (shallower than 600 m) with up to 6% relative abundance at mid shelf to upper bathyal depths.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Latest Pleistocene to Recent (Wq–Rec).

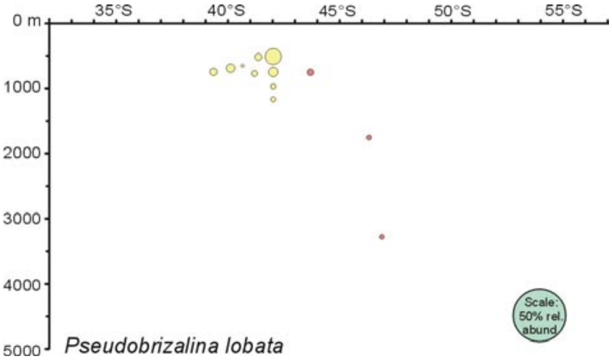


Figure 144. Latitude-depth distribution around NZ of *Pseudobrizalina lobata* (red circles are from east of NZ, yellow circles are from west of NZ).

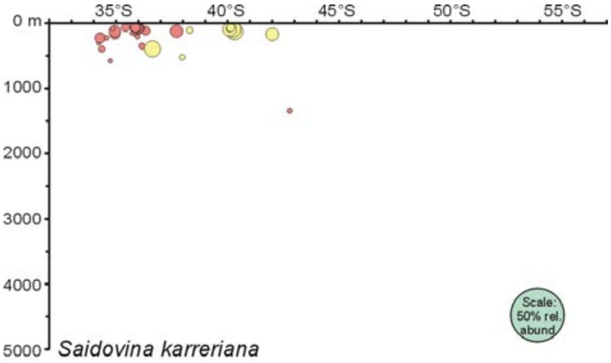


Figure 145. Latitude-depth distribution around NZ of *Saidovina karreriana* (red circles are from east of NZ, yellow circles are from west of NZ)

GENUS – *Siphogenerina* Schlumberger 1883

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Siphogenerina columellaris: Surface smooth or weakly striate.

Siphogenerina dimorpha: Coarsely perforate, sutural fosettes, no costae.

Siphogenerina raphana: Strong longitudinal costae (mostly inner shelf, see Hayward *et al*. 1999, pl.9, fig.4).

Siphogenerina semistriata: Weak longitudinal costae (rare, see Schubert 1911, figs 10a–b).

Siphogenerina columellaris (Brady 1881)
Pl. 20, Figs 29–30
Uvigerina (Sagrina) columellaris BRADY 1881b, p.64, pl.75, figs 15–17.
Siphogenerina columellaris (Brady). JONES 1994, pl.75, figs 15–17.

DISTINGUISHING FEATURES: Test narrow, elongate, cylindrical, nearly parallel-sided, moderately large; circular cross-section. Short triserial or biserial stage followed by uniserial stage. Sutures weakly incised. Unornamented or with extremely weak surface striae. Aperture terminal, circular opening, surrounded by a thick rounded lip. Wall finely perforate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic records from off the east coast of the North Island (34–40˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper bathyal (300–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Siphogenerina dimorpha (Parker & Jones 1865)
Pl. 20, Figs 31–32
Uvigerina (Sagrina) dimorpha PARKER & JONES 1865, p.364, pl.18, fig.18.
Siphogenerina dimorpha (Parker & Jones). JONES 1994, pl.76, figs 1–3.

DISTINGUISHING FEATURES: Test narrow, elongate, cylindrical, nearly parallel-sided, moderate size; circular cross-section. Short triserial or biserial stage followed by uniserial stage. Sutures incised and crossed by numerous narrow, tubular projections from the lower margin of each chamber forming fosettes between. No costae or striae. Aperture terminal, circular opening, surrounded by a thick rounded lip. Wall with regularly arranged very coarse pores.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered records off the east coast of the main islands of New Zealand (35–49˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Parker & Jones 1865).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid to lower bathyal (500–1200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Spiroloxostoma* Conata 1964

Hopkinsinella Bermudez & Fuenmayor 1966, p.508.

Spiroloxostoma glabra (Millett 1903)
Pl. 21, Figs 1–3
Uvigerina auberiana d'Orbigny var. *glabra* MILLETT 1903, p.268.
Spiroloxostoma glabra (Millett). HAYWARD *et al*. 1999, pl.9, fig.5.

DISTINGUISHING FEATURES: Test small, elongate; ovate in cross-section. Proloculus large. Chambers inflated and biserial, up to 7–8 pairs of chambers. Initial part of test twisted, later showing a minor twist or none at all. Sutures distinct and depressed. Aperture terminal, ovate, on short neck, with a distinct lip and projecting tooth. Wall finely rugose sometimes with a tendency towards development of striae.

NZ GEOGRAPHIC DISTRIBUTION (Fig. 146): Occurs at inner shelf depths (10–50 m) right around New Zealand, with rare specimens around the southern South Island and Subantarctic islands. At greater depths it occurs off both coasts of the North and northern South Islands, north of 42˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Culver & Buzas 1982, 1986).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 146): Most specimens occur on the shelf (0–200 m) with lower numbers at upper bathyal depths (100–400 m). Several rare deeper records are possibly displaced downslope. Highest abundances are in moderately sheltered inner shelf environments near the mouths of harbours and inlets.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

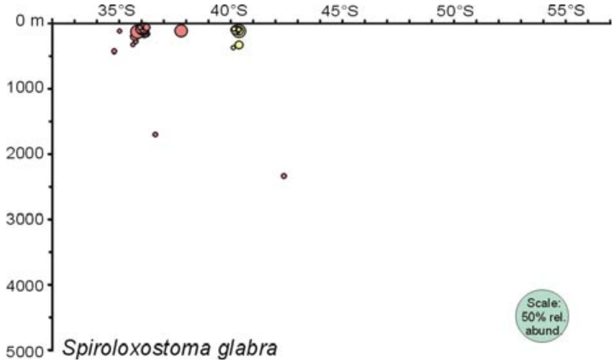


Figure 146. Latitude-depth distribution around NZ of *Spiroloxostoma glabra* (red circles are from east of NZ, yellow circles are from west of NZ).

FAMILY – Uvigerinidae Haeckel 1894

GENUS – *Neouvigerina* Thalmann 1952

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Neouvigerina ampullacea: Test inflated early with last 1–2 chambers drawn-out and uniserial; finely hispid (rare, see Loeblich & Tappan, 1994, pl. 246, figs 9–19).

Neouvigerina hispida: Test moderately inflated; covered with long fine spines.

Neouvigerina interrupta: Test slender, finely hispid; chambers small, inflated, loosely coiled, with later chambers becoming uniserial separated by short necks.

Neouvigerina proboscidea: Test moderately inflated, with short tubercles or weak spines.

Neouvigerina hispida (Schwager 1866)

Pl. 21, Figs 4–5

Uvigerina hispida SCHWAGER 1866, p.249, pl.7, fig.95.

Uvigerina auberiana d'Orbigny 1839. JONES 1994, pl.75, figs 6–9.

DISTINGUISHING FEATURES: Test elongate inflated. Chambers subspherical, inflated; closely arranged; sutures incised. Terminal aperture on elongate neck with phialine lip. Test covered in long fine spines.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences off the east coast of New Zealand (31–50˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal to lower abyssal (600–5000 m), most abundant at lower abyssal depths (4000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

Neouvigerina interrupta (Brady 1879)

Pl. 21, Figs 6–8

Uvigerina interrupta BRADY 1879b, p.274, pl.8, figs 17–18.

Siphouvigerina interrupta (Brady). JONES 1994, pl.75, figs 12–14.

Neouvigerina interrupta (Brady). LOEBLICH & TAPPAN 1994, pl.246, figs 5–8.

DISTINGUISHING FEATURES: Test narrowly elongate. Chambers small, subspherical, loosely arranged around a central axis and becoming uniserial separated by stalks in adult specimens. Terminal aperture on elongate neck with narrow phialine lip. Test covered in short fine spines spines or rounded tubercles.

TAXONOMIC REMARKS: The genus *Siphouvigerina* is distinguished from *Neouvigerina* by the presence of sharply undercut chambers with a carinate lower fringe.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 147): Occurs off both coasts of the North Island, north of 42˚S.

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 147): Occurs in relatively low numbers (up to 4%) at outer shelf to mid bathyal depths (100–1000 m), most commonly shallower than 600 m.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Pl–Rec).

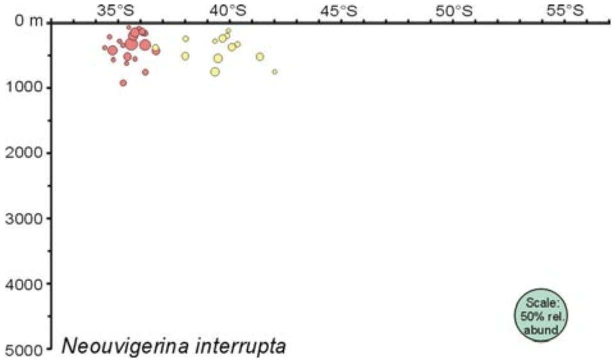


Figure 147. Latitude-depth distribution around NZ of *Neouvigerina interrupta* (red circles are from east of NZ, yellow circles are from west of NZ).

Neouvigerina proboscidea (Schwager 1866)

Pl. 21, Figs 9–11

Uvigerina proboscidea SCHWAGER 1866, p.250, pl.7, fig.96; BOERSMA 1986, pl.20, fig.2; KURIHARA & KENNETT 1986, pl.3, fig.6; VAN MORKHOVEN *et al.* 1986, p.28, pl.6; UJIIE 1990, pl.13, figs 10–11; KAWAGATA 1999, fig.5:10.

Uvigerina proboscidea var. *vadescens* CUSHMAN 1933a, p.85, pl.8, figs 14–15.

Neouvigerina proboscidea (Schwager). HAYWARD *et al.* 1999, pl.9, fig.22; HAYWARD *et al.* 2001, fig.14RR; HAYWARD *et al.* 2003, fig.4K.

DISTINGUISHING FEATURES: Test elongate inflated. Chambers subspherical, inflated; closely arranged, but sutures still visible. Terminal aperture on elongate neck with phialine lip. Test covered in short tubercles or weak spines giving the test a granular appearance.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 148): Widespread right around New Zealand.

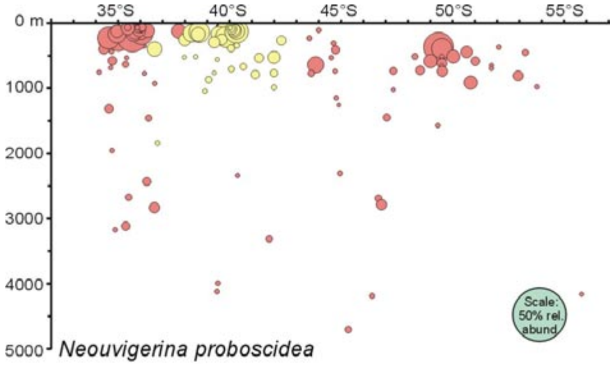


Figure 148. Latitude-depth distribution around NZ of *Neouvigerina proboscidea* (red circles are from east of NZ, yellow circles are from west of NZ).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (van Morkhoven *et al.* 1986).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 148): Specimens are found throughout the bathymetric range from inner shelf to lower abyssal (0–5000 m), however they are rare, and possibly displaced, at inner shelf and middle–lower abyssal depths (shallower than 50 m, deeper than 3000 m). The greatest abundance of this species (5–25%) is at outer shelf to upper bathyal depths (100–600 m), seemingly slightly deeper in the Subantarctic than further north.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene to Recent (Po–Rec).

GENUS – *Trifarina* Cushman 1923

Angulogerina Cushman 1927

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Trifarina angulosa: Test medium size; chamber angles carinate; test twisted; triangular cross-section throughout; longitudinal costae variable.

Trifarina bradyi: Chamber angles carinate; test straight; regular triangular cross-section; no longitudinal costae on faces.

Trifarina gracilis: Test moderate size; chamber angles rounded early, becoming carinate in later part; no longitudinal costae (rare, see Vella 1957, pl.8, fig.167).

Trifarina occidentalis: Test small, <0.3mm; chambers initially globular, triangular cross-section and carinate chamber angles in last few chambers; fine longitudinal costae throughout.

Trifarina pacifica: Chamber angles rounded; no costae (mostly inner shelf, see Hayward *et al.* 1999, pl.9, figs 25–26).

Trifarina angulosa sensu lato (Williamson 1858)

Pl. 21, Figs 12–15

Uvigerina angulosa WILLIAMSON 1858, p.67, pl.5, fig.140.

Trifarina angulosa (Williamson). HAYWARD *et al.* 1999, pl.9, figs 23–24; HAYWARD *et al.* 2001, figs 14SS–TT; HAYWARD *et al.* 2002, pl.1, figs 16–17; HAYWARD *et al.* 2007b, pl.1, fig.13.

Angulogerina angulosa (Williamson). UJIIE 1995, pl.6, fig.9.

Angulogerina carinata CUSHMAN 1927b, p.159, pl.4, fig.3.

Angulogerina carinata var. *bradyana* CUSHMAN 1932, p.45, pl.6, figs 9,10.

DISTINGUISHING FEATURES: Test of moderate to large size; elongate, fusiform with a pointed apertural end; twice as long as wide in adult, widest point in middle of test, triangular in section. Chamber angles carinate and distinct. Test usually with discontinuous longitudinal fine costae, that vary in strength from barely visible to quite strongly developed. Aperture lipped on a slightly produced neck.

REMARKS: Loeblich and Tappan (1964) have figured paratypes of *T. angulosa*, that are sparsely or non-costate. In our material we have seen considerable variability in the strength of the costate sculpture.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 149): Widespread throughout New Zealand, including the Subantarctic.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Murray 1991).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 149): Live populations of this species occur from deep inner shelf down to lower bathyal (25–2000 m). Scattered deeper records may be displaced. The greatest abundances of this common species are at upper bathyal and shallower depths (25–600 m) in the north but extend down into the lower bathyal (to 2000 m) in the Subantarctic, where they underlie the swift flowing Subantarctic Front in coarse sediment.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

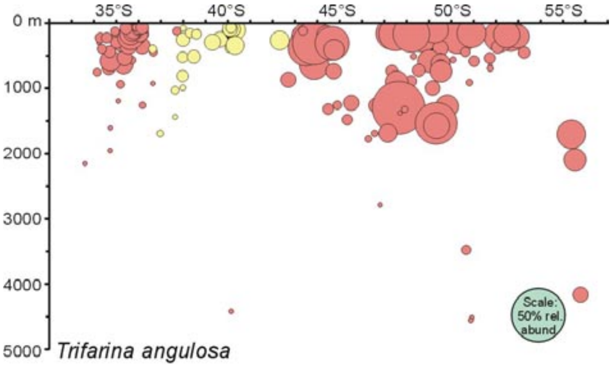


Figure 149. Latitude-depth distribution around NZ of *Trifarina angulosa* (red circles are from east of NZ, yellow circles are from west of NZ).

Trifarina bradyi Cushman 1923

Pl. 21, Figs 16–17

Trifarina bradyi CUSHMAN 1923, p.99, pl.22, figs 3–9; JONES 1994, pl.67, figs 1–3.

DISTINGUISHING FEATURES: Test narrow elongate; almost parallel-sided, slightly tapered with straight sides; triangular in cross-section. Chamber angles carinate; sutures weakly depressed. Chamber faces unornamented, lacking costae or striae. Aperture lipped on a slightly produced neck.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 150): Occurs off both coasts of New Zealand, mostly north of 43˚S in the west and north of 37˚S in the east, with rare occurrences south of this.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 150): Mostly occurs at outer shelf to mid bathyal depths (100–1000 m), with several rarer deep water records.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Eocene to Recent (Ab–Rec).

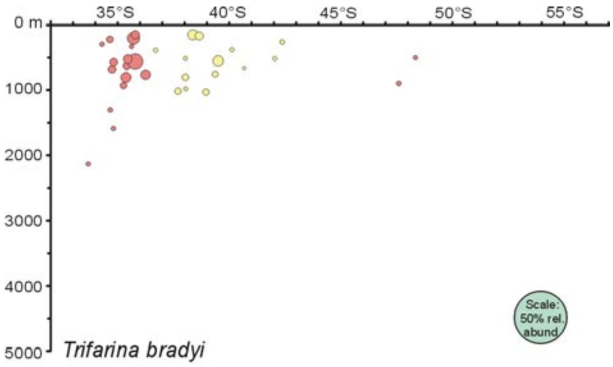


Figure 150. Latitude-depth distribution around NZ of *Trifarina bradyi* (red circles are from east of NZ, yellow circles are from west of NZ).

Trifarina occidentalis (Cushman 1923)

Pl. 21, Figs 18–20

Uvigerina occidentalis CUSHMAN 1923, p.34, pl.5, figs 3,4.

Trifarina occidentalis (Cushman). HAYWARD *et al.* 2001, figs 14UU–VV; HAYWARD *et al.* 2002, pl.1, figs 18–19; HAYWARD *et al.* 2003, fig.4L.

Uvigerina sp. YASSINI & JONES 1995, fig.613.

DISTINGUISHING FEATURES: Test small, elongate; twice as long as wide in adult, widest point in middle of test; subcircular cross-section early, later tending towards triangular. Chamber angles indistinct except in last few chambers. Chambers subspherical; sutures incised. Test with longitudinal fine costae, continuous over chambers, but not across sutures; costae strength variable. Aperture lipped on produced neck.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 151): Occurs right around New Zealand.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Cushman 1923).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 151): Total recorded range is outer shelf to lower abyssal (90–4700 m), but the zone of highest relative abundance (5–20%) is bathyal (200–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

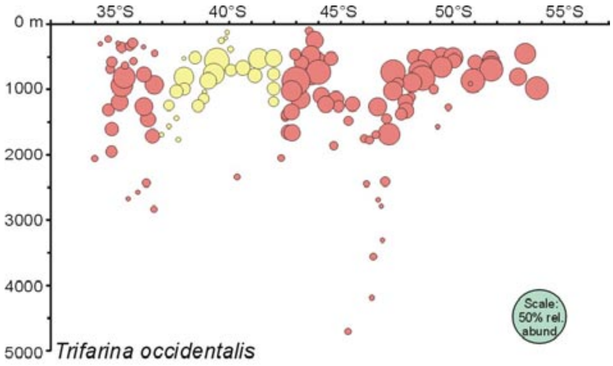


Figure 151. Latitude-depth distribution around NZ of *Trifarina occidentalis* (red circles are from east of NZ, yellow circles are from west of NZ).

GENUS – *Uvigerina* d'Orbigny 1826

KEY FEATURES OF NEW ZEALAND SPECIES:

***Uvigerina hornibrooki*:** Test and chambers moderately inflated, large; ornament of numerous moderately strong costae, often extending as spinose projections over overhanging chamber margins.

***Uvigerina mediterranea*:** Test inflated, low length/width ratio; ornament of moderately strong costae, not spinose.

***Uvigerina peregrina*:** Test elongate, high length/width ratio; ornament a mix of crenulate often broken costae; always with some spines, often at one or both ends.

Uvigerina hornibrooki Boersma 1984

Pl. 21, Figs 21–23

Uvigerina hornibrooki BOERSMA 1984, p.82, figs 1–4; BOERSMA 1986, pl.18, fig.1.

DISTINGUISHING FEATURES: Test ovate to elongate–ovate; coiling triserial throughout. Chambers and sutures indistinct because of costae. Each chamber with 10–12 strong costae, mostly continuous over each chamber and seldom crossing the sutures; many costae overhang chamber margins as spines, particularly long below apical chambers. Intercostal spaces smooth to papillate. Necked aperture with phialine lip.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Recorded by us from one station at 46˚S, east of the South Island.

WORLD GEOGRAPHIC DISTRIBUTION: South-west Pacific (Boersma 1986).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper bathyal (400–500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

Uvigerina mediterranea s.l. Hofker 1932

Pl. 21, Figs 24–26

Uvigerina mediterranea HOFKER 1932, p.118, figs 32a–g; CIMERMAN & LANGER 1991, pl.65, figs 7–9.

DISTINGUISHING FEATURES: Test ovate, about 1 1/3 times long as broad; coiling triserial throughout. Chambers inflated; periphery lobulate with distinct sutures. Each chamber with widely spaced subdued costae, never with crenulate edges nor spines. Intercostal spaces smooth. Aperture terminal at end of neck with a prominent phialine lip.

REMARKS: We have used a broad concept for this species (hence s.l.). The forms we see all have costate and no spinose ornament and are mostly rather inflated. Otherwise there is considerable variability in the strength and spacing of the costae in particular. We found it impossible to distinguish separate taxa especially among the juveniles and have thus opted for this usage.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 152): Occurs right around New Zealand.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Cimerman & Langer 1991).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 152): Largely confined to the outer shelf to bathyal (100–1700 m) with two rare deeper records possibly being displaced. The zone of highest relative abundance (5–15%) is the outer shelf to upper bathyal (150–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

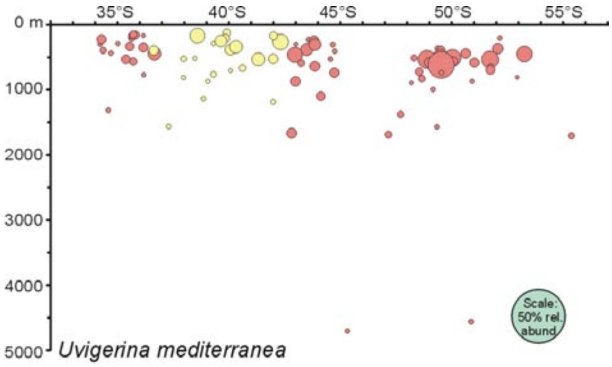


Figure 152. Latitude-depth distribution around NZ of *Uvigerina mediterranea* (red circles are from east of NZ, yellow circles are from west of NZ).

Uvigerina peregrina s.l. Cushman 1923

Pl. 21, Figs 27–31

Uvigerina peregrina CUSHMAN 1923, p.166, pl.42, figs 7–10; LOEBLICH & TAPPAN 1987, pl.573, figs 24–28; KAWAGATA 1999, fig.5:8; HAYWARD *et al.* 2001, figs 14WW–XX; HAYWARD *et al.* 2002, pl.1, figs 20–21; HAYWARD *et al.* 2003, fig.4M; SCHÖNFELD & ALTENBACH 2005, fig.2c; LOBEGEIER & SEN GUPTA 2008, pl.3, fig.11.

Uvigerina bradyana Fornasini. HAYWARD *et al.* 1999, pl.9, fig.27.

DISTINGUISHING FEATURES: Test fusiform, about 1 1/2 times long as broad; coiling triserial throughout. Chambers increasing gradually in size, relatively inflated; periphery lobulate with distinct sutures. Each chamber with 7–9 platy costae, often with crenulate edges. Intercostal spaces often have small spines. Last one or two chambers covered with thick, short spines and lack costae. Usually some spines on aboral end. Aperture terminal at end of short, slightly spinose neck with phialine lip.

REMARKS: We have used a broad concept for this species (hence s.l.). The forms we see all have a mix of costate and spinose ornament and are rather slender, but beyond these characteristics there is considerable variability. We found it impossible to distinguish separate taxa especially among the juveniles and have thus opted for this usage.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 153): Widespread right around New Zealand, though rare in the Subantarctic, south of 50˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Schönfeld & Altenbach 2005).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 153): Total recorded range is mid shelf to lower abyssal (50–5000 m). There is a broad zone of highest relative abundance (5–16%) at mid bathyal to lower abyssal depths (800–4500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene to Recent (Tt–Rec).

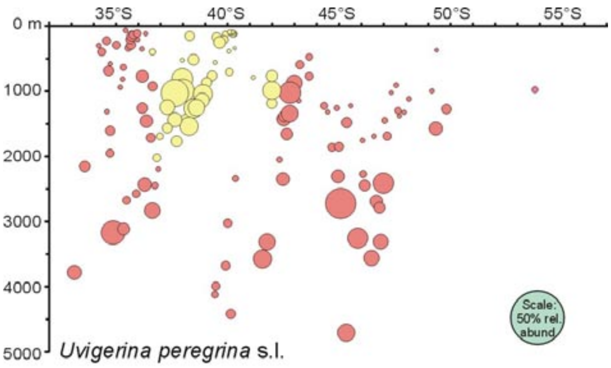


Figure 153. Latitude-depth distribution around NZ of *Uvigerina peregrina* (red circles are from east of NZ, yellow circles are from west of NZ).

ORDER – ROTALIIDA Lankester 1885

FAMILY – CHILOSTOMELLIDAE Brady 1881

GENUS – *Chilostomella* Reuss 1849

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

***Chilostomella oolina*:** Test elongate, about three times as long as broad, sides nearly parallel.

***Chilostomella ovoidea*:** Test ovoid, inflated, widest near the middle, may have elevated, serrate apertural rim.

Chilostomella oolina Schwager 1878

Pl. 21, Figs 32–35

Chilostomella oolina SCHWAGER 1878, p.527, pl.1, fig.16; UJIIE 1990, pl.22, figs 5–6; LOEBLICH & TAPPAN 1994, pl.349, figs 12–13; JONES 1994, pl.55, figs 12–14,17–18; YASSINI & JONES 1995, figs 697–699.

DISTINGUISHING FEATURES: Test elongate, about three times as long as broad; both ends broadly rounded, sides nearly parallel. Aperture a narrow curved slit at the suture between the ultimate and penultimate chambers.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare occurrences off the west and east coasts of central New Zealand between 38 and 44˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Schwager 1878).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Scattered through the bathyal and abyssal (300–4500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Po–Rec).

Chilostomella ovoidea Reuss 1850

Pl. 21, Figs 36–40

Chilostomella ovoidea REUSS 1850, p.380, pl.48, fig.12; LOEBLICH & TAPPAN 1987, pl.701, figs 6–7; LOEBLICH & TAPPAN 1994, pl.350, figs 1–3; JONES 1994, pl.55, figs 15–16, 19–23.

DISTINGUISHING FEATURES: Test ovoid, inflated, widest portion near the middle of the test. Aperture may have slightly elevated, serrate rim.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences off both coasts of the North Island (36–40˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Occurs at mid shelf to lower bathyal depths (60–1500 m), mostly shallower than 400 m.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Po–Rec).

FAMILY – Cibicididae Cushman 1927

GENUS – *Cibicides* de Montefort 1808

Cibicidoides Thalmann 1939

KEY FEATURES OF NEW ZEALAND SPECIES:

Cibicides bradyi: Test small, biconvex; broadly rounded periphery, no keel; 6–8 chambers per whorl; involute side smooth, finely perforate; evolute side coarsely perforate.

Cibicides corticatus: Test moderate size, planoconical; evolute side with granular secondary deposits; periphery irregular, sharply angled with thin keel (mostly in inner shelf depths, see Hayward *et al.* 1999, pl.14, figs 19–21).

Cibicides deliquatus: Test large, planoconvex; involute side gently convex, coarsely perforate; periphery sharp with narrow keel (rare, see Hornibrook *et al.* 1989, p.89, figs 22a–b).

Cibicides dispars: Test moderate size, planoconvex; involute side broadly convex with sutures curving back to meet acute periphery; evolute side flat, usually more perforate than involute side.

Cibicides fumeus: Test large, unequally biconvex; periphery rounded; outline lobular; chambers inflated, sutures moderately depressed; umbilicus depressed (rare, see Saidova 1975, pl.64, fig.5).

Cibicides lobatulus: Test moderate size, planoconvex; outline lobular; 5–6 chambers per whorl; sutures curved and depressed on involute side; chambers increasing in size markedly to become inflated, arcuate and lobulate.

Cibicides pachyderma: Test moderate size, unequally biconvex; periphery acute, keeled; 10–12 chambers per whorl; involute side with umbonal plug, sutures thick, flush and curved strongly towards periphery; evolute side coarsely perforate, sutures limbate, strongly curved, thickened shell in mature specimens.

Cibicides refulgens: Test moderate size; planoconical, involute side conical; periphery keeled; 7–12 chambers per whorl; sutures thick, curved towards periphery. Aperture small, hooded.

Cibicides robertsonianus: Test small to moderate size, unequally biconvex; 13–14 chambers per whorl; periphery angular. Involute side broadly convex near periphery, flat to concave umbilically; test brownish and transparent.

Cibicides subhaidingeri: Test large, unequally biconvex; 8–11 chambers per whorl; periphery acutely rounded, thickened, finely perforate; involute side broadly convex, no umbo; evolute side low conical, no secondary shell; sutures may be indistinct, smooth or slightly incised.

Cibicides temperatus: Test moderate size, unequally biconvex; 6–7 chambers per whorl; periphery keeled; umbilicus with glassy plug. Sutures on involute side thickened.

Cibicides tesnersianus: Test large, planoconvex; periphery moderately acute, perforate; evolute side depressed with chambers overlapping; involute side with inflated chambers, sutures distinct and sinuous (rare, see Saidova 1975, pl.64, fig.6, pl.107, fig.5).

Cibicides variabilis: Test moderately large, planoconvex; 6–7 chambers per whorl; chamber arrangement becoming irregular, often uncoiled.

Cibicides wuellerstorfi: Test moderate to large, compressed planoconvex; 8–9 chambers per whorl; periphery acute with strong keel; chambers strongly swept back to periphery; involute side low conical, fine to coarsely perforate, sutures flush to incised; evolute side flat, coarsely perforate, sutures limbate.

KEY TO COMMON NZ RECENT *CIBICIDES* SPECIES

1.	Test large size	2
	Test small–moderate size	5
2.	Test planoconvex	3
	Test unequally biconvex	4
3.	Sutures involute side distinct, sinuous	*C. tesnersianus*
	Sutures involute side distinct, curved	*C. deliquatus*
4.	Outline lobular	*C. fumeus*
	Outline smooth	*C. subhaidingeri*
5.	Periphery lobulate	6
	Periphery not lobulate	7
6.	Chamber arrangement becomes irregular	*C. variabilis*
	Chamber arrangement regular	*C. lobulatus*
7.	Test unequally biconvex	8
	Test planoconvex	11
8.	6–8 broad chambers per whorl	9
	9–14 chambers per whorl	10
9.	Finely perforate on both sides	*C. temperatus*
	Evolute side coarsely perforate	*C. bradyi*
10.	10–12 narrow chambers	*C. pachyderma*
	13–14 tabular chambers (involute side)	*C. robertsonianus*
11.	Profile planoconical	12
	Profile planoconvex	13

12.	Periphery irregular	*C. corticatus*
	Periphery smooth	*C. refulgens*
13.	Test strongly compressed	*C. wuellerstorfi*
	Involute side broadly convex	*C. dispars*

Cibicides bradyi (Trauth 1918)
Pl. 22, Figs 1–3

Truncatulina dutemplei (d'Orbigny). BRADY 1884, p.665, pl.95, figs 5a–c.

Truncatulina bradyi TRAUTH 1918, p.235, concept included pl.95, figs 5a–c of Brady (1884).

Cibicides bradyi (Trauth). BARKER 1960, pl.95, figs 5a–c; VAN MORKHOVEN *et al.* 1986, p.100, pl.30, figs 1a–c, 2a–c; HOLBURN & HENDERSON 2002, figs 3.9–3.14.

Cibicidoides bradyi (Trauth). KAWAGATA 1999, fig.7.1.

Gyroidina bradyi (Trauth). JONES 1994, pl.95, figs 5a–c.

DISTINGUISHING FEATURES: Test small, biconvex to almost parallel–sided; evolute side somewhat flattened; periphery broadly rounded, no keel. 6–8 inflated chambers per whorl; sutures radial on evolute side, oblique or slightly curved on involute side. Chamber walls coarsely perforate on evolute side and smooth, finely perforate on involute side. Aperture small, peripheral.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 154): Widespread off both coasts of the North Island and northern South Island (33–42˚S), with two rare records south of this.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994, Van Morkhoven *et al.* 1986).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 154): Occurs at mid bathyal to mid abyssal depths (800–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Oligocene–Recent (Ld–Rec).

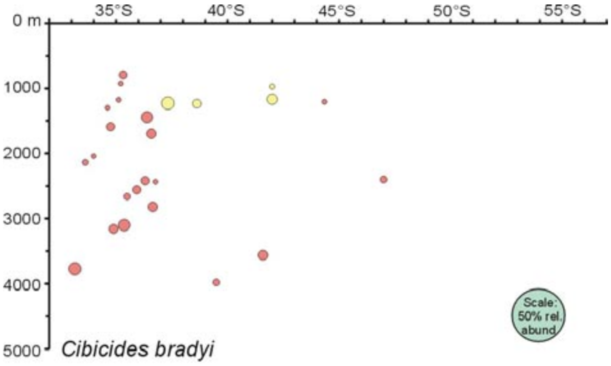


Figure 154. Latitude-depth distribution around NZ of *Cibicides bradyi* (red circles are from east of NZ, yellow circles are from west of NZ).

Cibicides dispars s.l. (d'Orbigny 1839)
Pl. 22, Figs 4–9

Truncatulina dispars D'ORBIGNY 1839b, p.38, pl.5, figs 25–27.

Cibicides marlboroughensis VELLA 1957, p.40, pl.9, figs 189–191; HAYWARD *et al.* 1999, pl.14, figs 25–27.

Cibicides dispars (d'Orbigny). BOLTOVSKOY *et al.* 1980, pl.8, figs 12–16; HAYWARD *et al.* 2001, figs 15J–L; HAYWARD *et al.* 2003, figs 4R–T.

Cibicidoides floridanus (Cushman). YASSINI & JONES 1995, figs 889–896.

DISTINGUISHING FEATURES: Test small to moderate size; evolute side flat to gently convex or even gently concave; involute side broadly convex; periphery acute. 9–10 chambers per whorl; sutures on involute side curving back to meet periphery; umbilicus flat and often filled with opaque white shell. Evolute side usually more coarsely perforate than involute side. Aperture peripheral, extending along evolute surface.

REMARKS: A broad view is taken of this species, hence the use of s.l.. There appears to be enormous confusion over the identity of Recent planoconvex *Cibicides* species, with many interchangeable names used in the literature. We have chosen one of the earliest names, the description of which appears to match our variable specimens quite well. *C. dispars* lacks the raised umbilical knob of *C. fletcheri*; is less conical than *C. refulgens*; and is more planoconvex with fewer chambers than *C. ungerianus*. Our specimens are a good match for topotypes of *C. dispars* illustrated by Boltovskoy *et al.* (1980) from the Falkland Islands.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 155): Abundant and widespread right around New Zealand (33–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Boltovskoy *et al.* 1980, Hayward *et al.* 1999).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 155): Occurs in large numbers at all depths from inner shelf to lower abyssal, with the greatest relative abundances (10–30%) at shelf and upper bathyal depths (0–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Miocene–Recent (Sw–Rec).

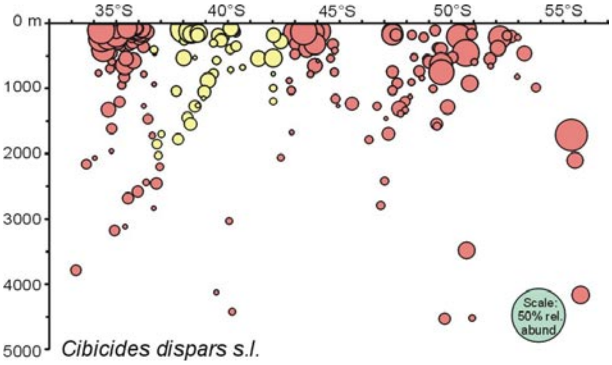


Figure 155. Latitude-depth distribution around NZ of *Cibicides dispars* s.l. (red circles are from east of NZ, yellow circles are from west of NZ).

Cibicides lobulatus (Walker & Jacob 1798)
Pl. 22, Figs 10–12

Nautilus lobulatus WALKER & JACOB in KANMACHER 1798, p.642, pl.14, fig.36.

Truncatulina lobulatus (Walker & Jacob). BRADY 1884, pl.92, fig.10.

Cibicides lobulatus (Walker & Jacob). HAYWARD & BUZAS 1979, pl.10, figs 124–126; BOLTOVSKOY *et al*. 1980, p.24, pl.9, figs 1–4.

DISTINGUISHING FEATURES: Test of moderate size; planoconvex, somewhat compressed; periphery lobulate with a narrow keel. 5–6 chambers per whorl; chambers inflated, increasing in size rapidly; sutures curved, fine and incised on involute side. Test finely perforate. Aperture small, peripheral, extending onto the evolute surface.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences right around New Zealand at inner shelf depths, but only recorded east of the South Island at greater depths (44–49˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Brady 1884, Boltovskoy *et al*. 1980).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mostly at inner shelf depths, but east of the South Island at upper and mid bathyal depths (200–1000 m), where maybe it is displaced.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Po–Rec).

Cibicides pachyderma (Rzehak 1886)
Pl. 22, Figs 13–15

Truncatulina pachyderma RZEHAK 1886, p.87, pl.1, figs 5a–c.

Cibicides neoperforatus HORNIBROOK 1976, p.93, figs 6a–c.

Cibicidoides pachyderma (Rzehak). VAN MORKHOVEN *et al*. 1986, p.68–70 (Lectotype illustrated). Non VAN MORKHOVEN *et al*. 1986, pl.22, figs 1a–c.

DISTINGUISHING FEATURES: Test moderate to large; biconvex; periphery moderately acute, keeled. 10–12 chambers per whorl; chambers on evolute side slightly inflated, relatively narrow, sutures depressed, gently curved; chambers on involute side slightly inflated, sutures flush to slightly depressed, weakly limbate. Evolute side coarsely perforate. Aperture small, peripheral.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 156): Occurs in low numbers right around New Zealand (33–56˚S), but rare south of 52˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Van Morkhoven *et al.* 1986).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 156): Mid shelf to lower abyssal (50–4500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Oligocene–Recent (Ld–Rec).

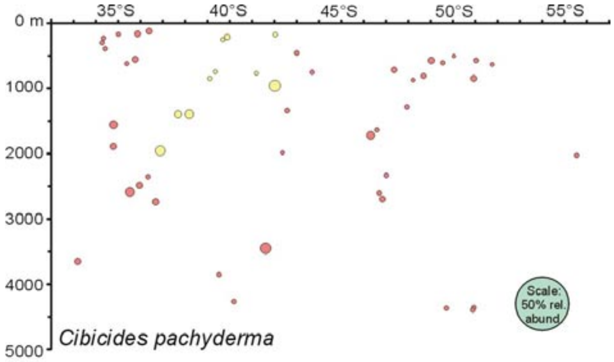


Figure 156. Latitude-depth distribution around NZ of *Cibicides pachyderma* (red circles are from east of NZ, yellow circles are from west of NZ).

Cibicides refulgens de Montfort 1808
Pl. 22, Figs 16–21

Cibicides refulgens DE MONTFORT 1808, p.122; HAYWARD & BUZAS 1979, pl.10, figs 130–131; JONES 1994, pl.92, figs 7–9; UJIIE 1995, pl.11, fig.1

DISTINGUISHING FEATURES: Test of moderate size; strongly planoconical, involute side conical; periphery delicately keeled; 7–12 chambers per whorl; sutures thick, curved towards periphery. Both sides perforate; peripheral aperture small, hooded, with a narrow slit extending along the suture on the evolute side.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare off eastern New Zealand (33–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper to lower bathyal (200–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Po–Rec).

Cibicides robertsonianus (Brady 1881)
Pl. 23, Figs 1–3

Planorbulina (*Truncatulina*) *robertsonianus* BRADY 1881, p.65.

Cibicidoides robertsonianus (Brady). JONES 1994, pl.95, fig.4.

DISTINGUISHING FEATURES: Test small to moderate size, unequally biconvex; involute side broadly convex near periphery, flat to concave umbilically; evolute side flat to slightly convex; periphery angular. 13–14 chambers per whorl, chambers look tabulate on evolute side; sutures on involute side straight to slightly curved. Evolute side perforate, lacking thick shell; test brownish and transparent. Aperture small, peripheral.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare around New Zealand (33–43˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper bathyal to upper abyssal (200–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent (Rec).

Cibicides subhaidingeri Parr 1950
Pl. 23, Figs 4–8

Cibicides subhaidingeri PARR 1950, p.364, pl.15, fig.7.

Cibicidoides subhaidingeri (Parr). JONES 1994, pl.95, fig.7; VAN MORKHOVEN *et al*. 1986, pl.28, figs 1a–c.

DISTINGUISHING FEATURES: Test large, unequally biconvex; involute side strongly convex, rounded. 8–11 chambers per whorl with only the last 4–5 chambers distinct and slightly inflated. Sutures generally indistinct; on involute side slightly curved; on evolute side sutures straight on later chambers, indistinct or obscured on early chambers with a thickened shell layer. Involute side rather coarsely perforate; evolute side perforate. Aperture peripheral, elongate, slit–like, lipped.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 157): Sporadic occurrences around most of New Zealand (33–52˚S), but more frequent off the west than east coast.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994, Edelman–Furstenburg *et al.* 2001).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 157): Outer shelf to lower abyssal (100–4500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Eocene–Recent (Ar–Rec).

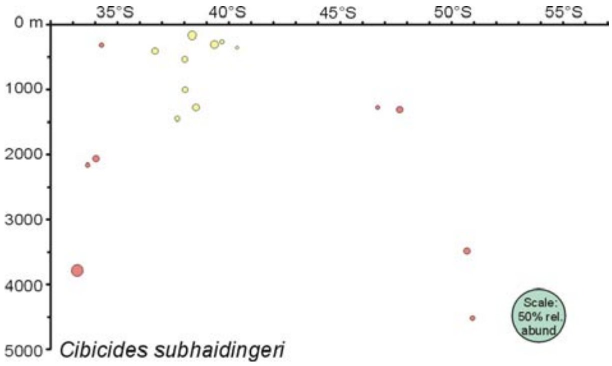


Figure 157. Latitude-depth distribution around NZ of *Cibicides subhaidingeri* (red circles are from east of NZ, yellow circles are from west of NZ).

Cibicides temperatus Vella 1957
Pl. 23, Figs 9–13

Cibicides temperata VELLA 1957, p.40, pl.9, figs 201–203; HORNIBROOK 1961, pl.24, figs 476–477,482.

Cibicidoides temperatus (Vella). HAYWARD & BUZAS 1979, pl.11, figs 135–137.

DISTINGUISHING FEATURES: Test of moderate size, unequally biconvex and rather thin, compressed; periphery acute, keeled. Involute side with a glassy plug, often hollowed on top. 6–7 chambers per whorl; sutures on involute side are gently curved, thickened and raised (except for last 1 or 2); sutures on evolute side are thin, flush and slightly curved, but obscured in early whorls by secondary shell deposits. Wall densely and finely perforate. Aperture peripheral, lipped, moderate size, extending onto evolute side.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs off the east coast of the North and South Islands (34–48˚S), not recorded so far from off the west coast or in the Subantarctic.

WORLD GEOGRAPHIC DISTRIBUTION: South–west Pacific (Vella 1957).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to lower bathyal (80–1500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Pliocene–Recent (Wo–Rec).

Cibicides variabilis (d'Orbigny 1826)
Pl. 23, Figs 14–16

Truncatulina variabilis D'ORBIGNY 1826, p.279 (type not illustrated).

Cibicides variabilis (d'Orbigny). BOLTOVSKOY *et al.* 1980, pl.9, figs 12–17.

DISTINGUISHING FEATURES: Test of moderate size, somewhat compressed, planoconvex; evolute side convex; involute side planar; variable in outline, lobate; periphery acute. 6–8 chambers in the final whorl; chamber size, shape and position variable. Wall coarsely perforate. Aperture peripheral, lipped.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs right around New Zealand (33–56˚S), but appears to be more abundant off the east coast of the South Island than in the north or off the west coast.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1826).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to lower bathyal (50–2000 m), with several, possibly displaced, deeper records.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Miocene–Recent (Sl–Rec).

Cibicides wuellerstorfi (Schwager 1866)
Pl. 23, Figs 17–22

Anomalina wuellerstorfi SCHWAGER 1866, p.258, pl.7, figs 105, 107.

Truncatulina wuellerstorfi (Schwager). BRADY 1884, pl.93, figs 8–9.

Planulina wuellerstorfi (Schwager). BARKER 1960, pl.93, figs 8–9.

Fontbotia wuellerstorfi (Schwager). UJIIE 1990, pl.17, figs 1–5.

Cibicidoides wuellerstorfi (Schwager). JONES 1994, pl.93, figs 8–9.

Cibicides wuellerstorfi (Schwager). HAYWARD & BUZAS 1979, pl.11, figs 140–142; KAWAGATA 1999, fig.7.5; LOBEGEIER & SEN GUPTA 2008, pl.1, figs 16a–b.

DISTINGUISHING FEATURES: Test of moderate to large size, almost circular in outline; compressed planoconvex with carinate periphery. 8–9 chambers in final whorl; sutures strongly expressed on both sides and strongly recurved. Involute side finely perforate, evolute side coarsely perforate. Aperture small, peripheral, lipped, extends onto evolute side.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 158): Occurs in moderate numbers right around

New Zealand (33–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 158): Upper bathyal to upper abyssal depths (400–3000 m), with several single specimen deeper records, possibly displaced.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Pl–Rec).

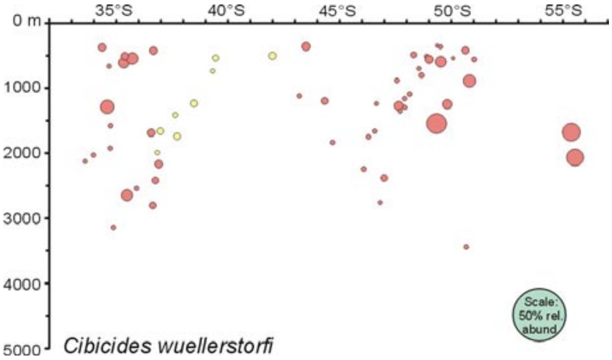


Figure 158. Latitude-depth distribution around NZ of *Cibicides wuellerstorfi* (red circles are from east of NZ, yellow circles are from west of NZ).

FAMILY – Discorbidae Ehrenberg 1838

GENUS – *Neoeponides* Reiss 1960

Neoeponides shreibersii (d'Orbigny 1846)
Pl. 24, Figs 1–3

Rotalina schreibersii D'ORBIGNY 1846, p. 154, pl.49, figs 4–6.

Neoeponides schreibersii (d'Orbigny). PAPP & SCHMIDT 1985, p. 59, pl.49, figs 7–9, 11–12; JONES 1994, pl.115, figs 1a–c.

NOT *Neoeponides schreibersii* (d'Orbigny). LOEBLICH & TAPPAN 1988, pl.604, figs 1–6, pl.605, figs 1–4.

DISTINGUISHING FEATURES: Test large, high trochospiral coil with near conical spiral side and gently convex involute side; periphery acutely rounded. 7–10 chambers per whorl. Spiral side chambers broad, low and crescentic, separated by oblique sutures. Involute side chambers wedgelike separated by incised radial sutures. Small tubercular chamberlets on umbilical ends of chambers around closed umbilicus. Aperture interiomarginal extending from umbilicus nearly to the periphery, with a narrow bordering lip.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Uncommon off the north-east coast of the North Island (32–36˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (D'Orbigny 1846; Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf–upper bathyal (100–400 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent (Rec).

FAMILY – Discorbinellidae Sigal 1952

GENUS – *Discorbinella* Cushman & Martin 1935

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Discorbinella bertheloti: Test planoconvex. Periphery angular with sharp keel. Convex side involute or nearly so. Sutures slightly thickened but not raised.

Discorbinella complanata: Test compressed, planoconvex. Periphery acute with sharp keel. Convex side evolute. Sutures strongly limbate, slightly raised.

Discorbinella deflata: Test planoconvex. Periphery acute with sharp keel. Convex side involute with a rib on the crest of each inflated chamber. Sutures on involute side depressed (see Hayward *et al.* 1999, pl.14, figs 7–9).

Discorbinella subcomplanata: Test compressed, planoconvex. Periphery truncate and bluntly rounded. Convex side evolute. Sutures strongly limbate and raised, especially on convex side.

Discorbinella timida: Test small, planoconvex. No peripheral flange or keel. 4–5 chambers per whorl. Convex side involute to slightly evolute. Sutures narrow, flush.

Discorbinella vitrevoluta: Test planoconvex. Slight peripheral flange indented by sutures. Convex side involute or nearly so. 5–6 chambers per whorl. Papillae around deep umbilical area (see Hayward *et al.* 1999, pl.14, figs 16–18).

KEY TO NZ RECENT *DISCORBINELLA* SPECIES

1. Test strongly compressed, planoconvex; convex side evolute 2
Test planoconvex, not strongly compressed; convex side involute or nearly so 3

2. Periphery acute, strongly keeled *D.complanata*
Periphery truncate, bluntly rounded *D.subcomplanata*

3. Small rib on crest of each inflated chamber on convex side *D. deflata*
No ornament on crest of chambers 4

4. 4–5 chambers per whorl; sutures narrow and flush *D. timida*
6–9 chambers per whorl 5

5. Strong, flange–like keel; umbilical papillae on flat side *D. vitrevoluta*
Narrow, sharp, keel; no umbilical papillae *D. bertheloti*

Discorbinella bertheloti (d'Orbigny 1839)
Pl. 24, Figs 4–6

Rosalina bertheloti D'ORBIGNY 1839c, p.135, pl.1, figs 28–30.

Discorbinella bertheloti (d'Orbigny). HAYWARD *et al.* 1999, pl.14, figs 1–3; HAYWARD *et al.* 2001, figs 15M–O; HAYWARD *et al.* 2003, figs 4U–W.

DISTINGUISHING FEATURES: Test compressed, planoconvex; circular in outline. Periphery angular with a thin sharp keel. Umbilical side flat to concave, slightly evolute; convex side involute to slightly evolute. 6–8 chambers in final whorl; sutures curved and slightly thickened. Apertural flaps usually distinct. Test wall shiny and transparent, and finely perforate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 159): Widespread records right around New Zealand between 34 and 54˚S. Appears to occur in greatest abundances in the north (north of 40˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Culver & Buzas 1982, 1986, Cimerman & Langer 1991, Loeblich & Tappan 1994, Yassini & Jones 1995).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 159): Widespread and common in fully marine, deep inner shelf to bathyal depths (30–2000 m), with the few abyssal records possibly displaced. Its greatest relative abundances (5–20%) are at mid shelf to upper bathyal depths (50–600 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Oligocene–Recent (Ld–Rec).

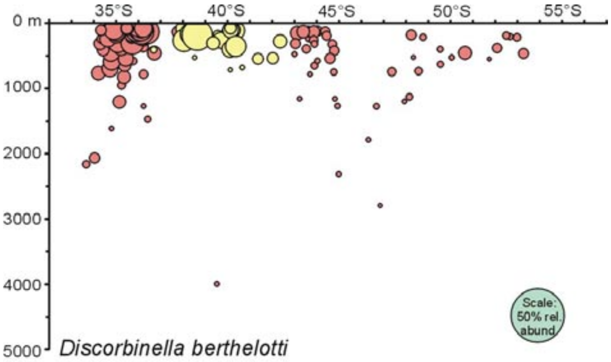


Figure 159. Latitude-depth distribution around NZ of *Discorbinella bertheloti* (red circles are from east of NZ, yellow circles are from west of NZ).

Discorbinella complanata (Sidebottom 1918)

Pl. 24, Figs 7–9

Discorbina bertheloti var. *complanata* SIDEBOTTOM 1918, p.253, pl.6, figs 1–3.

Discorbinella complanata (Sidebottom). HAYWARD *et al*. 1999, pl.14, figs 4–6; HAYWARD *et al.* 2001, figs 15P–R.

DISTINGUISHING FEATURES: Test small; strongly compressed, planoconvex to concavo–convex; convex side evolute. Periphery acute with a strong keel. 7–8 narrow chambers in final whorl; sutures limbate, slightly raised. Test otherwise translucent to transparent.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread in low numbers all around New Zealand (33–53˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Australasia (Parr 1950).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Wide depth range in low numbers from inner shelf to lower abyssal (30–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Latest Eocene–Recent (Ar–Rec).

Discorbinella subcomplanata (Parr 1950)

Pl. 24, Figs 10–12

Discorbis subcomplanatus PARR 1950, p.355, pl.14, figs 1–2.

Discorbinella subcomplanata (Parr). HAYWARD *et al.* 1999, pl.14, figs 10–12; HAYWARD *et al.* 2001, figs 15S–T.

DISTINGUISHING FEATURES: Test small to moderate size; compressed, planoconvex. Periphery truncate and bluntly rounded. Convex side evolute. Sutures strongly limbate and raised, especially on convex side. Umbilical flaps small. Surface smooth and finely perforate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Widespread off the east coast of New Zealand (34–56˚S), but not recorded from off the west coast.

WORLD GEOGRAPHIC DISTRIBUTION: Known records from Antarctica and New Zealand (Parr 1950).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Frequent occurrences in low numbers at shelf and bathyal depths (30–2000 m). Rare deeper records may be displaced.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene–Recent (Tk–Rec).

Discorbinella timida Hornibrook 1961

Pl. 24, Figs 13–15

Discorbinella timida HORNIBROOK 1961, p. 116, pl.14, figs 288, 293, 297; HAYWARD *et al.* 1999, pl.14, figs 13–15.

DISTINGUISHING FEATURES: Test small, fragile. Planoconvex in profile. Periphery acutely angled with a thin keel, no peripheral flange. Both convex and flat sides are involute. 4–5 chambers per whorl; sutures faint. Wall glossy, finely perforate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic single specimen occurrences right around New Zealand (36–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South–west Pacific (Hornibrook 1961).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to uppermost abyssal (50–2500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Po–Rec).

GENUS – *Laticarinina* Galloway & Wissler 1927

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Laticarinina altocamerata: Plano–convex, with wide peripheral flange; chambers conical on convex side.

Laticarinina pauperata: Strongly compressed; with an extremely wide peripheral flange.

Laticarinina altocamerata (Heron-Allen & Earland 1922)

Pl. 24, Figs 16–18

Truncatulina tenuimargo Brady var. *altocamerata* HERON-ALLEN & EARLAND 1922, p.209, pl.7, figs 24–27.

Parvicarinina altocamerata (Heron-Allen & Earland). HORNIBROOK 1961, pl.14, figs 296, 299, 301, 302, 305; JONES 1994, pl.93, fig.2.

Laticarinina altocamerata (Heron-Allen & Earland). HAYWARD & BUZAS 1979, pl. 19, figs 242–243; LOEBLICH & TAPPAN 1987, pl.631, figs 5–7; YASSINI & JONES 1995, figs 981–983.

DISTINGUISHING FEATURES: Test elliptical–circular in outline; planoconvex to concavo–convex. Moderately wide peripheral flange. Both sides evolute. 8–9 chambers per whorl, conical on convex side; sutures radial and depressed on the convex side and strongly curved on the flat spiral side. Aperture consists of several openings in the umbilical region of the flat spiral side, each covered with an umbilical flap of the posterior margin.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 160): Occurs sporadically right around the New Zealand region at 35–56˚S.

WORLD GEOGRAPHIC DISTRIBUTION: South–west Pacific (Heron-Allen & Earland 1922).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 160): Confined to outer shelf to bathyal depths (130–2000 m), with the majority of occurrences shallower than 1500 m.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Eocene–Recent (Ak–Rec).

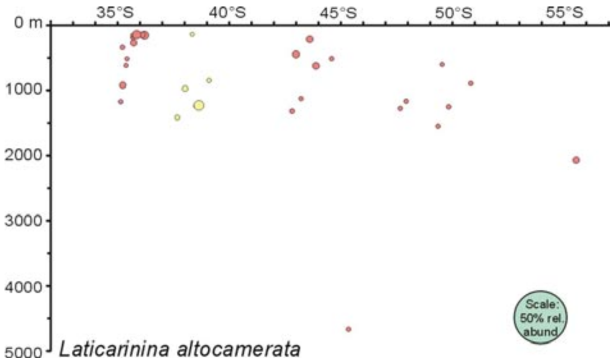


Figure 160. Latitude-depth distribution around NZ of *Laticarinina altocamerata* (red circles are from east of NZ, yellow circles are from west of NZ).

Laticarinina pauperata (Parker & Jones 1865)
Pl. 24, Figs 19-21

Pulvinulina repanda Fichtel & Moll var. *menardii* d'Orbigny, subvar. *pauperata* PARKER & JONES 1865, p.395, pl.16, figs 50, 51(a–b).

Laticarinina pauperata (Parker & Jones). LOEBLICH & TAPPAN 1987, pl.631, figs 1–4; UJIIE 1990, pl.14, figs 3–4; LOEBLICH & TAPPAN 1994, pl.312, figs 1–5; JONES 1994, pl.104, figs 3–11; YASSINI & JONES 1995, figs 976–977.

DISTINGUISHING FEATURES: Test circular in outline. Strongly compressed in profile with one side slightly more convex; extremely wide, laminated, translucent, peripheral keel or flange. Aperture a narrow slit perpendicular to the periphery at the base of the final chamber.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 161): Scattered records around New Zealand (36–50˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 161): Lower bathyal–upper abyssal (1500–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Eocene–Recent (Ab–Rec).

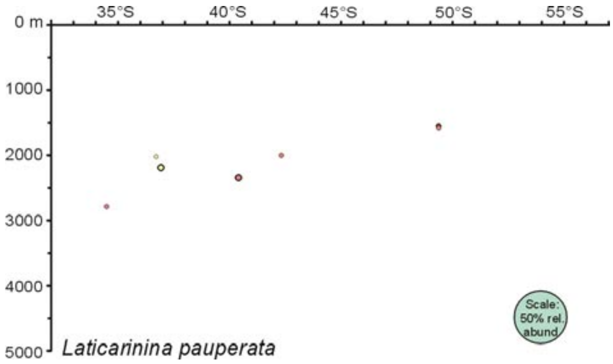


Figure 161. Latitude-depth distribution around NZ of *Laticarinina pauperata* (red circles are from east of NZ, yellow circles are from west of NZ).

FAMILY – Elphidiidae Galloway 1933

GENUS – *Notorotalia* Finlay 1939

KEY FEATURES OF NEW ZEALAND SPECIES:

***Notorotalia aucklandica**:* Test large; spiral side convex, domed; central region of umbilical surface deeply concave; 12–14 chambers/whorl; sutural ribs well developed, spiral ribs extend from suture to suture in early chambers, but not in later chambers.

***Notorotalia depressa**:* Test moderate to large; compressed, almost parallel–sided; 10–12 chambers/whorl; umbilical surface with flattened or gently concave umbilical area; sutural ribs well–developed, spiral ribs thin and usually not reaching anterior sutural rib.

***Notorotalia finlayi**:* Test small to moderate size; planoconvex; 11–13 chambers/whorl; sutural ribs well developed, spiral ribs strong but dying out before reaching anterior sutural rib; sutural pores usually developed at posterior margin of chambers (mostly inner shelf, see Hayward *et al.* 1999, pl.16, figs 19–21).

***Notorotalia hornibrooki**:* Test small to moderate size; compact and biconvex, typically more convex spiral side; 8–9 chambers/whorl; umbilical sutural ribs strong, gently curved and only slightly oblique to periphery; spiral side often lacks sculpture (mostly inner shelf, see Hayward *et al.* 1999, pl.16, figs 31–33).

Notorotalia inornata: Test large; biconvex; 11–12 chambers/whorl; sutural ribs fade out towards periphery, spiral ribs truncated at or before middle of each chamber; smooth thin callus deposit on spiral side (mostly inner shelf, see Hayward *et al.* 1999, pl.16, figs 22–24).

***Notorotalia olsoni**:* Test large, planoconvex; 10–11 chambers/whorl; sutural ribs weak on umbilical surface, difficult to discern on spiral surface; spiral ribs fine, dense; spiral surface lacking callus, dense ribbing producing reticulate appearance (mostly inner shelf, see Hayward *et al.* 1999, pl.16, figs 25–27).

***Notorotalia profunda**:* Test small to moderate size; biconvex, usually more convex on the umbilical side; 6–8 chambers/whorl, compact; sutures oblique, curved; sutural ribs weak or absent; sculpture weakly reticulate on spiral side.

***Notorotalia zelandica**:* Test large; biconvex, but centre of umbilical side somewhat flattened; 12–14 chambers/whorl; prominent callus knob on spiral side; sutural ribs weak, spiral ribs extend from suture to suture.

KEY TO NZ RECENT *NOTOROTALIA* SPECIES

1. Spiral ribs do not extend from suture to suture 2
   Spiral ribs, in early chambers at least, extend from suture to suture 4
2. Test large, spiral ribs truncated at or before middle of each chamber *N. inornata*
   Test small to moderate size; spiral ribs extend over most of each chamber 3
3. Test moderate to large size, almost parallel sided, compressed; spiral ribs thin *N. depressa*
   Test small to moderate size, planoconvex; spiral ribs strong *N. finlayi*
4. Test small to moderate size, compact, <10 chambers/whorl 5
   Test large, >10 chambers/whorl 6
5. Test with 8–9 chambers/whorl; more convex on spiral side; umbilical sutural ribs strong; spiral side often lacks sculpture. *N. hornibrooki*
   Test with 6–8 chambers/whorl; usually more convex on umbilical side; sutural ribs weak or absent, sculpture weakly reticulate on spiral side. *N. profunda*
6. Prominent callus knob on spiral side; test biconvex, but umbilical side flattened; sutural ribs weak but spiral ribs always extend from suture to suture. *N. zelandica*
   Lacks callus knob 7
7. Central region of umbilical surface deeply concave, sutural ribs well developed, spiral ribs extend across chamber in early chambers but not later *N. aucklandica*
   Test planoconvex, sutural ribs very weak on umbilical side, fine dense spiral ribs which on the spiral surface produces a reticulate appearance *N. olsoni*

Notorotalia aucklandica Vella 1957

Pl. 25, Figs 1–3

Notorotalia aucklandica VELLA 1957, p.57, pl.3, figs 39–43; HAYWARD *et al.* 1999, pl.16, figs 13–15.

DISTINGUISHING FEATURES: Large size, biconvex to planoconvex with high-domed spiral side; umbilical side convex to flat with deeply concave central region. Periphery acute with a weak keel. 12–14 chambers/whorl. Sutural ribs well developed and gently curved; spiral ribs extend from suture to suture in early chambers, but not in later chambers.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Only recorded off southern New Zealand, around Stewart Island, Pukaki Rise, Auckland and Campbell Islands (47–53˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Endemic to New Zealand.

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Common at shelf depths (0–200 m), with one deeper record, possibly displaced.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent (Rec).

Notorotalia depressa Vella 1957

Pl. 25, Figs 4–6

Notorotalia depressa VELLA 1957, p.47, pl.1, figs 13,19–20; HAYWARD *et al.* 1999, p.169, pl.16, figs 16–18.

DISTINGUISHING FEATURES: Test moderate to large, compressed and almost parallel–sided. Both spiral and umbilical sides slightly convex, but umbilical side with a flattened or gently concave umbilical area. 10–12 chambers/whorl. Sutural ribs well–developed, moderately curved on umbilical side with thin spiral ribs which do not usually reach the anterior suture.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 162): Widespread around all three main islands plus Auckland Islands (34–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Endemic to New Zealand.

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 162): Occurs at inner shelf to mid bathyal depths (10–750 m), with two deeper records possibly displaced. Its greatest relative abundances (5–15%) are in exposed and moderately sheltered, fully marine, shelf depths (10–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Pliocene–Recent (Wp–Rec).

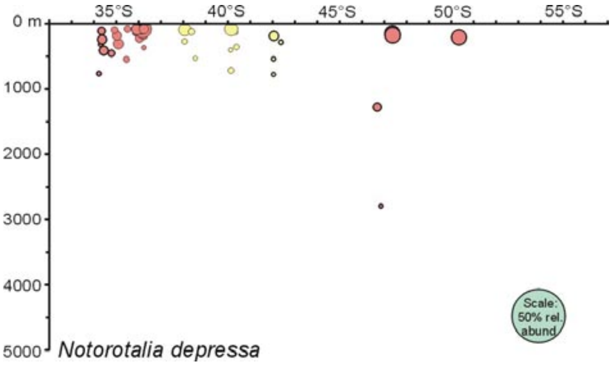


Figure 162. Latitude-depth distribution around NZ of *Notorotalia depressa* (red circles are from east of NZ, yellow circles are from west of NZ).

Notorotalia profunda Vella 1957

Pl. 25, Figs 7–9

Notorotalia profunda Vella 1957, p.48–49, pl.1, figs 6–8; HAYWARD *et al.* 2001, figs 16L–N.

DISTINGUISHING FEATURES: Test small, stout, biconvex with an angular keeled periphery. 7–8 chambers/whorl. Spiral ribs strong, crisp and continuous from suture to suture, sometimes locally reticulate with secondary ribs.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 163): Occurs off the east and west coasts of northern and central New Zealand between 35 and 45˚S, with no records south of the Bounty Trough (c. 45˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Endemic to New Zealand.

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 163): Occurs between mid shelf and lower bathyal depths (65–1300 m), with greatest relative abundances (5–10%) at outer shelf to upper bathyal depths (90–400 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Pliocene–Recent (Wm–Rec).

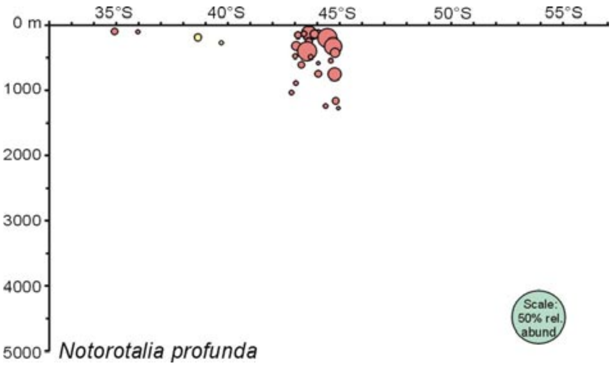


Figure 163. Latitude-depth distribution around NZ of *Notorotalia profunda* (red circles are from east of NZ, yellow circles are from west of NZ).

Notorotalia zelandica Finlay 1939

Pl. 25, Figs 10–12

Notorotalia zelandica FINLAY 1939a, p.518. HAYWARD *et al.* 1999, pl.16, figs 34–36.

DISTINGUISHING FEATURES: Test large; spiral side convex with a distinct knob of callus in the centre; umbilical side convex with flattened or slightly concave umbilical area. 11–12 chambers in the last whorl. Sutural ribs gently arcuate on umbilical side with dense heavy spiral ribs that usually extend from suture to suture. A more or less continuous spiral rib usually present adjacent to periphery.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences around all three main islands (34–48˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Endemic to New Zealand.

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Widespread but sporadic in moderate numbers in exposed and moderately sheltered, fully marine, inner shelf to upper bathyal depths (10–400 m). Most common around central New Zealand with its greatest abundances (up to 10% of faunas) in exposed, sandy inner–shelf environments (10–50 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Pliocene–Recent (Wm–Rec).

FAMILY – Epistomariidae Hofker 1954

GENUS – *Nuttallides* Finlay 1939

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Nuttallides bradyi: Small; periphery lobulate, keeled; profile near equally biconvex.

Nuttallides umbonifera: Periphery acute, not lobulate, nor keeled; profile more convex on umbilical side.

Nuttallides bradyi (Earland 1934)

Pl. 25, Figs 13–15

Eponides bradyi EARLAND 1934, pl.8, figs 36–38.

Osangulariella bradyi (Earland). SAIDOVA 1975, pl.75, fig.4.

Nuttallides bradyi (Earland). LOEBLICH & TAPPAN 1987, pl.669, figs 17–20.

DISTINGUISHING FEATURES: Test lenticular, small, subequally biconvex in profile. Periphery slightly lobulate, weakly keeled. 8–10 chambers per whorl; sutures strongly oblique, limbate, and curving into the peripheral keel on the spiral side; nearly radial on the umbilical side.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Occurs right around the two main islands of New Zealand (32–47˚S), but does not extend south into the Subantarctic.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Otto *et al.* 1985).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Sporadic occurrences from mid shelf to lower abyssal (50–5000 m). Its distribution pattern shallows upwards from north to south, from mainly abyssal north of 40˚S to mainly bathyal and shelf south of this.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Nuttallides umbonifera (Cushman 1933)

Pl. 25, Figs 16–19

Pulvinulinella umbonifera CUSHMAN 1933a, p.90, pl.9, fig. 9

Osangulariella umbonifera (Cushman). JONES 1994, pl.95, figs 9–10.

Epistominella umbonifera (Cushman). CORLISS 1979, pl.2, figs 10–12.

Nuttallides umbonifera (Cushman). TODD 1965, pl.11, fig.1; HERMELIN 1989, pl.12, figs 15–17; THOMAS *et al.* 1990, pl.9, figs 13–16; HAYWARD *et al.* 2007b, pl.1, figs 19–20.

Nuttallides bradyi (Earland). LOEBLICH & TAPPAN 1987, pl.669, figs 21–23.

DISTINGUISHING FEATURES: Test biconvex, moderately large; umbilical side often more convex than the spiral side, commonly with an umbilical plug. Periphery smoothly rounded, not lobulate; no keel. 6–9 chambers per whorl, sutures strongly oblique, limbate, and curving into the periphery on the spiral side; nearly radial on the umbilical side. Aperture interiomarginal. Walls often etched.

REMARKS: There is some uncertainty about the generic placement of this species. We have chosen to place it in *Nuttallides* because of its umbilical plug and the position of the aperture.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 164): Scattered occurrences off the east coast of New Zealand in deep water between 39 and 56˚S. Not recorded from off the west coast, possibly because no abyssal stations.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 164): Most abundant (10–60%) at mid–lower abyssal depths (3000–5000 m) beneath corrosive Circumpolar Deep Water, with a few rare lower bathyal records (1000–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Mid Miocene–Recent (Sl–Rec).

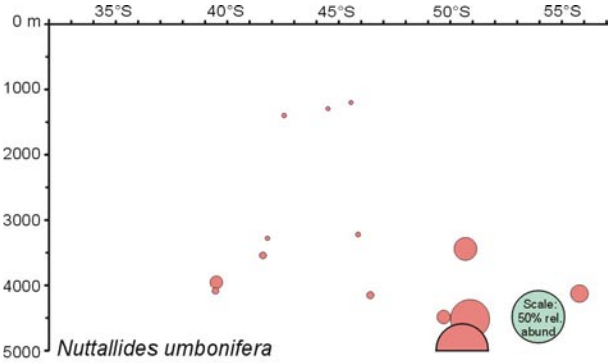


Figure 164. Latitude-depth distribution around NZ of *Nuttallides umbonifera* (red circles are from east of NZ).

FAMILY – Eponididae Hofker 1951

GENUS – *Alabaminella* Saidova 1975

Alabaminella weddellensis (Earland 1936)
Pl. 25, Figs 20–22
Eponides weddellensis EARLAND 1936, p.57.
Alabaminella weddellensis weddellensis (Earland). SAIDOVA 1975, pl.108, fig.1.
Alabaminella weddellensis (Earland). LOEBLICH & TAPPAN 1987, pl.593, figs 18–22; HAYWARD *et al*. 2001, figs 15U–W; HAYWARD *et al.* 2003, figs 4O–Q; HAYWARD *et al.* 2007b, pl.1, figs 14–15.
Eponides pusillus PARR 1950, p.360, pl.14, fig.16.

DISTINGUISHING FEATURES: Test small; unequally biconvex with spiral side more convex than umbilical; periphery broadly rounded. 5–6 chambers in the final whorl; broad low chambers and oblique sutures on spiral side; sutures depressed and radial on umbilical side. Umbilicus depressed and closed. Aperture a minute, slitlike, interiomarginal and extraumbilical.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 165): Common and widespread right around New Zealand between 32 and 56˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Earland 1936; Loeblich & Tappan 1987).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 165): Occurs in relatively high abundances (10–35%) at all depths between mid shelf and lower abyssal (85–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Po–Rec).

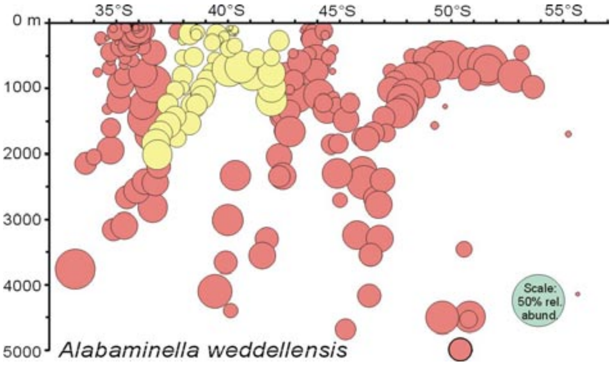


Figure 165. Latitude-depth distribution around NZ of *Alabaminella weddellensis* (red circles are from east of NZ, yellow circles are from west of NZ).

GENUS – *Ioanella* Saidova 1975

Ioanella tumidula (Brady 1884)
Pl. 26, Figs 1–3
Truncatulina tumidula BRADY 1884, p.666, pl.95, fig.8.
Ioanella tumidula (Brady). LOEBLICH & TAPPAN 1987, pl.595, figs 4–10; JONES 1994, pl.95, fig.8; UJIIE 1995, pl.8, fig. 5; HAYWARD *et al*. 2001, figs 16D–F.

DISTINGUISHING FEATURES: Test minute; unequally biconvex with a moderately high spire; broad, rounded, lobulate periphery. Approximately 3 whorls of inflated chambers with 5–6 chambers per whorl. Umbilical side with deep narrow umbilicus. Aperture an interiomarginal arch near the umbilicus, with small secondary opening at the produced umbilical ends of the chambers. Wall smooth.

TAXONOMIC NOTES: Distinguished from *Alabaminella weddellensis* by the presence of a lobulate periphery, a higher spiral side and by the secondary apertures on the umbilical end of chambers.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 166): Numerous records right around New Zealand between 34 and 51˚S. Not recorded from the far south and rare and deeper off the north-east and west coasts of the North Island.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 166): Occurs in moderately high relative abundances (3–10%) at all depths from outer shelf to lower abyssal (90–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Miocene–Recent (Sl–Rec).

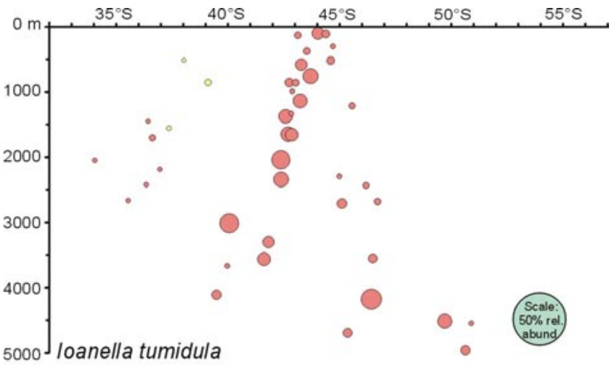


Fig. 166. Latitude-depth distribution around NZ of *Ioanella tumidula* (red circles are from east of NZ, yellow circles are from west of NZ).

GENUS – *Porogavelinella* Kawagata 1999

Porogavelinella ujiiei Kawagata 1999
Pl. 26, Figs 4–6

Porogavelinella ujiiei KAWAGATA 1999, p.40, fig.11.1–11.6; HAYWARD *et al*. 2001, figs 16A–C.

DISTINGUISHING FEATURES: Test minute; circular outline; test flattened on spiral side; flattened to slightly concave on umbilical side; periphery broadly rounded, slightly lobulate. 9–10 chambers per whorl in adult. Spiral side evolute, umbilical side involute. Aperture interiomarginal to extraumbilical, low slit extending to near the periphery, partly covered with thin and short umbilical flaps. Wall thin, finely perforate, except for distinct large pores scattered around umbilicus.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 167): Widespread right around New Zealand from 34 to 55˚S.

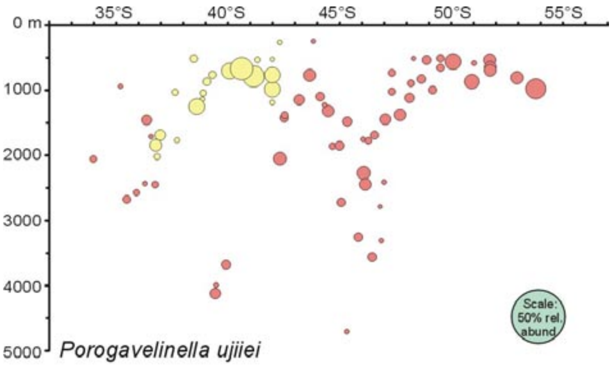


Figure 167. Latitude-depth distribution around NZ of *Porogavelinella ujiiei* (red circles are from east of NZ, yellow circles are from west of NZ).

WORLD GEOGRAPHIC DISTRIBUTION: Only described and recorded from the South–west Pacific (Kawagata 1999), but could be more widespread but not yet recorded because of its small size.

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 167): Most occurrences are at mid bathyal to mid abyssal depths (500–4000 m), with two shallower and one deeper rare records. Greatest relative abundances (4–11%) are at mid bathyal depths (500–1000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Po–Rec).

FAMILY – Gavelinellidae Hofker 1956

GENUS – *Discanomalina* Asano 1951

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:
Discanomalina coronata: Periphery broadly truncate in section, no protuberances.
Discanomalina semipunctata: Periphery irregular with protuberances.

Discanomalina coronata (Parker & Jones 1857)
Pl. 26, Figs 7–8

Anomalina coronata PARKER & JONES 1857, p.294, pl.10, figs 15–16; CHAPMAN 1909, pl.17, fig.10.

Discanomalina coronata (Parker & Jones 1857). JONES 1994, pl.97, figs 1–2.

DISTINGUISHING FEATURES: Test large, robust. Periphery broadly truncate in section. Low trochospiral to nearly planispiral, rapidly enlarging whorls. 7–9 chambers in final whorl; chambers with umbilical flaplike projections on one or both sides. Aperture a low interiomarginal and equatorial slit bordered above by a narrow lip, slit–like supplementary openings present beneath the umbilical flaps. Wall coarsely perforate, with non–perforate apertural face, and chamber flaps.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare records from the Subantarctic region of New Zealand (47–51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Parker & Jones 1857).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to uppermost bathyal (100–400 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Discanomalina semipunctata (Bailey 1851)
Pl. 26, Figs 9–12

Rotalina semipunctata BAILEY 1851, p.11, figs 17–19.

Discanomalina japonica ASANO 1951, text-figs 3–5.

Discanomalina semipunctata (Bailey). SAIDOVA 1975, pl.70, fig.10; LOEBLICH & TAPPAN 1987, pl.718, figs 1–9; LOEBLICH & TAPPAN 1994, pl.361, figs 4–6; JONES 1994, pl.97, figs 3–6.

DISTINGUISHING FEATURES: Test free or attached, irregular, robust, low trochospiral to nearly planispiral, rapidly enlarging whorls; periphery broadly rounded, lobulate with one or more projections. 7–9 laterally inflated chambers in the final whorl; chambers with umbilical flaplike projections on one or both sides. Aperture a low interiomarginal and equatorial slit bordered above by a narrow lip, slit–like supplementary openings present beneath the umbilical flaps. Wall coarsely perforate, with non–perforate apertural face, chamber flaps and area of attachment.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Extremely rare occurrences right around New Zealand (36–51˚S)

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Loeblich & Tappan 1987).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Only recorded here at mid bathyal depths (600–1000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Gyroidina* d'Orbigny 1826

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

***Gyroidina danvillensis*:** Test small; periphery broadly rounded; 5–6 chambers per whorl; spiral side sutures radial, slightly curved.

Gyroidina kawagatai: Test small, somewhat compressed; periphery acutely rounded; spiral side sutures oblique, slightly curved.

Gyroidina orbicularis: Test moderately large; developing a rounded keel; umbilical side inflated; spiral side sutures oblique, slightly curved;

Gyroidina soldanii: Test large; planoconvex; acutely rounded peripheral angle; spiral side sutures radial.

Gyroidina danvillensis Howe & Wallace 1932
Pl. 26, Figs 13–15

Gyroidina danvillensis HOWE & WALLACE 1932, p.69, pl.13, fig.3; HAYWARD & BUZAS 1979, pl.18, figs 224–225.

Gyroidina nipponica ISHIZAKI 1944, p.102, pl.3, figs 3a–c.

Gyroidinoides nipponicus (Ishizaki). UJIIE 1990, pl.27, figs 1a–c.

DISTINGUISHING FEATURES: Test small; plano-convex; spiral side flat to weakly convex medially, umbilical side domed convex; periphery broadly rounded. 5–6 chambers in final whorl; sutures radial, slightly curved on spiral side; sutures radial and almost straight on umbilical side. Umbilicus typically closed. Aperture an interiomarginal extraumbilical slit.

REMARKS: Superficially resembles juvenile *Anomalinoides sphericus* from which it differs by the fewer chambers per whorl, the smaller proloculus, and the greater domed convexity on the umbilical side (typical of *Gyroidina*). This species differs from the other three recorded *Gyroidina* species in this study by the combination of its low number of chambers per whorl and its small size.

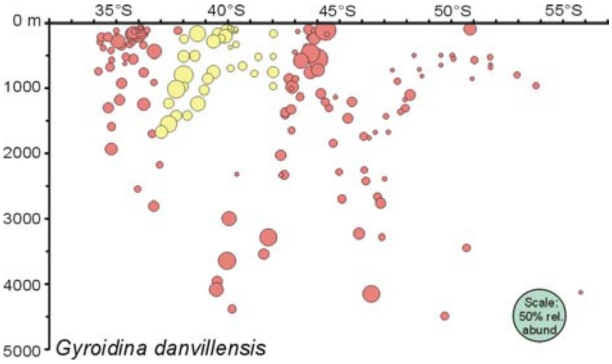


Figure 168. Latitude-depth distribution around NZ of *Gyroidina danvillensis* (red circles are from east of NZ, yellow circles are from west of NZ).

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 168): Common occurrences right around New Zealand between 34 and 56˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Howe & Wallace 1932, Ujiie 1990).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 168): Occurs at all depths from outer shelf to lower abyssal (80–5000 m) with rare shallower records. Occurs most frequently and in greatest relative abundances (4–9%) at outer shelf to mid bathyal depths (100–1000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Eocene–Recent (Dw–Wn).

Gyroidina kawagatai (Ujiie 1995)
Pl. 26, Figs 16–18

Gyroidinoides kawagatai UJIIE 1995, p.73, pl.14, figs 3a–c; HAYWARD *et al.* 2001, figs 15EE–GG.

DISTINGUISHING FEATURES: Test small, somewhat compressed; spiral side almost flat, umbilical side low convex; peripheral angle acutely rounded. 10–11 chambers in final whorl; sutures oblique, slightly curved on spiral side; sutures radial and almost straight on umbilical side. Umbilicus typically closed. Aperture an interiomarginal extraumbilical slit.

REMARKS: Much smaller, more compressed and lacking the keel development of *G. orbicularis*.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 169): Widespread around central New Zealand

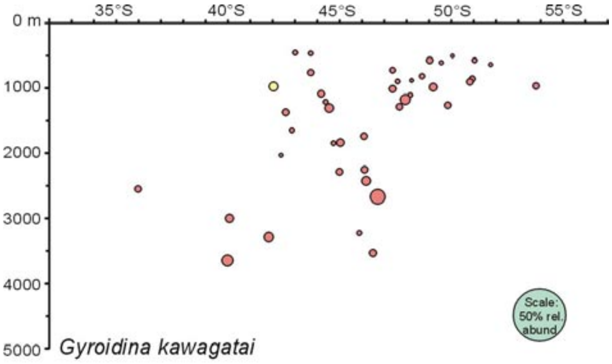


Figure 169. Latitude-depth distribution around NZ of *Gyroidina kawagatai* (red circles are from east of NZ, yellow circle is from west of NZ).

(40–52˚S) with sporadic occurrences further north and south and rare off the west coast.

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Ujiie 1995).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 169): Occurs in low numbers from deep upper bathyal to mid abyssal depths (400–4000 m), with shallower distribution in the south (mostly mid–upper bathyal).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Oligocene–Recent (Lw–Rec).

Gyroidina orbicularis (d'Orbigny 1826)
Pl. 27, Figs 1–6

Gyroidina orbicularis D'ORBIGNY 1826, p.278; PARKER, JONES & BRADY 1865, pl.3, fig.85; LOEBLICH & TAPPAN 1987, pl.716, figs 8–13; UJIIE 1990, pl.26, figs 3–7; JONES 1994, pl.115, fig.6; HESS 1998, pl.15, figs 12–13.

Gyroidinus pulisukensis SAIDOVA 1975, pl.66, fig.9; pl.107, fig.8.

Gyroidina pulisukensis (Saidova). LOEBLICH & TAPPAN 1987, pl.716, figs 14–18.

DISTINGUISHING FEATURES: Test moderate to moderately large in size; planoconvex with a moderate to high rounded dome profile on the umbilical side, higher in larger specimens; flat to gently convex profile over the central region on the spiral side; periphery acutely rounded becoming angular with a narrow rounded keel in adults. 7½–9 chambers in final whorl; strongly oblique, straight to slightly curved sutures on the spiral side; sutures radial, slightly curved on umbilical side. Aperture an interiomarginal extraumbilical slit.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 170): Scattered widespread occurrences right around New Zealand between 33 and 56˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1826).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 170): Occurs with rather even distribution throughout the bathyal and abyssal (200–5000 m) with no zone of peak abundance.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene–Recent (Tt–Rec).

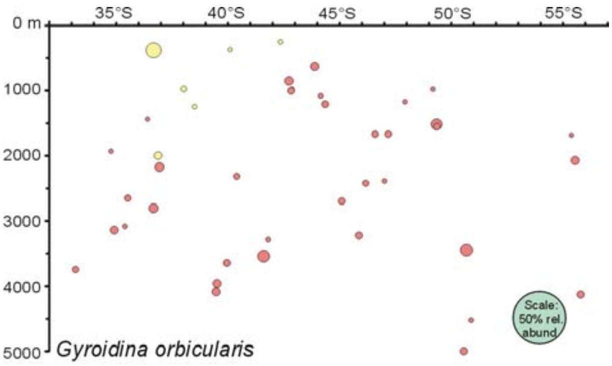


Figure 170. Latitude-depth distribution around NZ of *Gyroidina orbicularis* (red circles are from east of NZ, yellow circles are from west of NZ).

Gyroidina soldanii (d'Orbigny 1826)
Pl. 27, Figs 7–12

Gyroidina soldanii D'ORBIGNY 1826, p.278; D'ORBIGNY 1846, pl.8, figs 10–12.

Gyroidinoides soldanii (d'Orbigny). JONES 1994, pl.107, figs 7a–c; HAYWARD *et al.* 2001, figs 15HH–II; HAYWARD *et al.* 2003, figs 4FF–GG.

Gyroidina neosoldanii BROTZEN 1936, p.158; LOEBLICH & TAPPAN 1994, pl.361, figs 13–15; pl.362, figs 1–7.

Gyroidina cf. *neosoldanii* Brotzen. McCULLOCH 1977, pl.139, figs 5–8.

Gyroidinoides neosoldanii (Brotzen) BARKER 1960, pl.107, figs 6–7.

Gyroidina lamarckiana (d'Orbigny). HESS 1998, pl.15, figs 7–9; LUKINA 1980, figs 151a–c.

Hansenisca soldanii (d'Orbigny). LOEBLICH & TAPPAN 1987, pl.719, figs 5–9.

DISTINGUISHING FEATURES: Test of moderate size; planoconvex with a moderate to high rounded dome profile on the umbilical side, higher in larger specimens; and a flat to gently convex profile on the spiral side; periphery broadly rounded with an acutely rounded spiral side edge becoming more angular in larger specimens; narrow deep umbilicus. 8–10 chambers in final whorl; sutures radial, and slightly curved on the spiral side; sutures radial and flush on the involute side. Aperture an interiomarginal extraumbilical slit.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 171): Scattered widespread occurrences right around New Zealand between 33 and 56˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1826).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 171): Occurs from outer shelf to lower abyssal (100–5000 m). No obvious zones of greater abundance, except that it appears to be more common off the west coast of the North Island and almost absent at shelf and bathyal depths in the Subantarctic.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Lw–Rec).

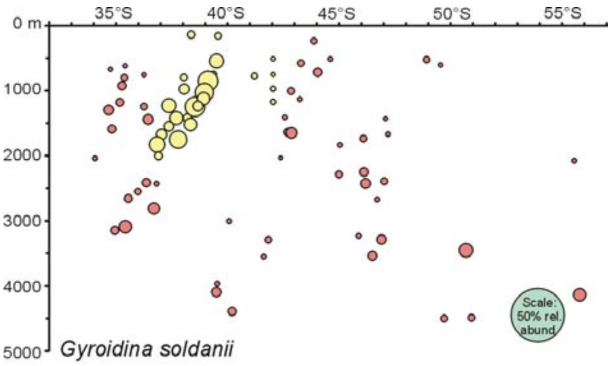


Figure 171. Latitude-depth distribution around NZ of *Gyroidina soldanii* (red circles are from east of NZ, yellow circles are from west of NZ).

GENUS – *Hanzawaia* Asano, 1944

Hanzawaia cf. ***wilcoxensis*** (Cushman & Pontin 1932)
Pl. 27, Figs 13–17

cf. *Valvulineria wilcoxensis* CUSHMAN & PONTIN 1932, p.70, pl.9, fig.6.

DISTINGUISHING FEATURES: Test trochospiral, moderately compressed with almost flat parallel sides; circular, slightly lobulate in outline; periphery acutely rounded. 7–8 chambers per whorl; sutures distinct, weakly depressed, radial to slightly curved. Fully evolute on spiral side; slightly evolute on gently concave umbilical side. Aperture a narrow slit, extending from periphery around to umbilicus with elongate flap on the end of each chamber extending over the umbilical end of the aperture. Test wall smooth, moderately perforate.

REMARKS: The North American Eocene species *Valvulineria wilcoxensis* is the closest described taxon that we have found to our modern specimens. The main difference seems to be the limbate early sutures described for the fossil species. Our specimens do not fit any described genus well. They lack the more prominent umbilical flap/plug and short arched aperture of type *Valvulineria*, and most *Hanzawaia* are more compressed and have an angled, often keeled periphery.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic rare occurrences right around New Zealand (35–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Unknown.

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Middle shelf to upper abyssal (40–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Heronalleniidae Loeblich & Tappan 1986

GENUS – *Heronallenia* Chapman & Parr 1931

KEY FEATURES OF NEW ZEALAND SPECIES:

Heronallenia gemmata: Compressed, almost flat; chambers on both sides strongly recurved back along periphery around colourless internal protuberance (rare, see Earland, 1934, pl.8, figs 28–29).

Heronallenia lingulata: Compressed, almost flat; periphery truncate; sutures costate, weakly curved on spiral side (rare, see Hayward *et al.* 1999, pl.13, figs 4–6).

Heronallenia nodulosa**:** Compressed, planoconvex; spiral side with one large protruding nodular tubercle per chamber (rare, see McCulloch 1977, pl.125, figs 15–16).

Heronallenia pulvinulinoides: Moderately compressed, planoconvex; sutures weakly depressed and recurved on spiral side (rare, see Hayward *et al.* 1999, pl.13, figs 7–9).

Heronallenia translucens: Moderately compressed, planoconvex; sutures flush on both sides.

Heronallenia unguiculata: Planoconvex; costae and tubercles on convex spiral side.

Heronallenia translucens Parr 1945
Pl. 27, Figs 18–20

Heronallenia translucens PARR 1945, p.211, pl.9, figs 15–16.

DISTINGUISHING FEATURES: Test small, oval in outline, planoconvex, with the spiral side moderately inflated and umbilical side almost flat; peripheral edge subacute with a weak rounded keel; sutures flush, recurved on spiral side. Radial grooves around aperture. Test wall finely perforate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic rare occurrences right around New Zealand (35–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: South–west Pacific (Parr 1945).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Abyssal only (2000–4500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

Heronallenia unguiculata (Sidebottom 1918)
Pl. 28, Figs 1–3

Discorbina lingulata Burrows and Holland var. *unguiculata* SIDEBOTTOM, 1918, p.255, pl.6, figs 12–14.

Heronallenia unguiculata (Sidebottom). LOEBLICH & TAPPAN 1994, pl.295, figs 8–10.

DISTINGUISHING FEATURES: Test moderately small, oval in outline; planoconvex with moderately convex spiral side; periphery with rounded keel. Crescentic chambers on spiral side; umbilical side flat or slightly concave with open umbilical aperture. Tubercles and sutural costae on spiral side. Radial grooves around aperture. Test wall finely perforate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences in low numbers around most of New Zealand.

WORLD GEOGRAPHIC DISTRIBUTION: Probably West Pacific (Sidebottom 1918, Loeblich and Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Inner shelf to bathyal (20–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Heterolepidae Gonzáles–Donoso 1969

GENUS – *Anomalinoides* Brotzen 1942

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Anomalinoides colligerus: Test moderately compressed; circular outline; acutely rounded periphery; bi–evolute, but more evolute on one side than other; more coarsely perforate on one side than other (rare, see Jones 1994, pl.94, figs 2–3).

Anomalinoides glabratus: Test moderately compressed; circular to weakly lobular outline; acutely rounded periphery; one side evolute, other involute.

Anomalinoides semicribratus: Test strongly inflated, nearly equally biconvex; broadly rounded periphery; slightly lobular outline; coarsely punctate on evolute side; smooth on involute side.

Anomalinoides sphericus: Test inflated; circular outline; broadly rounded periphery; one side evolute, other involute; sutures almost straight; deep narrow umbilicus.

Anomalinoides glabratus (Cushman 1924)
Pl. 28, Figs 4–6

Anomalina glabrata CUSHMAN 1924, p.39, pl.12, figs 5–7.

Anomalinoides tasmanica (Parr). HAYWARD *et al.* 2001, figs 15A–B.

DISTINGUISHING FEATURES: Test moderately compressed; circular outline weakly lobulate; acutely rounded periphery; one side evolute, other involute, umbilicate; 7–9 chambers in final whorl increasing gradually and evenly in size; sutures distinct, flush, slightly limbate, recurved on both sides; aperture a low, elongate slit extending nearly the full width of the oblique face of the last chamber, and with a slight lip; wall densely perforate, polished.

REMARKS: Our specimens differ from *A. tasmanica* by the fewer chambers.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 172): Occurs off both coasts of New Zealand between 33 and 47˚S.

WORLD GEOGRAPHIC DISTRIBUTION: South–west Pacific (Cushman 1924).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 172): Mostly occurs at outer shelf to upper abyssal depths (100–3000 m) with two rare deeper records that may be transported. Greatest relative abundances (1–3%) occur at mid and lower bathyal depths (600–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

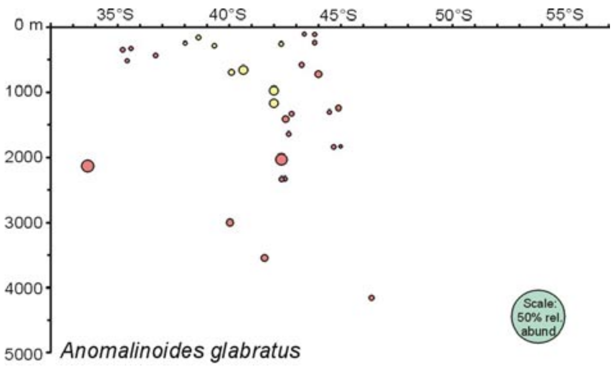


Figure 172. Latitude-depth distribution around NZ of *Anomalinoides glabratus* (red circles are from east of NZ, yellow circles are from west of NZ).

Anomalinoides semicribratus (Beckmann 1954)
Pl. 28, Figs 7–9

Anomalina pompilioides var. *semicribrata* BECKMANN 1954, p. 400, pl.27, fig.3.

Linaresia semicribrata (Beckmann). LOEBLICH & TAPPAN 1987, pl.722, figs 1–7; UJIIE 1990, pl.29, figs 5–6.

Linaresia bikiniensis (McCulloch). LOEBLICH & TAPPAN 1994, pl.368, figs 1–6.

Anomalinoides semicribrata (Beckmann). HAYWARD & BUZAS 1979, pl.5, figs 54–55; VAN MORKHOVEN *et al*. 1986, pl.48, figs 1–3.

Anomalinoides globulosus (Chapman & Parr). VAN MORKHOVEN *et al*. 1986, pl.9, figs 1–3.

DISTINGUISHING FEATURES: Test inflated; periphery broadly rounded, slightly lobular in outline. Umbilical side involute; spiral side partially evolute and centrally excavated. Sutures slightly depressed; gently curved on spiral side; radial and straight on the umbilical side. Aperture peripheral, extending somewhat to spiral side; distinct apertural lip. Surface coarsely perforate on spiral side; much less developed on umbilical side, which is sometimes smooth.

REMARKS: This species differs from *A. globulosus* which is coarsely perforate on all sides (see Jones, 1994, pl.94, figs 4–5), not just the spiral side as in *A. semicribratus*. Our specimens are similar to the Recent ones described by Ujiie (1990) as the spiral side is coarsely perforate and the umbilical side smooth. In the original description, Beckmann (1954) shows the opposite for the fossil types, with the umbilical side coarsely perforate and spiral side smooth to more sparsely perforate. Fossil specimens figured by Hayward & Buzas (1979) and Loeblich & Tappan (1987) match the original description. Maybe the Recent specimens could be considered a new species.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic records off the coasts of the North and northern South Island (33–45˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (e.g., Van Morkhoven *et al*., 1986; Ujiie, 1990; Loeblich & Tappan, 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Lower bathyal–mid abyssal (1000–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Po–Rec).

Anomalinoides sphericus (Finlay 1940)
Pl. 28, Figs 10–12

Anomalina spherica FINLAY 1940, p.460, pl.6, figs 166–171.

Anomalinoides sphericus (Finlay). HAYWARD *et al.* 1999, pl.15, figs 27–29; HAYWARD *et al.* 2001, figs 15C–E.

DISTINGUISHING FEATURES: Test inflated, compact, low trochospiral; circular outline not lobulate; broadly rounded periphery; one side evolute, other involute; 7–8 chambers in the last whorl; sutures almost straight; deep narrow umbilicus; aperture a low interiomarginal arch extending from umbilicus to spiral side; surface finely and densely punctuate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 173): Scattered occurrences off both coasts between 34 and 47˚S, with one occurrence to the south at 51˚S.

WORLD GEOGRAPHIC DISTRIBUTION: No other known records, possibly endemic to New Zealand.

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 173): Mostly occurs at deep inner shelf to upper bathyal depths (30–600 m), with a few rare deeper occurrences. Greatest relative abundances (5–10%) are at deep inner and mid shelf depths off north–east North Island (34–36˚S).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Miocene–Recent (Sw–Rec).

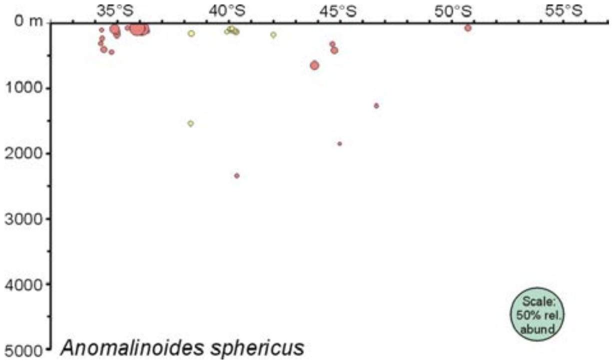


Figure 173. Latitude-depth distribution around NZ of *Anomalinoides sphericus* (red circles are from east of NZ, yellow circles are from west of NZ).

FAMILY – Nonionidae Schultze 1854

GENUS – *Astrononion* Cushman & Edwards 1937

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Astrononion novozealandicum: Umbilical depression; thin elongate sutural plates.

Astrononion stelligerum: Almost no umbilical depression; thick, rhomboidal sutural plates (see Jones 1994, pl.109, figs 3–4).

Astrononion novozealandicum Cushman & Edwards 1937

Pl. 28, Figs 13–16

Astrononion novozealandicum CUSHMAN & EDWARDS 1937, p.35, pl.3, figs 18a–b; HEDLEY *et al.* 1965, pl.7, fig.28; HAYWARD *et al.* 1999, pl.15, figs 8–9; KAWAGATA 1999, fig.9.4; HAYWARD *et al.* 2001, figs 15F–G.

Pacinonion novozealandicum (Cushman & Edwards). UJIIE 1995, pl.12, fig. 1.

DISTINGUISHING FEATURES: Test small to medium size; planispiral, involute; circular in outline; in profile parallel–sided with broadly rounded periphery. 10 chambers in final whorl; chambers slightly inflated. Sutures slightly depressed with thin elongate sutural plate extending from the umbilicus to half way to rounded periphery; with a small pit at the termination of each sutural plate. Aperture an interiomarginal slit.

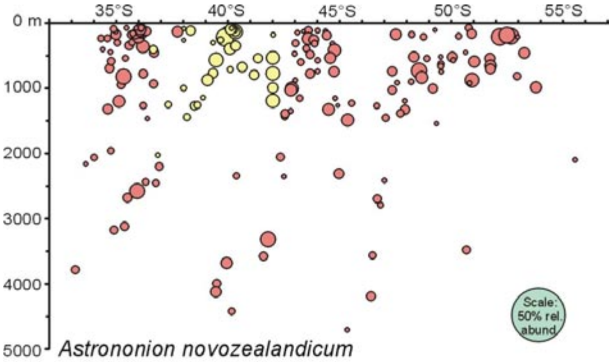


Figure 174. Latitude-depth distribution around NZ of *Astrononion novozealandicum* (red circles are from east of NZ, yellow circles are from west of NZ).

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 174): Widespread right around New Zealand from 33 to 56˚S.

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Collins 1974, Saidova 1975).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 174): Occurs at all depths from sheltered inner shelf to lower abyssal (5–5000 m), with fewer occurrences at lower bathyal and abyssal depths south of 47˚S. No zone of maximum abundance is obvious.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Pliocene–Recent (Wo–Rec).

GENUS – *Melonis* de Montfort 1808

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Melonis affinis Test moderately compressed; 9–12 chambers in final whorl.

Melonis pompilioides Test stout, globular; 7–8 chambers in final whorl; coarsely perforate.

Melonis affinis (Reuss 1851)

Pl. 28, Figs 17–18

Nonionina affinis REUSS 1851, pl.5, figs 32a,b.

Nonionina barleeana WILLIAMSON 1858, pl.3, figs 68–69.

Gavelinonion barleeanum (Williamson). BARKER 1960, pl.109, figs 8–9.

Melonis barleeanum (Williamson). HERMELIN 1989, pl.17, fig.12; LOEBLICH & TAPPAN 1987, pl.696, figs 5–6.

Melonis barleeanus (Williamson). LOEBLICH & TAPPAN 1994, pl.347, figs 1–5.

Melonis affinis (Reuss). HAYWARD & BUZAS 1979, pl.20, fig.256; JONES 1994, pl.109, figs 8–9; YASSINI & JONES 1995, figs 946–947; HAYWARD *et al.* 2001, figs 16G–H.

DISTINGUISHING FEATURES: Test planispiral, involute; moderately compressed and biumbilicate with umbilici open and incised. 9–12 gradually enlarging chambers in final whorl; sutures flush to slightly depressed, slightly curved to almost sigmoidal. Aperture a low interiomarginal and equatorial slit extending to the umbilici and slightly overlapped by a short apertural lip. Test wall hyaline to almost opaque, coarsely perforate.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 175): Common right around New Zealand from 33 to 54˚S, although becoming rare south of 50˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 175): Occurs throughout the wide depth range of outer shelf to lower abyssal (90–5000 m) with no apparent zone of maximum abundance.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Latest Oligocene–Recent (Lw–Rec).

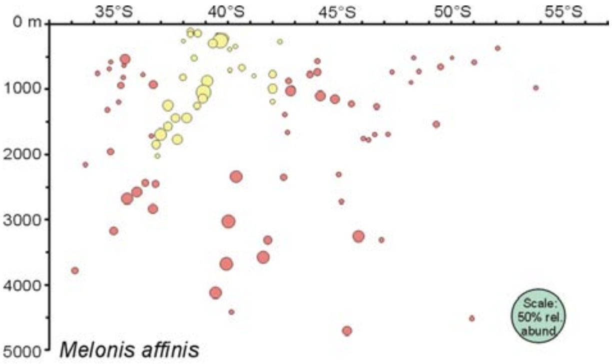


Figure 175. Latitude-depth distribution around NZ of *Melonis affinis* (red circles are from east of NZ, yellow circles are from west of NZ).

Melonis pompilioides (Fichtel & Moll 1798)
Pl. 28, Figs 19–20

Nautilus pompilioides FICHTEL & MOLL 1798, p.31, pl.2, figs A–C.

Nonionina pompilioides (Fichtel & Moll). BARKER 1960, pl.109, figs 10–11.

Melonis pompilioides (Fichtel & Moll). RESIG 1981, pl.7, fig.12; LOEBLICH & TAPPAN 1987, pl.696, figs 7–8; HERMELIN 1989, pl.17, figs 13–14; LOEBLICH & TAPPAN 1994, pl.347, figs 8–10; JONES 1994, pl.109, figs 10–11; UJIIE 1995, pl.12, fig. 2.

DISTINGUISHING FEATURES: Test stout, biumbilicate, globular and symetrical. 7–8 chambers in final whorl; sutures slightly depressed to flush, radial to slightly curved backwards. Chamber size increases gradually and terminates with a somewhat flattened, non–perforate apertural face. Aperture lipped, interiomarginal and equatorial, reaches the open and incised umbilici. Test wall coarsely perforate, except for the apertural face.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 176): Only recorded from off the east coast of the main islands of New Zealand, from 33 to 47˚S.

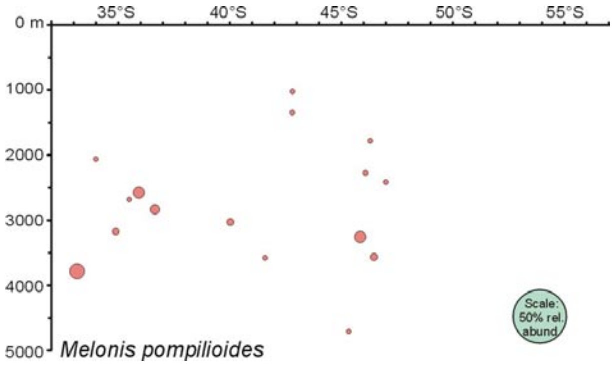


Figure 176. Latitude-depth distribution around NZ of *Melonis pompilioides* (red circles are from east of NZ).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 176): Restricted to lower bathyal and abyssal depths (1000–5000 m), with its greatest relative abundance (1–5%) at upper to mid abyssal depths (2500–4000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Latest Oligocene–Recent (Lw–Rec).

GENUS – *Nonion* Montfort 1808

Nonion pacificum (Cushman 1924)
Pl. 28, Figs 21–22, Pl. 29, Figs 1–2

Nonionina umbilicatula (Montagu) var. *pacifica* CUSHMAN 1924, p.48, pl.16, fig.3.

Nonion pacificum (Cushman 1924). ASANO 1950, text-figs 13–14; LOEBLICH & TAPPAN 1994, pl.342, figs 8–12.

DISTINGUISHING FEATURES : Test planispiral, involute; compressed, almost parallel-sided; with a narrowly rounded periphery, outline slightly lobulate. 5–8 chambers in the last whorl; sutures smooth to slightly depressed, straight to weakly curved. Aperture an elongate slit extending from umbilicus to umbilicus and wrapped around the periphery at the base of the apertural face. No apertural lip but upper margin often has a slightly ragged appearance.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Uncommon occurrences right around New Zealand (33–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Pacific (Cushman, 1924; Asano, 1950).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Bathyal–upper abyssal (200–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Nonionella* Cushman 1926

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Nonionella auris: Trochospiral; lacks a lobe on final chamber.

Nonionella magnalingua: Auriculate adult outline; last chamber with a large inflated lobe extending over umbilicus.

Nonionella auris (d'Orbigny 1839)
Pl. 29, Figs 3–5
Valvulina auris D'ORBIGNY 1839b, p.47, pl.2, figs 15–17.
Nonionoides auris (d'Orbigny). LOEBLICH & TAPPAN 1994, pl.345, figs 5–16.
Nonionella auris (d'Orbigny). YASSINI & JONES 1995, figs 1055–1056; HAYWARD *et al*. 2001, figs 16I–K.
Nonionella iridea Heron-Allen & Earland. LOBEGEIER & SEN GUPTA 2008, pl.2, fig.9a–b

DISTINGUISHING FEATURES: Test slightly compressed in a low trochospiral coil, with a broadly rounded periphery. 5–9 chambers rapidly increasing in size in the last whorl producing a flaring adult test. Spiral side evolute; umbilical side involute. Large spherical proloculus protrudes on spiral side in young specimens (Pl. 29, Fig. 3). Aperture an interiomarginal small opening at the base of the apertural face.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 177): Common occurrences from right around New Zealand (33–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1839b).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 177): Upper bathyal to lower abyssal (200–5000 m), with a single specimen recorded from on the shelf. A zone of maximuim relative abundance (4–13%) spans the upper bathyal to upper abyssal (400–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Po–Rec).

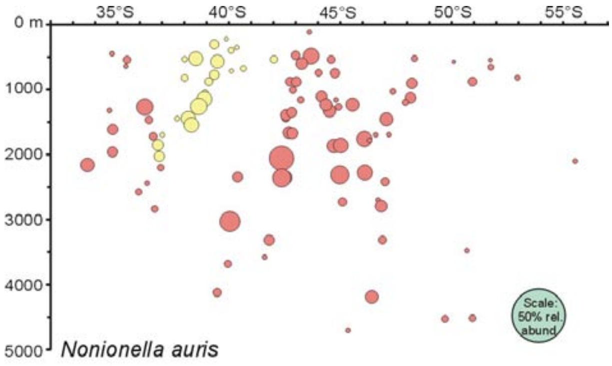


Figure 177. Latitude-depth distribution around NZ of *Nonionella auris* (red circles are from east of NZ, yellow circles are from west of NZ).

Nonionella magnalingua Finlay 1940
Pl. 29, Figs 6–8
Nonionella magnalingua FINLAY 1940, p.456, pl.65, figs 144,146; HAYWARD *at al.* 1999, pl.15, figs 12–13.

DISTINGUISHING FEATURES: Test compressed, trochospiral. Chambers enlarging rapidly forming auriculate outline. Spiral side partially evolute; umbilical side involute. Last chamber with a large inflated lobe extending completely over the umbilicus. Aperture a small interiomarginal arch. Surface smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 178): Scattered occurrences right around both islands (35–52˚S), more frequent north of 45˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Apparently endemic to New Zealand.

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 178): Low numbers at deep inner shelf to mid bathyal depths (30–1000 m), with single specimen records from deeper that may be displaced.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Oligocene–Recent (Ld–Rec).

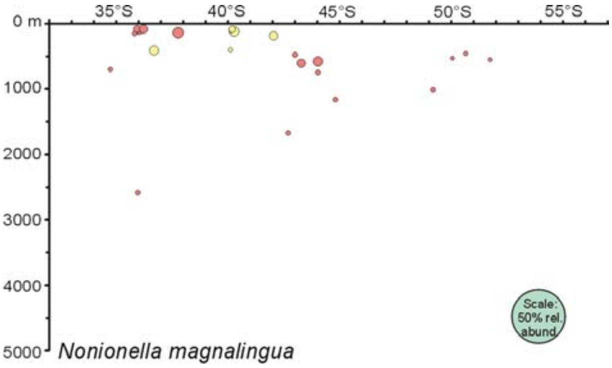


Figure 178. Latitude-depth distribution around NZ of *Nonionella magnalingua* (red circles are from east of NZ, yellow circles are from west of NZ).

GENUS – *Nonionellina* Voloshinova 1958

Nonionellina flemingi (Vella 1957)
Pl. 29, Figs 9–10
Nonion flemingi VELLA 1957, p.37, pl.9, figs 183–184.
Nonionellina flemingi (Vella). LEWIS & JENKINS 1969, pl.1, figs 1–9; HAYWARD *at al.* 1999, pl.15, figs 14–15; HAYWARD *et al.* 2003, figs 4JJ–KK.

DISTINGUISHING FEATURES: Test initially trochospiral, becoming planispiral and involute in adult. Periphery acutely rounded. Chambers enlarging rapidly as added, with a narrow, furcate lobe extension to the last chamber, extending down over the umbilicus on each side. Sutures between adult chambers often with large pores. Surface smooth.

REMARKS: The generic placement of this species has caused considerable confusion. Of all the described genera in the Nonionidae, it is closest to *Nonionellina*. The lobe extensions on the chambers and the presence of large sutural pores might justify establishment of a new monotypic New Zealand genus.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 179): Common off both coasts of the North Island and northern South Island (33–45˚S), but infrequent as far south as Auckland Islands (51˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Appears to be endemic to New Zealand.

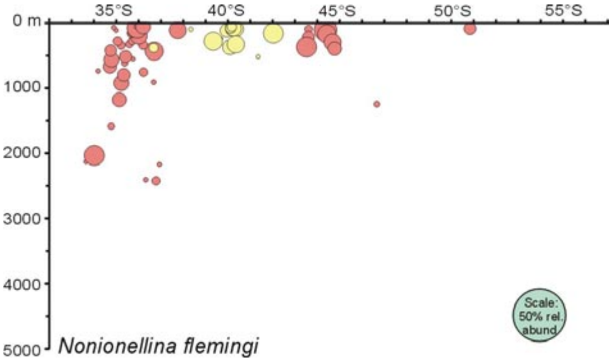


Figure 179. Latitude-depth distribution around NZ of *Nonionellina flemingi* (red circles are from east of NZ, yellow circles are from west of NZ).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 179): Widespread and common (5–12%) at mid shelf to upper bathyal depths (50–500 m) and also abundant (up to 40%) in the quiet, deeper (20–50 m), muddy parts of inlets or sounds. North–east of the North Island this species extends deeper down to upper abyssal depths (2500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Middle Miocene–Recent (Sw–Rec).

GENUS – *Nonionoides* Saidova 1975

KEY FEATURES OF COMMON NEW ZEALAND SPECIES:

Nonionoides grateloupii: Test strongly compressed; last chamber only slightly more inflated than test.

Nonionoides turgida: Test slightly compressed; last chamber inflated and extending near full length of test (see Hayward *et al.* 1999, pl.15, figs 16–17).

Nonionoides grateloupii (d'Orbigny 1826)
Pl. 29, Figs 11–14
Nonionina grateloupii D'ORBIGNY 1826, p.294.
Nonionoides grateloupii (d'Orbigny). SAIDOVA 1975, pl.67, fig.5; LOEBLICH & TAPPAN 1987, pl.692, figs 7–14; LOEBLICH & TAPPAN 1994, pl.342, figs 1–5.

DISTINGUISHING FEATURES: Test slightly asymmetrical, with evolute spiral side and nearly involute and deeply umbilicate opposite side; chambers of nearly constant height but increasing rapidly in breadth to result in an auriculate test outline; sides flattened; periphery rounded. Sutures slightly depressed, gently curved. Aperture a low interiomarginal and equatorial arch. Surface smooth, but with fine pustules bordering the umbilical rim of the chambers,

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Scattered occurrences around the main islands of New Zealand (35–46˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (d'Orbigny 1826, Loeblich & Tappan 1987).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf to bathyal (100–2000 m) with one specimen from much deeper being possibly displaced. Main occurrences are at lower bathyal depths (1000–2000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene–Recent (Tt–Rec).

GENUS – *Pullenia* Parker & Jones 1862

KEY FEATURES OF NEW ZEALAND SPECIES:

Pullenia bulloides: Test globular, broadly rounded periphery; 4–5 chambers in final whorl; apertural face short.

Pullenia quinqueloba: Test moderately compressed, circular to slightly lobulate outline; 5–6 chambers in final whorl; umbilici closed.

Pullenia salisburyi: Test moderately compressed, moderately lobulate outline; 5–8 chambers in final whorl; umbilici slightly open.

Pullenia bulloides (d'Orbigny 1846)
Pl. 29, Figs 15–17
Nonionina bulloides D'ORBIGNY 1846, p.107, pl.5, figs 9–10.
Pullenia sphaeroides SAIDOVA 1975, pl.70, fig.7.
Pullenia bikiniensis McCulloch. LOEBLICH & TAPPAN 1994 p.159, pl.348, figs 9–14.
Pullenia bulloides (d'Orbigny 1846). BARKER 1960, pl.84, figs 12–13; LUKINA 1980, fig.169a–c; THOMAS *et al.* 1990, pl.10, fig.15; JONES 1994, pl.84, figs 12–13; YASSINI & JONES 1995, figs 966–967; KAWAGATA 1999, fig.9.5; HAYWARD *et al.* 2001, figs 16T–U; HAYWARD *et al.* 2003, figs 4RR–SS.

DISTINGUISHING FEATURES: Test globular, symmetrically planispiral, involute; circular in outline; periphery broadly rounded. 4–5 chambers in the final whorl with flush to slightly depressed, radial sutures. Aperture a narrow interiomarginal slit, extending across the periphery to the umbilici. Surface smooth, shiny; commonly opaque or slightly translucent.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 180): Widespread right around New Zealand (33–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

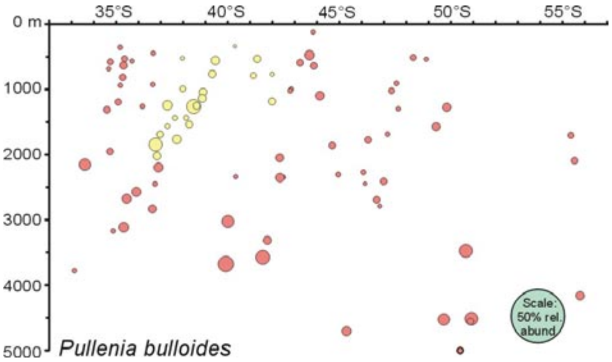


Figure 180. Latitude-depth distribution around NZ of *Pullenia bulloides* (red circles are from east of NZ, yellow circles are from west of NZ).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 180): Widespread in relatively low abundances throughout the bathyal and abyssal (300–5000 m) with only one record from the shelf. Slightly more abundant (3–5%) at mid–lower abyssal depths (3000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Paleocene–Recent (Dt–Rec).

Pullenia quinqueloba (Reuss 1851)
Pl. 29, Figs 18–20

Nonionina quinqueloba REUSS 1851, p.71, pl.5, figs 31a–b.

Pullenia subcarinata (d'Orbigny). BARKER 1960, pl.84, figs14–15; LUKINA 1980, figs 170–172.

Pullenia borealis SAIDOVA 1975, pl.69, fig.9; LOEBLICH & TAPPAN 1994, pl.348, figs 1–6.

Pullenia quinqueloba (Reuss). HAYWARD & BUZAS 1979, p.72; THOMAS *et al.* 1990, pl.10, fig.19; UJIIE 1990, pl.24, figs 1–5; JONES 1994, pl.84, figs 14–15; YASSINI & JONES 1995, figs 941–943, 1002–1003; HAYWARD *et al*. 2001, figs 16V–W; LOBEGEIER & SEN GUPTA 2008, pl.3, figs 4a–b.

DISTINGUISHING FEATURES: Test moderately compressed, symmetrically planispiral, involute; slightly lobulate circular outline; periphery acutely rounded in profile. 5–6 chambers in the final whorl; sutures depressed, weakly curved. Aperture an interiomarginal crecentic slit extending to closed umbilici.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 181): Widespread around all, except the southernmost part of the New Zealand region (33–54˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 181): Occurs from mid shelf to lower abyssal (50–5000 m), becoming restricted to mid bathyal depths south of 50˚S. Slightly higher relative abundances (3–4%) at mid and lower abyssal depths (3000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Paleocene–Recent (Dt–Rec).

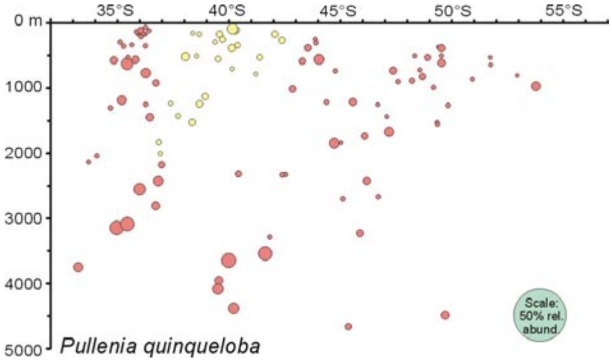


Figure 181. Latitude-depth distribution around NZ of *Pullenia quinqueloba* (red circles are from east of NZ, yellow circles are from west of NZ).

Pullenia salisburyi Stewart & Stewart 1930.
Pl. 29, Figs 21–24

Pullenia salisburyi STEWART & STEWART 1930, p.72, pl.8, figs 2a–b; BOLTOVSKOY 1978, pl.6, fig.19; NOMURA 1995, pl.2, figs 28a–b; YASSINI & JONES 1995, figs 938–939; HAYWARD *et al*. 2001, figs 16X–Y.

DISTINGUISHING FEATURES: Test moderately large, symmetrically planispiral, involute; periphery acutely rounded in profile; lobulate outline. 6–8 chambers in final whorl, slightly inflated; sutures depressed; umbilici slightly open. Aperture an interiomarginal and equatorial slit extending to umbilici.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 182): Widespread around all, except the southernmost part of the New Zealand region (33–52˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Boltovskoy 1978).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 182): Occurs in low numbers from outer shelf to lower abyssal depths (150–5000 m), with slightly higher relative abundances (2–3%) at mid bathyal to upper bayssal depths (500–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Pliocene–Recent (Wo–Rec).

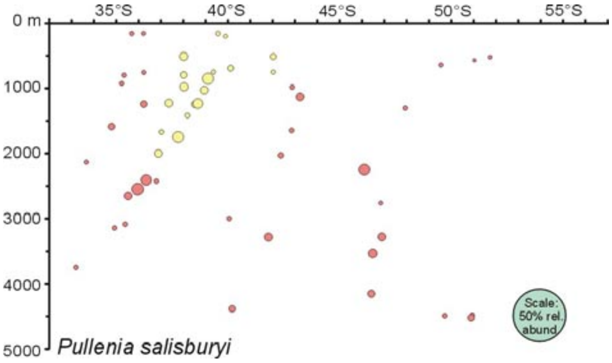


Figure 182. Latitude-depth distribution around NZ of *Pullenia salisburyi* (red circles are from east of NZ, yellow circles are from west of NZ).

GENUS – *Pulleniella* Ujiie 1990

Pulleniella asymmetrica Ujiie 1990
Pl. 30, Figs 1–2

Pulleniella asymmetrica UJIIE 1990, p.45, pl.23, figs 3–4; KAWAGATA 1999, fig.9.7a–b.

DISTINGUISHING FEATURES: Test small, spheroidal but slightly compressed around umbilical areas; faintly strepto–planispiral and nearly involute; periphery broadly rounded, somewhat lobulate in outline. Almost 4 chambers per whorl; sutures gently curved, slightly depressed. Aperture asymmetrical, low arch extending from umbilicus on one side to halfway to umbilicus on opposite side.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 183): Only recorded from east of the North Island (33–40˚S).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Ujiie 1990).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 183): Five sporadic records from abyssal depths (2000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

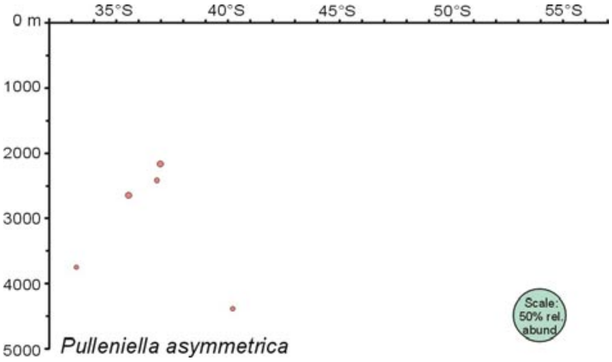


Figure 183. Latitude-depth distribution around NZ of *Pulleniella asymmetrica* (red circles are from east of NZ).

FAMILY – Oridorsalidae Loeblich & Tappan 1984

GENUS – *Oridorsalis* Andersen 1961

Oridorsalis umbonatus (Reuss 1851)
Pl. 30, Figs 3–6
Rotalia umbonatus REUSS 1851, p.75, pl.5, fig.35.
Truncatulina tenera BRADY 1884, pl.95, fig.11.
Oridorsalis umbonatus (Reuss). UJIIE 1990, pl.28, figs 1–6; HAYWARD *at al.* 1999, pl.15, figs 24–26; KAWAGATA 1999, fig.10.4; HAYWARD *et al.* 2001, figs 16R–S; HAYWARD *et al.* 2003, figs 4LL–NN; LOBEGEIER *et al.* 2008, pl.2, figs 14a–b.

DISTINGUISHING FEATURES: Test moderate size, trochospiral; periphery lobulate. 4–5 chambers in the final whorl; sutures distinct and slightly depressed. Primary aperture interiomarginal, with secondary apertures at junctions of spiral and intercameral sutures on spiral side, and at bend in sutures on umbilical side. Wall smooth and translucent, finely perforate.

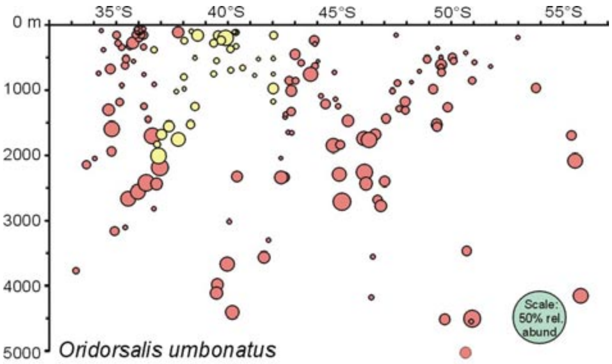


Figure 184. Latitude-depth distribution around NZ of *Oridorsalis umbonatus* (red circles are from east of NZ, yellow circles are from west of NZ).

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 184): Widespread right around the New Zealand region (33–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Murray 1991).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 184): Widespread and common at outer shelf to lower abyssal depths (100–5000 m), uncommon at mid shelf depths and rarely washed in to inner shelf depths (shallower than 50 m). Most abundant (3–7%) at mid bathyal to lower abyssal depths (600–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Eocene–Recent (Ab–Rec).

FAMILY – Osangulariidae Loeblich & Tappan 1964

GENUS – *Osangularia* Brotzen 1940

Osangularia bengalensis (Schwager 1866)
Pl. 30, Figs 7–9
Anomalina bengalensis SCHWAGER 1866, p.259, pl.7, fig.111.
Osangularia bengalensis (Schwager). LOEBLICH & TAPPAN 1987, pl.708, figs 4–5; UJIIE 1990, pl.29, figs 1–2; JONES 1994, pl.96, fig.3; UJIIE 1995, pl.13, figs 1a–c; KAWAGATA 1999, fig.10.2; HAYWARD *et al.* 2003, figs 4OO–QQ.

DISTINGUISHING FEATURES: Trochospiral; almost planoconvex in profile with a carinate periphery, often with short serrations. 9–11 chambers in final whorl; sutures thickened, oblique, and curved on spiral side; sutures depressed and curved on involute side. Aperture lunate areal, at an acute angle to the base of the chamber face.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 185): Occurs throughout the New Zealand region (34–46˚S) though more frequent off the coasts of the North Island (north of 40˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Loeblich & Tappan 1987).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 185): Upper bathyal to mid abyssal (400–4000 m),

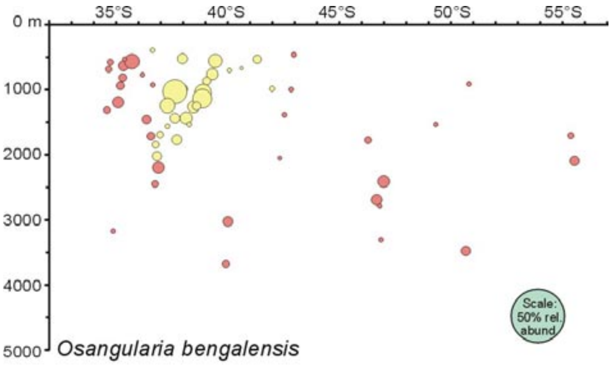


Figure 185. Latitude-depth distribution around NZ of *Osangularia bengalensis* (red circles are from east of NZ, yellow circles are from west of NZ).

with a zone of greater relative abundance (4–13%) at mid to lower bathyal depths (500–1300 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Mid Miocene–Recent (Sw–Rec).

FAMILY – Placentulinidae Kasimova, Poroshina & Geodakchan 1980

GENUS – *Cancris* de Montfort 1808

Cancris oblongus (Williamson 1858)
Pl. 30, Figs 10–15
Rotalina oblonga WILLIAMSON 1858, pl.4, figs 98–100.
Cancris oblongus (Williamson). JONES 1994, pl.106, fig.5.

DISTINGUISHING FEATURES : Test large, elongate ovate in outline; periphery slightly lobulate, somewhat angular becoming carinate around the last chamber. Low trochospiral, consisting of less than 2 complete whorls; chambers increasing rapidly in size, the last chamber occupies two thirds of the final whorl; sutures gently depressed, curved on the spiral side, nearly radial on the involute side and excavated around the open umbilicus; part of the umbilicus covered by small flat projection from the umbilical border of the last chamber.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Off both coasts of the North and northern South Islands (34–42˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to upper bathyal (50–500 m), mostly shallower than 200 m.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene–Recent (Tk–Rec).

GENUS – *Valvulineria* Cushman 1926

Valvulineria minuta (Schubert 1904)
Pl. 30, Figs 16–18
Discorbina rugosa (d'Orbigny). BRADY 1884, pl.91, fig. 4.
Discorbina rugosa (d'Orbigny) var. *minuta* SCHUBERT 1904, p. 420.
Rotamorphina minuta (Schubert). UJIIE 1990, pl.15, figs 2–3.
Valvulineria minuta (Schubert). JONES 1994, pl.91, fig.4; KAWAGATA 1999, pl.6, figs 1–2.

DISTINGUISHING FEATURES: Test small, moderately compressed, periphery broadly rounded; outline circular, slightly lobulate. Two whorls visible on spiral side, umbilical side involute. Umbilical region deeply depressed often filled with sediment; narrow raised lobes extend from the umbilical end of later chambers into the umbilicus. 7–8 chambers in final whorl; chambers slightly inflated, gradually increasing in size as added; sutures slightly depressed, curved. Aperture an arched slit at the base of the chambers extending from the periphery to the umbilical region.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Numerous occurrences in low numbers along the east coast of New Zealand (35–54˚S) but not recorded so far from off the west coast.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid shelf to bathyal (50–2000 m), with a single specimen recorded from deeper and possibly displaced.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Planulinidae Bermůdez 1952

GENUS – *Planulina* d'Orbigny 1826

Planulina ariminensis d'Orbigny 1826
Pl. 30, Figs 19–22
Planulina ariminensis D'ORBIGNY 1826, p.280, pl.14, figs 1–3; LOEBLICH & TAPPAN 1987, pl.633, figs 1–4; JONES 1994, pl.93, figs 10–11.

DISTINGUISHING FEATURES: Test discoidal, flat sides; periphery truncate, with thick imperforate marginal keel. Low trochospiral coil of about 2 whorls; spiral side evolute, umbilical side partially evolute. 9–10 broad, low chambers in the final whorl; sutures imperforate, thickened and elevated, strongly curved backwards.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Only recorded from around New Zealand in the Subantarctic region between 52 and 56˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Rare specimens from lower bathyal–upper abyssal depths (1000–3000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Pseudoparrellidae Voloshinova 1952

GENUS – *Eilohedra* Lipps 1965

Eilohedra vitrea (Parker 1953)
Pl. 31, Figs 1–5
Epistominella vitrea Parker in PARKER *et al.* 1953, p.9, pl.4, figs 34–36,40–41.
Eilohedra vitrea (Parker). HAYWARD *et al.* 1999, pl.13, figs 14–16.
Epistominella levicula RESIG 1958, p.304, text-fig.16.
Eilohedra levicula (Resig). LIPPS 1965, pl.3, fig.5, text-fig. 3; RESIG 1981, pl.3, figs 9,12; LOEBLICH & TAPPAN 1987, pl.626, figs 9–11; LOEBLICH & TAPPAN 1994, pl.303, figs 1–13; UJIIE 1995, pl.10, fig.2; HAYWARD *et al.* 2003, figs 4X–Z.

DISTINGUISHING FEATURES: Test small; unequally biconvex with rounded periphery, spiral side always more strongly convex than involute side; circular to slightly lobulate outline. 5–6 slightly inflated chambers in the last whorl; sutures on the spiral side oblique, straight to gently curved; sutures on involute side radial, slightly depressed; umbilicus closed. Aperture slit–like, extending up the apertural face parallel to the periphery.

REMARKS: After close examination of large populations from the shelf and bathyal depths together with the type descriptions and illustrations of *E. vitrea* and *E. levicula* we conclude that the two species cannot be distinguished and slight supposed differences in the lobular nature of the peripheral outline or obliqueness of the sutures on the spiral side are within the intrapopulation variability.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 186): Numerous records throughout the New Zealand region (35–51˚S), though more common off the west coast (37–42˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Parker 1953).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 186): Inner shelf to uppermost abyssal (20–2500 m), most common (10–30%) at mid shelf to lower bathyal depths (70–1300 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Pleistocene–Recent (Wc–Rec).

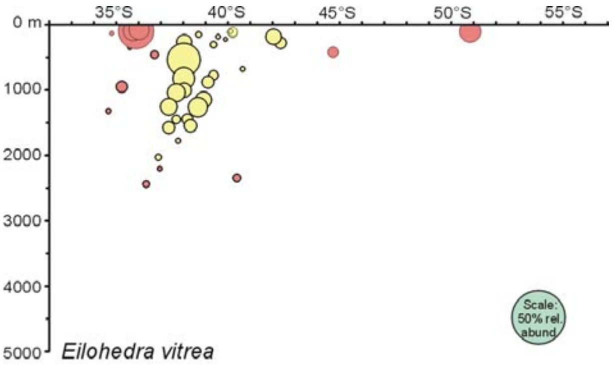


Figure 186. Latitude-depth distribution around NZ of *Eilohedra vitrea* (red circles are from east of NZ, yellow circles are from west of NZ).

GENUS – *Epistominella* Husezima & Maruhasi 1944

Epistominella exigua (Brady 1884)
Pl. 31, Figs 6–10
Pulvinulina exigua BRADY 1884, p.696, pl.103, figs 13–14; Cushman 1915, pl.23, fig.5; Cushman 1921, pl.68, fig.3.
Pulvinulinella exigua (Brady). HOFKER 1951, text-figs 219–221.
Pseudoparrella exigua (Brady). LIPPS 1965, pl.1, fig.9; AKIMOTO 1990, pl.20, fig.7, pl.24, fig.3; LOEBLICH & TAPPAN 1994, pl.307, figs 1–7; KAWAGATA 1999, figs 6–8.
Epistominella exigua (Brady). TODD 1965, pl.10, fig.1; ECHOLS 1971, pl.15, fig.4; CORLISS 1979, pl.2, figs 7–9; BURKE 1981, pl.2, figs 1–2; RESIG 1981, pl.6, figs 6–7; KURIHARA & KENNETT 1986, pl.3, figs 10–12; INOUE 1989, pl.18, fig.12, pl.26, fig.2; UJIIE 1990, pl.14, fig.1; VAN MARLE 1991, pl.15, figs 4–6; HAYWARD *et al*. 2001, figs 15Y–AA; HAYWARD *et al.* 2003, figs 4CC–EE; HAYWARD *et al.* 2007b, pl.1, figs 16–18.
Alabaminoides exiguus (Brady). JONES 1994, pl.103, figs 13–14.

DISTINGUISHING FEATURES: Test small to moderate size; low trochospiral; biconvex; periphery acutely rounded; circular, slightly lobulate outline. About three whorls, usually with 5 chambers in each; sutures oblique, straight on spiral side, radial and slightly curved on umbilical side. Aperture an elongate vertical slit in face, near and parallel to the peripheral margin. Wall glassy, translucent.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 187): Widespread and abundant right around New Zealand (33–56˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 187): Outer shelf to lower abyssal (100–5000 m) with one specimen record shallower than 100 m. It has a zone of highest relative abundance (10–45%) at lower bathyal and abyssal depths (1000–5000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Early Miocene–Recent (Po–Rec).

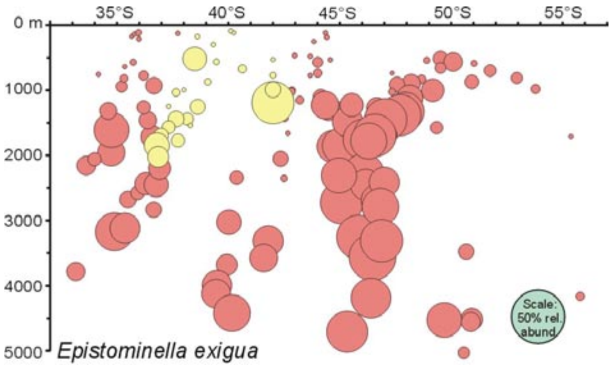


Figure 187. Latitude-depth distribution around NZ of *Epistominella exigua* (red circles are from east of NZ, yellow circles are from west of NZ).

FAMILY – Quadrimorphinidae Saidova 1981

GENUS – *Quadrimorphina* Finlay 1939

Quadrimorphina laevigata (Phleger & Parker 1951)
Pl. 31, Figs 11–13
Valvulineria laevigata PHLEGER & PARKER 1951, p.25, pl.13, figs 11–12.
Quadrimorphina laevigata (Phleger & Parker). UJIIE 1990, pl.15, fig.1; KAWAGATA 1999, fig.10.1
Quadrimorphina pescicula SAIDOVA 1975, p.246,

pl.67, fig.9, pl.108, fig.3; LOEBLICH & TAPPAN 1994, pl.353, figs 1–9.

Quadrimorphina allomorphinoides (Reuss). HERMELIN 1989, pl.14, fig.6.

DISTINGUISHING FEATURES: Test ovate in outline; biconvex; periphery acutely rounded. 3–6 slightly elongated chambers in final whorl; sutures curved on spiral side, nearly radial on umbilical side, slightly depressed. Aperture interiomarginal and umbilical, low opening covered by a large rounded to triangular lip. Wall smooth.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 188): Occurs off both coasts of the North Island (34–38˚S) with one record off the east coast of the South Island.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Phleger & Parker 1951).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 188): Low numbers at bathyal and uppermost abyssal depths (400–2500 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Pliocene–Recent (Wm–Rec).

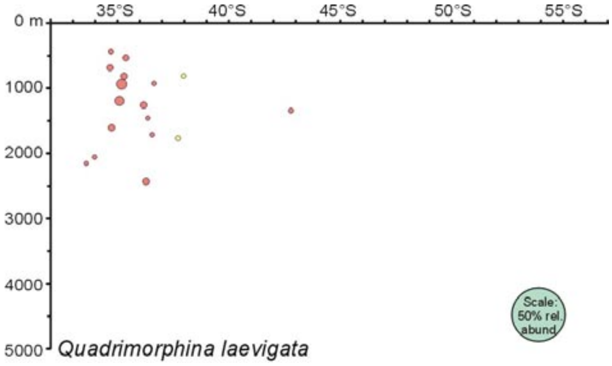


Figure 188. Latitude-depth distribution around NZ of *Quadrimorphina laevigata* (red circles are from east of NZ, yellow circles are from west of NZ).

FAMILY – Rosalinidae Reiss 1963

GENUS – *Gavelinopsis* Hofker 1951

Gavelinopsis praegeri (Heron-Allen & Earland 1913)
Pl. 31, Figs 14–21

Discorbina praegeri HERON-ALLEN & EARLAND 1913b, p.122, pl.10, figs 8–10.

Gavelinopsis praegeri (Heron-Allen & Earland). UJIIE 1990, pl.14, fig.6; HAYWARD *at al.* 1999, pl.10, figs 15–17; KAWAGATA 1999, fig.6.5; HAYWARD *et al.* 2001, figs 15BB–DD; HAYWARD *et al.* 2007b, pl.1, figs 21–22.

Discorbis lobatulus PARR 1950, p.354, pl.13, figs 23–25.

Gavelinopsis lobatula (Parr). JONES 1994, pl.88, fig.1.

Eponides punctulatus (d'Orbigny). YASSINI & JONES 1995, figs 783–785.

DISTINGUISHING FEATURES: Test of small to moderate size; biconvex to slightly planoconvex, both sides low domed or flattened medially; periphery usually lobulate, carinate or sharply rounded. 5–6 chambers per whorl; chambers inflated with sutures depressed and non–limbate, almost radial on umbilical side and strongly recurved on spiral side. Umbilical plug present or absent. Aperture a low slit at base of last formed chamber. Wall coarsely perforate, often translucent and thin, frequently tinged brown.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 189): Abundant right around New Zealand (34–54˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Murray 1991, Cimerman & Langer 1991).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 189): Widespread and abundant at inner shelf to lower bathyal depths (10–2000 m). Rare records at abyssal depths may be displaced. A zone of peak relative abundances (10–40%) occurs at mid shelf to mid bathyal depths (50–1000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene–Recent (Tt–Rec).

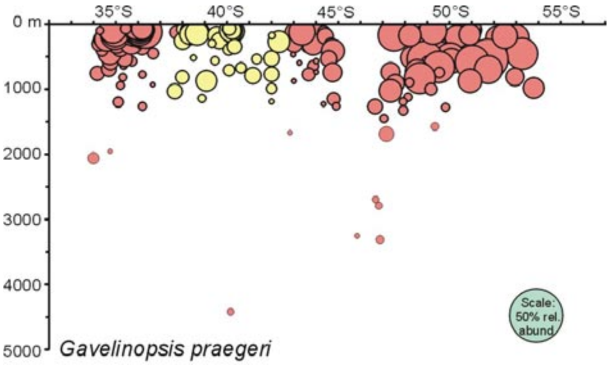


Figure 189. Latitude-depth distribution around NZ of *Gavelinopsis praegeri* (red circles are from east of NZ, yellow circles are from west of NZ).

GENUS – *Planodiscorbis* Bermůdez 1952

Planodiscorbis rarescens (Brady 1884)
Pl. 32, Figs 1–6

Discorbina rarescens BRADY 1884, p.651, pl.90, figs 2–3.

Planodiscorbis rarescens (Brady). SAIDOVA 1975, pl.55, fig.10; LOEBLICH & TAPPAN 1987, pl.609, figs 11–13; UJIIE 1990, pl.13, fig.12; LOEBLICH & TAPPAN 1994, pl.285, figs 1–10; JONES 1994, pl.90, figs 2–3; YASSINI & JONES 1995, figs 907,910–911; KAWAGATA 1999, fig.6.6.

DISTINGUISHING FEATURES: Test circular in outline; profile planoconvex to concavo–convex; spiral side flat or concave, umbilical side gently convex; thin, almost flange–like peripheral keel. 5–6 broad, low, and crescentic chambers in final whorl; subtriangular and strongly overlapping on umbilical side; sutures strongly curved oblique on the spiral side, nearly radial on the umbilical side; umbilicus closed. Aperture a low interiomarginal arch at the base of the final chamber, midway between the umbilicus and periphery on the spiral side.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Rare scattered occurrences off the east coast of both islands between 37 and 53˚S.

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Mikhalevich 2008).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mostly at mid to outer shelf depths (80–200 m), but one record from upper abyssal may be displaced.

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Oligocene–Recent (Lwh–Rec).

GENUS – *Rosalina* d'Orbigny 1826

KEY FEATURES OF NEW ZEALAND DEEP-WATER SPECIES:

Rosalina irregularis: Test of variable encrusting shape. Subrounded to acute periphery; chambers irregular. Wall densely perforate, although usually less so on umbilical side.

Rosalina paupereques: Test small, planoconvex; periphery acute with thin keel; 4–5 chambers/whorl. Wall finely perforate and translucent (see Hayward *et al.* 1999, pl.11, figs 6–8).

Rosalina vitrizea: Delicate, planoconvex; periphery acute with flange–like keel. 6–7 chambers/whorl. Umbilical side covered in fine papillae. Wall finely perforate and translucent (see Hayward *et al.* 1999, pl.11, figs 9–11).

Rosalina irregularis (Rhumbler 1906)
Pl. 32, Figs 7–11

Discorbina irregularis RHUMBLER 1906, p.70–71, pl.5, figs 57–58.

Rosalina irregularis (Rhumbler). HAYWARD *at al.* 1999, pl.11, figs 4–5; HAYWARD *et al.* 2001, figs 16Z–AA; HAYWARD *et al.* 2003, figs 4TT–UU.

DISTINGUISHING FEATURES: Test variable in overall shape due to attached habit; conical to concavo–convex with a subrounded to acute periphery. Chambers generally becoming more irregular and longer than wide with each successive whorl. Wall densely perforate, although usually less so on umbilical side.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 190): Widespread right around New Zealand (34–54˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Haynes 1973, Culver & Buzas 1980).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 190): Occurs at inner shelf to lower bathyal depths (0–1500 m). Records deeper than 1000 m may be displaced. It occurs most commonly (up to 20%) in sheltered bays and off moderately sheltered to exposed coastlines at inner shelf depths (0–50 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Miocene–Recent (Tt–Rec).

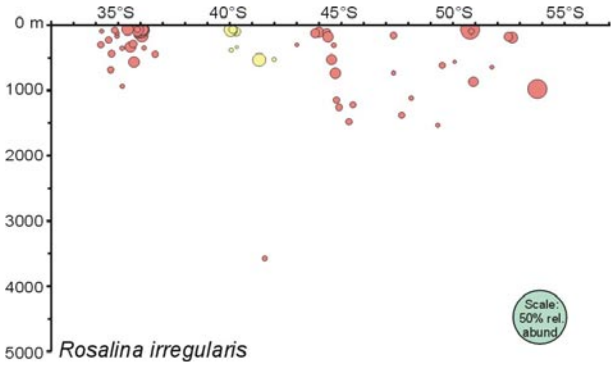


Figure 190. Latitude-depth distribution around NZ of *Rosalina irregularis* (red circles are from east of NZ, yellow circles are from west of NZ).

FAMILY – Sphaeroidinidae Cushman 1927

GENUS – *Sphaeroidina* d'Orbigny 1826

Sphaeroidina bulloides d'Orbigny 1826
Pl. 32, Figs 12–13

Sphaeroidina bulloides D'ORBIGNY 1826, p.267; UJIIE 1990, pl.11, figs 3–5; HAYWARD *et al.* 1999, pl.11, figs 15–16; HAYWARD *et al.* 2001, fig.16BB.

DISTINGUISHING FEATURES: Test subglobular; chambers strongly embracing, usually with three chambers visible externally. Aperture crescentic with a flap–like tooth. Wall smooth, sutures slightly depressed.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION (Fig. 191): Widespread right around New Zealand (33–54˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Culver & Buzas 1981, 1986, Yassini & Jones 1995).

NEW ZEALAND BATHYMETRIC DISTRIBUTION (Fig. 191): Widespread in low numbers at mid shelf to lower abyssal depths (50–5000 m). Sometimes washed into inner shelf depths, harbours and onto exposed beaches. Occurs more frequently at outer shelf and lower bathyal depths (100–1000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Latest Eocene–Recent (Ar–Rec).

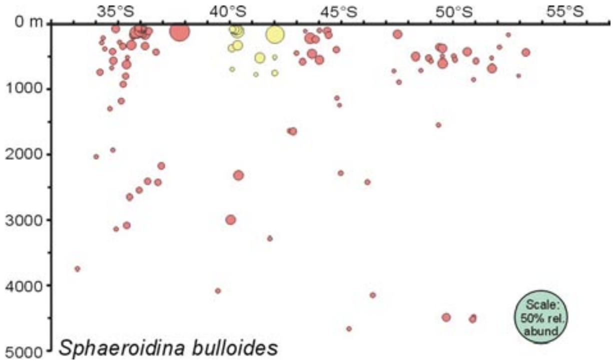


Figure 191. Latitude-depth distribution around NZ of *Sphaeroidina bulloides* (red circles are from east of NZ, yellow circles are from west of NZ).

FAMILY – Spirotectinidae Saidova, 1981

GENUS – *Spirotectina* Saidova 1975

Spirotectina crassa Saidova 1975
Pl. 32, Figs 14–17
Spirotectina crassa SAIDOVA 1975, p.273, pl.75, fig.5; LOEBLICH & TAPPAN 1987, pl.696, figs 9–13.

DISTINGUISHING FEATURES: Test low trochospiral, nearly planispiral; periphery acutely rounded. Spiral side partially evolute, with umbonal boss; umbilical side involute, umbilicus closed. About 6 chambers in final whorl; sutures radial, slightly curved, crossed by septal bridges. Aperture a wide interiomarginal equatorial arch, extending across the base of the apertural face; small rounded supplementary sutural openings sometimes visible between the sutural bridges over the final suture.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Sporadic occurrences east of the North Island (34–40˚S).

WORLD GEOGRAPHIC DISTRIBUTION: West Pacific (Loeblich & Tappan 1987).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Upper to mid bathyal depths (300–700 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

FAMILY – Victoriellidae Chapman & Crespin 1930

GENUS – *Biarritzina* Loeblich & Tappan 1964

Biarritzina proteiformis (Goës 1882)
Pl. 32, Figs 18–19
Carpenteria balaniformis var. *proteiformis* GOËS 1882, p.94, pl.6, figs 208–214, pl.7, figs 215–219.
Carpenteria proteiformis (Goës). JONES 1994, pl.97, figs 8–14.
Biarritzina proteiformis (Goës). CHAPRONIERE 1984, pl.13, figs 1a-c; LOEBLICH & TAPPAN 1987, pl.655, figs 1–5; LOEBLICH & TAPPAN 1994, pl.331, figs 4–8.

DISTINGUISHING FEATURES: Test attached by flaring base; early stage trochospirally enrolled in a loose elevated spire, later becomes uniserial. Chambers globular to pyriform, inflated. Aperture terminal, rounded, on a neck, may be present on more than one chamber. Wall finely perforate, but with scattered coarser pores.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Two recorded occurrences off the east coast of the northern North Island (35–37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Outer shelf depths (100–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

GENUS – *Carpenteria* Gray 1858

Carpenteria monticularis Carter 1877
Pl. 33, Figs 1–2
Carpenteria monticularis CARTER 1877, p.211, pl.13, figs 9–12; JONES 1994, pl.98, figs 13,15–16, pl.99, figs 1–5; LOEBLICH & TAPPAN 1994, pl.391, fig.5

DISTINGUISHING FEATURES: Test attached, trochospiral, planoconical ; periphery weakly keeled and angular. Spiral side flat; umbilical side low conical. 8–10 conical chambers in final whorl. Aperture slit-like, interiomarginal extending from the keeled periphery to the umbilicus. Wall surface covered with pores traversed by longitudinal grooves dividing the surface into an oblique irregular reticulation.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: One recorded occurrence off the east coast of the northern North Island (36˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Cosmopolitan (Jones 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid bathyal depths (600–1000 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Late Eocene–Recent (Ak–Rec).

GENUS – *Rupertina* Loeblich & Tappan 1961

Rupertina pustulosa Hatta 1992
Pl. 33, Figs 3–5
Rupertina pustulosa HATTA in HATTA & UJIIÉ 1992, p.192, pl.41, figs 2–4; HAYWARD *at al.* 1999, pl.15, fig.1.

DISTINGUISHING FEATURES: Test attached by a basal disc; early chambers tightly trochospiral, later loosely coiled and high-spired. Wall covered in large prominent, rounded tubercles, coarsely perforate between.

NEW ZEALAND GEOGRAPHIC DISTRIBUTION: Recorded from two areas (Poor Knights and Cuvier Islands) off the east coast of northern New Zealand (35–37˚S).

WORLD GEOGRAPHIC DISTRIBUTION: Recorded from the tropical and subtropical western Pacific (Hatta & Ujiié 1992, Loeblich & Tappan 1994).

NEW ZEALAND BATHYMETRIC DISTRIBUTION: Mid to outer shelf depths (50–200 m).

RECORDED NEW ZEALAND STRATIGRAPHIC RANGE: Recent.

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APPENDIX I. Details of deep-sea samples used in quantitative ecologic distribution analyses

See Table 3 for fuller explanations. GNS/AM Cat No. = catalog number of GNS Science, Lower Hutt (F) or Auckland War Memorial Museum (L); Ch. Ass = chord sample association; Jac. Ass. = Jaccard sample association; Species diversity measures: α = Fischer Alpha Index, H = Information Function, E = evenness; BF Abund = absolute abundance of benthic foraminifera (specimens per g sediment), PF = % planktics of foraminifera; FI = planktic foraminiferal fragmentation index; Chl-ann, Chl-spr, Chl-sum = mean annual, spring and summer surface chlorophyll-a values (µmole/l); Seas Index = Seasonality Index; Jz = organic carbon flux; SST = sea surface temperature; BTemp = bottom water temperature; SAL = bottom water salinity; O_2 = bottom water dissolved oxygen; P = annual surface phosphate.

Stn. No.	GNS/AM Cat. No.	Original Stn No.	Latitude	Longitude	Depth (m)	Ch. Ass.	Jac. Ass.	Species diversity			BF Abund (n/gsed)	PF %	FI	Mud %	Chl-ann	Chl-spr	Chl-sum	Seas Index	Jz	SST (˚C)	BTemp (˚C)	SAL (psu)	O_2 (mg/L)	P (µmole/l)
								α	H	E														
E1	F202351	H430	43° 35' 24"S	173° 38' 12"E	90	G9	i	13	2.83	0.47	507	24	35	2	0.75	0.71	1.01	0.28	14.44	12.4	16.6	35.5	6.2	0.51
E2	F202352	H427	43° 35' 03"S	173° 59' 42"E	215	F1	i	12	2.59	0.40	2693	53	7	12	0.90	1.00	1.23	0.28	7.92	12.4	14.2	35.3	6.1	0.52
E3	F202353	E48	43° 30' 00"S	174° 00' 00"E	366	F1	i	12	2.70	0.44	1292	50	9	42	0.88	1.08	1.16	0.28	4.53	12.6	12.1	35.0	6.4	0.5
E4	F202354	E435	43° 15' 00"S	174° 29' 00"E	574	D2	d4	11	2.81	0.50	4156	78	35	73	0.68	0.93	0.72	0.29	1.98	12.6	8.9	34.6	6.4	0.49
E5	F202355	F755	43° 00' 00"S	174° 30' 00"E	854	D7	d4	7	2.45	0.50	9034	68	15	57	0.66	0.75	0.72	0.26	1.27	12.6	6.9	34.5	5.5	0.47
E6	F202356	F754	42° 48' 00"S	174° 32' 00"E	1324	D8	nc	15	2.92	0.47	647	65	25	24	0.73	1.00	0.78	0.27	0.94	13.4	4.3	34.5	4.2	0.44
E7	F202357	E93	42° 49' 30"S	174° 10' 00"E	1646	D8	d4	12	2.74	0.47	464	70	12	97	0.66	1.01	0.70	0.28	0.65	13.4	3.1	34.6	3.7	0.45
E8	F202358	J1003	42° 21' 00"S	174° 59' 12"E	2332	C1	nc	7	1.95	0.32	620	65	23	96	0.72	0.99	0.85	0.25	0.52	13.4	2.1	34.7	4	0.4
E9	F202359	G126	43° 22' 00"S	175° 17' 00"E	101	F3	i	7	1.93	0.27	2120	38	31	3	0.48	0.52	0.62	0.17	6.61	12.8	16.3	35.5	5.4	0.48
E10	F202360	G123	43° 06' 00"S	175° 15' 00"E	121	F3	i	9	2.11	0.29	2995	42	25	3	0.52	0.74	0.74	0.22	6.18	12.8	15.9	35.5	5.4	0.46
E11	F202361	F756	43° 01' 00"S	175° 34' 00"E	285	F3	i	5	1.18	0.16	9703	27	12	3	0.58	0.81	0.71	0.26	3.08	12.8	13.8	35.3	6.3	0.43
E12	F202362	U951	42° 42' 55"S	176° 54' 46"E	850	D8	nc	10	2.25	0.38	22988	83	14	65	0.46	0.69	0.44	0.29	0.73	14.1	6.9	34.5	4.5	0.36
E13	F202363	W268	42° 51' 02"S	178° 59' 00"E	980	D8	e3	7	2.23	0.41	11846	88	13	70	0.53	0.72	0.60	0.28	0.78	14.3	6.3	34.4	4.6	0.3
E14	F202364	D115	42° 40' 00"S	178° 40' 00"E	1637	D8	e3	8	2.46	0.44	2874	87	27	92	0.49	0.70	0.56	0.31	0.42	14.3	3.1	34.6	4	0.3
E17	F202367	R657	42° 32' 00"S	178° 30' 33"W	1408	D8	e3	6	2.10	0.39	2944	97	11	85	0.42	0.62	0.41	0.28	0.38	14.5	3.9	35.5	3.8	0.29
E18	ODP 1125A		42° 33' 00"S	178° 10' 59"W	1365	D8	e3	8	2.41	0.43	6332	97	7	73	0.43	0.60	0.42	0.33	0.42	14.5	4.2	34.5	4.1	0.29
E19	F202368	S938	40° 01' 58"S	179° 59' 44"E	3003	C7	b	15	2.99	0.51	522	93	21	86	0.35	0.58	0.27	0.31	0.14	16.3	1.6	34.7	4.5	0.2
E20	F202369	Q859	39° 56' 24"S	178° 30' 48"W	3654	A2	b	19	3.38	0.67	122	81	41	97	0.31	0.56	0.20	0.34	0.09	17.5	1.2	34.7	4.8	0.22
E21	ODP 1124B		39° 29' 54"S	176° 32' 53"W	3967	A2	b	18	3.09	0.50	63	53	48	96	0.26	0.40	0.17	0.29	0.07	16.1	1.1	34.7	5	0.24
E22	F202370	S931	39° 27' 36"S	176° 25' 36"W	4096	C7	b	15	2.79	0.41	354	84	27	87	0.25	0.38	0.17	0.29	0.06	16.1	1.1	34.7	5	0.24
E23	F202371	G58	44° 00' 00"S	176° 00' 00"W	91	F3	i	12	2.64	0.43	4197	31	46	8	0.43	0.46	0.62	0.30	6.20	13.1	16.6	35.5	5.7	0.37
E24	F202372	E126	43° 50' 00"S	176° 09' 30"W	106	F3	i	18	2.99	0.41	3416	38	56	9	0.58	0.52	0.94	0.31	8.37	13.8	16.1	35.5	5.7	0.36
E25	F202373	G56	43° 50' 00"S	175° 40' 00"W	232	D2	d4	9	2.92	0.60	10368	92	9	41	0.39	0.36	0.60	0.27	2.11	13.9	14	35.3	5	0.36
E26	F202374	C618	43° 52' 00"S	175° 20' 00"W	623	E3	nc	16	3.13	0.56	2852	94	4	4	0.41	0.54	0.54	0.20	0.83	13.9	8.7	34.6	4.9	0.37
E27	F202375	C620	43° 40' 00"S	174° 47' 00"W	752	D7	d4	13	2.84	0.46	7043	97	3	54	0.39	0.42	0.49	0.19	0.65	12.6	7.5	34.5	4.8	0.36
E28	F202376	R623	43° 12' 00"S	174° 00' 00"W	1128	D8	e3	12	2.70	0.44	8914	96	3	61	0.33	0.45	0.36	0.28	0.34	14.0	5.3	34.4	4.1	0.34
E29	F202377	S925	42° 20' 28"S	171° 31' 07"W	2030	C1	e3	15	3.09	0.49	3274	97	4	80	0.28	0.36	0.27	0.18	0.15	14.4	2.4	34.6	3.9	0.34
E30	ODP 1123B		41° 47' 10"S	171° 30' 56"W	3290	C7	b	20	3.22	0.52	734	98	9	92	0.29	0.43	0.25	0.24	0.09	14.8	1.4	34.7	4.7	0.32
E31	F202378	S924	41° 35' 00"S	171° 30' 59"W	3550	A2	b	16	3.09	0.55	672	98	12	93	0.28	0.39	0.22	0.25	0.08	14.8	1.2	34.7	4.8	0.3
E32	F202379	G179	43° 52' 00"S	179° 28' 00"W	289	E3	g	6	2.18	0.40	5532	85	6	3	0.47	0.55	0.57	0.17	2.26	13.4	13.7	35.3	5.7	0.37
E33	F202380	E74	44° 00' 00"S	176° 40' 00"E	547	D8	d4	9	2.68	0.46	3654	83	30	88	0.68	0.84	0.60	0.24	2.05	12.0	9.2	34.6	6.1	0.5
E34	F202381	G33	43° 40' 00"S	177° 00' 00"E	457	D2	d4	10	2.56	0.43	2382	79	31	77	0.66	0.87	0.66	0.24	2.34	13.1	10.8	34.8	5.8	0.46
E35	F202382	E75	44° 00' 00"S	177° 25' 00"E	715	D8	d4	6	2.34	0.49	3160	85	20	81	0.57	0.54	0.73	0.27	1.21	12.1	4.8	34.3	5.7	0.48
E36	F202383	Q213	44° 08' 00"S	178° 00' 12"E	1080	D8	e3	9	2.73	0.55	5643	90	14	61	0.45	0.48	0.48	0.31	0.57	12.2	3.4	34.4	4.7	0.47
E37	F202384	U939	44° 29' 39"S	179° 30' 04"E	1300	D8	e3	7	2.52	0.52	11382	95	12	80	0.34	0.32	0.37	0.29	0.31	12.3	2.9	34.5	4.2	0.46
E38	F202385	W272	44° 41' 13"S	179° 04' 23"E	1841	C6	e3	10	2.51	0.40	5939	95	4	67	0.28	0.22	0.34	0.39	0.16	12.3	2.4	34.6	4.1	0.5
E39	F202386	H553	44° 59' 48"S	179° 12' 12"W	1832	C6	e3	9	2.34	0.32	2072	97	6	85	0.27	0.24	0.30	0.24	0.16	12.5	2.4	34.6	4.1	0.49

Stn. No.	GNS/AM Cat. No.	Original Stn No.	Latitude	Longitude	Depth (m)	Ch. Ass.	Jac. Ass.	Species diversity α	H	E	BF Abund (n/gsed)	PF %	FI	Mud %	Chl-ann	Chl-spr	Chl-sum	Seas Index	Jz	SST (˚C)	BTemp (˚C)	SAL (psu)	O_2 (mg/L)	P (μmole/l)
E40	F202387	U938	45° 04’ 29"S	179° 30’ 23"E	2700	C6	e3	8	2.16	0.35	1213	97	4	76	0.26	0.22	0.31	0.24	0.10	11.4	1.8	34.7	4.6	0.52
E41	F202388	H552	45° 50’ 24"S	179° 11’ 24"W	3232	C5	b	8	2.13	0.32	3324	97	5	57	0.29	0.26	0.37	0.22	0.10	11.6	1.4	34.7	4.8	0.58
E42	F202389	Q575	45° 19’ 30"S	174° 05’ 42"W	4680	C5	nc	19	2.75	0.33	347	77	41	57	0.33	0.35	0.40	0.23	0.08	12.7	0.8	34.7	4.9	0.46
E43	F202390	H380	44° 21’ 00"S	172° 38’ 48"E	100	F1	i	12	2.88	0.53	5370	41	48	31	0.65	0.59	0.80	0.28	10.46	11.4	16.3	35.5	6.1	0.7
E44	F202391	H362	44° 24’ 29"S	173° 03’ 30"E	165	F1	i	13	2.83	0.50	4284	25	7	6	0.71	0.71	1.11	0.41	7.27	11.6	15.2	35.4	6.3	0.65
E45	F202392	E424	44° 40’ 00"S	172° 38’ 00"E	293	F1	i	13	2.72	0.43	6929	57	20	6	0.53	0.58	0.91	0.43	2.63	11.4	13.7	35.3	6.5	0.7
E46	ODP 1119A		44° 45’ 20"S	172° 23’ 36"E	393	F1	i	13	2.74	0.43	8519	74	10	56	0.53	0.42	0.89	0.41	1.99	11.4	11.7	34.9	6.5	0.71
E47	F202393	G664	44° 34’ 00"S	173° 09’ 00"E	511	D3	i	12	2.54	0.35	16551	76	2	30	0.64	0.51	1.12	0.47	1.99	11.6	9.9	34.8	6.1	0.66
E48	F202394	E425	44° 44’ 00"S	172° 44’ 00"E	721	D3	i	14	2.58	0.35	8015	82	9	27	0.53	0.39	0.91	0.49	1.07	11.4	7.9	34.6	5.2	0.7
E49	F202395	E426	44° 47’ 00"S	172° 48’ 00"E	1130	D3	i	18	2.83	0.37	12236	89	2	55	0.40	0.32	0.58	0.29	0.46	11.4	5.3	34.4	4.7	0.7
E50	F202396	E427	44° 54’ 00"S	172° 54’ 00"E	1240	D3	i	16	2.56	0.27	17877	84	4	53	0.30	0.26	0.41	0.30	0.27	11.4	4.8	34.5	4.5	0.7
E51	F202397	H534	45° 20’ 30"S	172° 41’ 36"E	1462	C6	e3	7	2.55	0.51	4314	95	3	80	0.28	0.23	0.36	0.34	0.20	10.9	2.7	34.5	4.2	0.71
E52	DSDP 594		45° 31’ 25"S	174° 56’ 53"E	1204	D8	e3	11	2.80	0.50	6005	93	3	90	0.29	0.22	0.39	0.37	0.26	11.0	3.1	34.4	4.6	0.7
E53	F202398	H567	46° 03’ 06"S	174° 35’ 30"E	1733	C6	e3	8	2.23	0.36	2081	97	2	76	0.27	0.20	0.32	0.35	0.16	10.4	2.5	34.6	4	0.72
E54	F202399	Q206	46° 04’ 36"S	176° 29’ 30"E	2250	C6	e3	8	2.32	0.41	1958	98	1	74	0.26	0.21	0.32	0.29	0.12	10.4	2.1	34.7	4.3	0.72
E55	F202400	H559	46° 08’ 54"S	177° 11’ 18"E	2424	C6	e3	12	2.71	0.38	2841	98	2	77	0.26	0.21	0.34	0.31	0.11	10.5	2	34.7	4.5	0.72
E57	F202402	H550	46° 27’ 11"S	179° 15’ 12"W	3538	C5	b	11	2.20	0.30	1460	99	8	80	0.27	0.27	0.33	0.19	0.08	10.9	1.2	34.7	4.8	0.66
E58	F202403	Q581	46° 23’ 12"S	178° 27’ 00"W	4163	C7	b	12	2.51	0.37	336	67	48	98	0.27	0.29	0.30	0.19	0.07	11.1	1.1	34.7	4.8	0.63
E61	F202405	S1052#4	42° 29’ 47"S	178° 29’ 51"E	2328	C1	c	18	2.83	0.37	1525	73	28	96	0.44	0.70	0.42	0.32	0.25	14.3	2.1	34.7	3.9	0.3
E62	F202406	S1053#4	42° 48’ 34"S	178° 30’ 23"E	1003	D1	nc	13	2.96	0.55	1910	86	14	53	0.52	0.68	0.60	0.27	0.75	14.3	6.1	34.4	4.4	0.3
E63	F202407	S1072C	42° 58’ 27"S	178° 29’ 57"E	446	D2	d4	11	2.73	0.48	3214	86	22	28	0.61	0.81	0.77	0.26	2.14	14.3	11.1	34.9	5.2	0.3
E64	F202408	U1250#5	44° 20’ 05"S	178° 29’ 57"E	1206	C6	d3	10	2.54	0.44	2012	89	20	76	0.35	0.31	0.44	0.36	0.35	12.2	4.9	34.4	4.4	0.49
E65	F202409	S1064F#3	44° 57’ 14"S	178° 32’ 19"E	2284	C6	e3	11	2.53	0.39	3653	98	3	57	0.27	0.21	0.34	0.28	0.12	12.2	2.1	34.7	4.4	0.5
E66	F202410	U1165#2	46° 39’ 57"S	178° 29’ 19"E	2670	C6	e3	14	2.88	0.47	6133	98	2	42	0.26	0.22	0.32	0.29	0.10	10.6	1.8	34.7	4.6	0.72
E67	F202615	RR050333	40° 09’ 55"S	176° 08’ 03"W	4394	A2	b	17	2.95	0.44	86	-	-	88	0.29	0.49	0.19	0.32	0.07	15.7	0.8	34.7	4.9	0.25
E68	F202616	RR050349	40° 22' 40"S	177° 59' 43"E	2317	C4	c	22	3.16	0.44	-	87	4	98	0.36	0.56	0.25	0.32	0.19	16.8	2.1	34.7	3.7	0.19
N1	F202454	P72	33° 10' 42"S	175° 31' 48"E	3757	C2	c	13	2.74	0.42	7725	95	9	96	0.18	0.29	0.11	0.38	0.04	19.2	1.8	34.7	3.6	0.29
N2	F202455	U178	34° 54' 24"S	177° 59' 54"E	3148	C2	c	14	2.70	0.38	2599	95	6	96	0.21	0.31	0.11	0.38	0.06	18.7	1.8	34.7	3.6	0.27
N3	F202456	U175	35° 22' 54"S	177° 56' 48"E	3091	C2	c	15	2.89	0.46	3617	96	2	93	0.21	0.33	0.12	0.37	0.06	18.4	1.8	34.7	3.6	0.27
N4	F202457	X185	36° 39' 43"S	177° 07' 49"E	2810	C2	c	26	3.42	0.54	1492	91	5	92	0.24	0.37	0.17	0.27	0.09	18.2	1.9	34.7	3.6	0.28
N5	F202458	U172	35° 30' 36"S	177° 49' 12"E	2654	C2	c	21	3.44	0.61	829	97	2	72	0.21	0.31	0.12	0.35	0.07	18.4	1.9	34.7	3.6	0.27
N6	F202459	U169	35° 56' 30"S	177° 28' 24"E	2550	C2	c	25	3.58	0.63	1410	97	2	86	0.20	0.30	0.13	0.34	0.07	18.4	1.9	34.7	3.6	0.27
N7	F202460	S793	36° 19' 12"S	176° 48' 08"E	2411	C6	e2	21	3.19	0.50	1547	94	5	94	0.25	0.36	0.19	0.26	0.10	18.3	2	34.7	3.6	0.28
N8	F202461	Z3200	33° 38' 46"S	174° 09' 14"E	2133	C1	nc	15	3.11	0.52	3589	95	6	77	0.19	0.26	0.12	0.33	0.08	19.2	2.3	34.3	3.6	0.33
N9	F202462	P81	34° 01' 03"S	173° 30' 36"E	2036	D4	d2	15	2.62	0.34	2297	94	2	93	0.25	0.32	0.20	0.23	0.12	18.6	2.4	34.6	3.6	0.33
N10	F202463	F62	34° 46' 00"S	175° 42' 00"E	1931	C6	e2	14	2.93	0.48	7716	95	3	90	0.22	0.32	0.14	0.27	0.11	18.7	2.5	34.6	3.7	0.3
N11	F202464	S801	36° 35' 36"S	176° 42' 42"E	1694	C6	e2	12	2.79	0.45	1501	93	6	82	0.27	0.40	0.19	0.24	0.16	18.3	2.9	34.6	3.7	0.28
N12	F202465	F65	34° 46' 30"S	175° 16' 00"E	1587	C6	e2	17	2.99	0.46	6863	93	3	83	0.22	0.31	0.15	0.24	0.13	18.7	3.3	34.6	3.8	0.31
N13	F202466	U146	36° 23' 54"S	176° 35' 12"E	1440	C6	e2	13	2.76	0.43	3287	95	3	87	0.26	0.37	1.03	0.22	0.18	18.3	3.6	34.5	3.9	0.28
N14	F202467	F911	34° 38' 00"S	174° 36' 00"E	1295	C4	e2	20	3.32	0.59	3258	95	2	38	0.24	0.35	0.15	0.26	0.19	18.8	4.3	34.5	4.1	0.32
N15	F202468	F902	36° 13' 00"S	176° 29' 30"E	1242	D4	e2	14	2.96	0.51	11797	95	3	86	0.29	0.41	0.23	0.23	0.25	18.3	4.6	34.5	4.1	0.28
N16	F202469	F59	35° 08' 00"S	175° 23' 30"E	1176	D4	d2	17	3.23	0.56	6816	94	2	65	0.22	0.32	0.16	0.25	0.18	18.1	4.8	34.5	4.2	0.31
N17	F202470	F58	35° 13' 36"S	175° 19' 00"E	922	D4	d2	17	3.04	0.47	10109	92	2	84	0.25	0.38	0.18	0.27	0.28	18.1	6.1	34.4	4.8	0.31
N18	F202471	F896	36° 40' 30"S	176° 19' 12"E	909	D8	d3	9	2.36	0.37	4000	88	2	80	0.31	0.47	0.25	0.23	0.39	18.3	6.1	34.4	4.9	0.28
N19	F202472	E544	35° 20' 00"S	175° 23' 24"E	797	D4	d2	18	3.22	0.55	26266	91	4	74	0.25	0.39	0.17	0.28	0.32	18.1	7.1	34.5	4.9	0.3
N20	F202473	F900	36° 13' 00"S	176° 23' 00"E	754	D4	d2	12	2.76	0.44	12601	91	2	71	0.30	0.42	0.24	0.20	0.43	18.3	7.5	34.5	4.8	0.28

Stn. No.	GNS/AM Cat. No.	Original Stn No.	Latitude	Longitude	Depth (m)	Ch. Ass.	Jac. Ass.	Species diversity			BF Abund (n/gsed)	PF %	FI	Mud %	Chl-ann	Chl-spr	Chl-sum	Seas Index	Jz	SST (˚C)	BTemp (˚C)	SAL (psu)	O_2 (mg/L)	P (µmole/l)
								α	H	E														
N21	F202474	I369	34° 11' 18"S	173° 02' 24"E	736	G8	h4	11	1.95	0.21	31519	35	11	31	0.34	0.43	0.39	0.22	0.55	18.6	7.6	34.5	4.8	0.33
N22	F202475	E589	34° 42' 42"S	174° 10' 00"E	669	G7	d2	15	3.08	0.52	15277	73	3	39	0.27	0.40	0.21	0.21	0.41	18.8	8.4	34.6	4.8	0.33
N23	F202476	I24	35° 22' 18"S	175° 47' 12"E	615	E1	d2	21	3.28	0.51	2390	88	5	21	0.23	0.34	0.15	0.26	0.37	18.1	8.9	34.7	4.7	0.3
N24	F202477	E590	34° 47' 00"S	174° 17' 00"E	561	G7	d2	14	2.95	0.48	21903	75	3	36	0.29	0.40	0.22	0.20	0.55	18.8	10	34.8	4.5	0.33
N25	F202478	Z1038	35° 45' 00"S	176° 25' 00"E	549	E1	d2	22	3.28	0.50	8903	82	4	22	0.24	0.32	0.16	0.29	0.43	18.4	10.1	34.8	4.5	0.28
N26	F202479	I20	35° 25' 00"S	175° 12' 48"E	514	G7	d2	19	3.17	0.48	20143	81	3	57	0.28	0.44	0.21	0.24	0.58	18.1	10.7	34.9	4.5	0.31
N27	F202480	Z7003	36° 41' 36"S	176° 14' 19"E	430	G7	d2	15	3.10	0.54	28913	70	3	74	0.31	0.47	0.25	0.23	0.82	18.3	12.2	35.1	4.5	0.28
N28	F202481	E587	34° 45' 00"S	174° 03' 00"E	421	G7	h3	14	2.87	0.47	21790	28	6	26	0.32	0.42	0.28	0.21	0.87	18.8	12.3	34.1	4.5	0.33
N29	F202482	P525	34° 24' 11"S	173° 10' 36"E	380	G8	h4	18	2.90	0.39	3907	30	27	13	0.42	0.57	0.44	0.36	1.42	18.6	13.1	35.2	4.6	0.33
N30	F202483	F69	35° 13' 00"S	174° 48' 48"E	340	G7	h3	12	2.65	0.42	18295	46	7	33	0.33	0.45	0.29	0.18	1.09	18.0	13.7	35.2	4.6	0.32
N31	F202484	I64	36° 12' 00"S	176° 11' 48"E	335	G7	h3	14	2.80	0.42	17559	48	7	41	0.33	0.47	0.27	0.28	1.11	18.3	13.9	35.2	4.6	0.28
N32	F202485	AU4001	35° 35' 12"S	175° 20' 36"E	320	G7	h3	17	3.23	0.56	-	78	2	-	0.30	0.43	0.24	0.23	1.04	18.1	14	35.3	4.6	0.3
N33	F202486	E373	34° 16' 00"S	173° 05' 00"E	284	G8	h4	23	2.94	0.36	5742	34	15	13	0.40	0.50	0.47	0.26	1.76	18.6	14.7	35.3	4.6	0.33
N34	F202487	E592	35° 03' 30"S	174° 29' 30"E	276	G6	h3	17	3.17	0.54	7138	41	14	16	0.31	0.43	0.27	0.18	1.27	18.0	15	35.4	4.6	0.32
N35	F202488	E530	35° 43' 00"S	175° 30' 30"E	271	G7	h3	9	2.88	0.59	59751	52	8	57	0.36	0.46	0.27	0.23	1.58	18.1	15.1	35.4	4.6	0.3
N36	F202489	P523	34° 19' 42"S	173° 07' 30"E	210	G8	h4	19	3.19	0.50	4990	23	13	9	0.34	0.46	0.59	0.31	1.92	18.6	16.3	35.5	4.7	0.33
N37	F202490	E347	34° 37' 00"S	173° 25' 00"E	209	G6	h3	16	3.14	0.55	21103	40	11	14	0.40	0.53	0.42	0.21	2.38	18.6	16.3	35.5	4.7	0.33
N38	F202491	C783	36° 00' 00"S	175° 45' 48"E	192	G6	h3	15	3.09	0.55	15173	45	12	44	0.39	0.52	0.42	0.23	2.53	18.3	16.8	35.5	4.7	0.29
N39	F202492	AU3157	35° 40' 30"S	175° 14' 36"E	191	G6	h3	10	2.81	0.53	-	57	2	-	0.39	0.50	0.34	0.22	2.60	18.1	16.8	35.5	4.7	0.3
N40	F202493	AU3166	35° 40' 42"S	175° 01' 00"E	153	G6	h3	10	2.62	0.43	-	39	4	-	0.40	0.56	0.42	0.23	3.34	18.1	17.6	35.6	4.8	0.31
N41	F202494	I66	36° 12' 06"S	175° 50' 03"E	152	G6	h3	12	3.01	0.55	33207	47	17	56	0.45	0.64	0.51	0.24	4.03	18.3	17.6	35.6	4.8	0.29
N42	F202495	E584	34° 59' 30"S	174° 07' 30"E	150	G6	h4	17	3.17	0.53	16208	29	17	12	0.58	0.59	0.57	0.25	5.88	18.8	17.6	35.6	4.8	0.33
N43	F202496	AU17806	36° 06' 06"S	175° 44' 21"E	146	G6	h3	13	3.06	0.55	-	32	5	-	0.43	0.57	0.49	0.21	3.84	18.3	17.9	35.6	4.8	0.29
N44	F202497	AU4008	35° 51' 12"S	175° 17' 36"E	143	G6	h3	13	3.14	0.61	-	33	3	-	0.50	0.75	0.51	0.31	4.87	18.1	17.9	35.6	4.8	0.3
N45	F202498	AU3153	35° 45' 12"S	175° 08' 54"E	137	G6	h3	13	3.09	0.56	-	43	3	-	0.46	0.76	0.41	0.43	4.58	18.1	17.9	35.6	4.8	0.3
N46	F202499	G457	36° 04' 00"S	175° 38' 00"E	122	G6	h3	14	3.02	0.54	13536	40	13	50	0.44	0.63	0.48	0.26	4.86	18.3	18.9	35.6	4.9	0.29
N47	F202500	AU3164	35° 48' 06"S	174° 54' 24"E	118	G6	h3	9	2.77	0.55	-	27	4	-	0.50	0.84	0.47	0.43	5.99	18.0	18.9	35.6	4.9	0.31
N48	F202501	E577	34° 59' 30"S	174° 02' 36"E	108	G6	h3	16	3.13	0.52	21500	16	25	36	0.77	1.18	0.76	0.29	12.42	18.8	19.2	35.7	4.9	0.33
N49	F202502	G421	36° 22' 00"S	175° 49' 00"E	100	G6	h3	11	2.74	0.46	13491	16	23	42	0.58	0.95	0.61	0.31	8.92	18.3	19.6	35.7	5	0.29
N50	F202503	AU3148	35° 59' 06"S	174° 55' 48"E	97	G6	h3	13	3.11	0.58	-	36	1	-	0.54	0.90	0.51	0.37	8.26	18.6	19.6	35.7	5	0.31
N51	F202504	AU17804	36° 05' 39"S	175° 31' 27"E	96	G4	h3	13	2.89	0.50	-	20	-	-	0.66	1.25	0.61	0.28	11.16	18.3	19.6	35.7	5	0.29
N52	F202505	AU4020	36° 00' 36"S	175° 17' 48"E	84	G4	h3	12	2.85	0.49	-	20	4	-	0.83	1.33	1.06	0.34	18.06	18.3	20.2	35.7	5.1	0.3
N53	F202506	AU4019	36° 04' 12"S	175° 14' 30"E	73	G4	h3	9	2.70	0.50	-	22	5	-	0.83	1.33	1.06	0.31	20.78	18.3	20.6	35.7	5.2	0.3
N54	F202507	AU3162	35° 56' 00"S	174° 48' 00"E	71	G4	h3	13	2.90	0.49	-	24	4	-	0.67	1.09	0.66	0.38	15.47	18.6	20.6	35.7	5.2	0.31
N55	F202508	P639	34° 53' 18"S	173° 30' 33"E	65	G1	h2	15	3.11	0.57	26161	10	-	38	1.00	1.64	1.13	0.35	30.91	18.6	20.9	35.7	5.1	0.33
N56	F202509	L30924	36° 09' 01"S	175° 17' 55"E	50	G1	h2	15	3.04	0.52	7101	12	-	38	0.64	1.09	0.65	0.31	20.48	18.3	21.2	35.7	5.1	0.29
N57	F202061	g25	36° 04' 06"S	175° 25' 48"E	56	G1	h2	18	3.28	0.58	-	8	-	-	0.64	1.09	0.65	0.31	18.36	18.3	21	35.7	5.1	0.29
N58	F202042	g36	36° 04' 42"S	175° 26' 36"E	59	G1	h2	23	3.37	0.54	-	21	-	-	0.64	1.09	0.65	0.31	17.43	18.3	20.9	35.7	5.1	0.29
N59	F202060	g38	36° 05' 30"S	175° 26' 48"E	51	G1	h2	18	3.42	0.68	-	4	-	-	0.88	1.40	1.13	0.31	32.23	18.3	21.2	35.7	5.1	0.29
N60	F201866	g40	36° 05' 42"S	175° 28' 12"E	68	G1	h2	14	2.81	0.40	-	19	-	-	0.88	1.40	1.13	0.31	24.17	18.3	20.7	35.7	5.2	0.29
N61	F202052	g41	36° 06' 24"S	175° 27' 36"E	53	G1	h2	20	3.39	0.62	-	9	-	-	0.88	1.40	1.13	0.31	31.01	18.3	21.2	35.7	5.2	0.29
N62	F201865	g42	36° 06' 24"S	175° 28' 30"E	60	G1	h2	16	2.92	0.42	-	17	-	-	0.88	1.40	1.13	0.31	27.39	18.3	20.9	35.7	5.1	0.29
N63	F201857	g44	36° 06' 54"S	175° 28' 24"E	50	G1	h2	16	3.05	0.49	-	16	-	-	0.88	1.40	1.13	0.31	32.87	18.3	21.2	35.7	5.1	0.29
N64	F201880	g45	36° 06' 54"S	175° 29' 36"E	58	G1	h2	11	2.87	0.52	-	6	-	-	0.88	1.40	1.13	0.31	28.34	18.3	20.9	35.7	5.1	0.29
N65	F201870	g46	36° 07' 12"S	175° 29' 24"E	51	G1	h2	15	3.17	0.58	-	5	-	-	0.88	1.40	1.13	0.31	32.23	18.3	21.2	35.7	5.1	0.29
N66	F201921	e6	35° 54' 02"S	174° 43' 27"E	53	G1	h2	20	3.34	0.58	-	22	-	5	0.79	1.40	0.79	0.44	26.33	18.6	21.2	35.7	5.1	0.31

Stn. No.	GNS/AM Cat. No.	Original Stn No.	Latitude	Longitude	Depth (m)	Ch. Ass.	Jac. Ass.	Species diversity α	H	E	BF Abund (n/gsed)	PF %	FI	Mud %	Chl-ann	Chl-spr	Chl-sum	Seas Index	Jz	SST (°C)	BTemp (°C)	SAL (psu)	O_2 (mg/L)	P (μmole/l)
N67	F201922	e7	35° 54' 06"S	174° 43' 16"E	53	G1	h2	18	3.18	0.52	-	21	-	3	0.79	1.40	0.79	0.44	26.33	18.6	21.2	35.7	5.1	0.31
N68	F201923	e8	35° 54' 10"S	174° 43' 12"E	52	G1	h2	16	3.14	0.55	-	19	-	4	0.79	1.40	0.79	0.44	26.84	18.6	21.2	35.7	5.1	0.31
N69	F201632	P504	34° 18' 30"S	172° 51' 48"E	80	NC	nc	14	2.87	0.43	-	28	-	-	0.51	0.62	0.72	0.26	9.21	18.4	20.2	35.7	5.1	0.33
N70		AU17649	35° 28' 32"S	174° 43' 59"E	60	G1	h2	17	3.36	0.64	-	26	-	-	0.48	0.73	0.51	0.32	11.03	18.0	20.9	35.7	5.1	0.32
N71		AU4027	36° 12' 06"S	175° 11' 48"E	51	G4	nc	12	2.80	0.48	-	14	-	-	0.33	2.01	1.97	0.24	7.28	18.3	21.2	35.7	5.1	0.3
N72		AU17659	35° 28' 02"S	174° 44' 08"E	50	G1	h2	18	3.40	0.67	-	16	-	-	0.48	0.73	0.51	0.32	13.24	18.0	21.2	35.7	5.1	0.32
N73	F202617	MD063012	36° 46' 44"S	179° 07' 20"E	2427	C4	c	24	3.34	0.53	116	94	4	80	0.24	0.39	0.16	0.33	0.09	18.0	1.9	34.7	3.6	0.28
N74	F202618	MD063015	36° 55' 42"S	178° 49’ 38"E	2175	C4	c	22	3.28	0.50	167	95	4	55	0.23	0.37	0.17	0.34	0.10	18.1	2.2	34.6	3.6	0.28
N75	F202619	MD063017	37° 44' 46"S	176° 59’ 46"E	106	G2	h3	14	3.27	0.69	322	20	9	93	0.78	1.22	0.65	0.41	12.95	17.6	19.2	35.7	4.9	0.28
N76		AU42401	31° 48' 00"S	176° 50' 00"W	4500	A1	b	13	2.77	0.44	600	76	16	66	0.13	0.17	0.07	0.41	0.02	19.9	1.8	34.7	3.6	0.2
S1	F202510	J520	50° 45' 00"S	166° 11' 54"E	50	F2	f	7	2.33	0.35	15020	13	5	18	0.49	0.49	0.71	0.44	13.57	9.7	8.6	34.4	6.53	0.95
S2	F202511	J522	50° 48' 12"S	166°09' 00"E	80	NC	f	7	2.40	0.42	9232	22	6	87	0.26	0.21	NaN	0.41	3.33	9.7	8.5	34.4	6.54	0.95
S3	F202512	B195	49° 14' 31"S	171° 45' 00"E	82	F2	f	3	1.32	0.29	6171	33	5	5	0.34	0.30	0.55	0.34	4.76	9.3	8.5	34.3	6.56	0.8
S4	F202513	E402	47° 19' 00"S	168° 34' 00"E	113	F2	f	10	2.72	0.47	1933	26	11	3	0.39	0.28	0.64	0.38	4.26	11.2	12	34.7	5.86	0.67
S5	F202514	J535	50° 53' 00"S	166° 35' 48"E	140	F2	f	9	2.12	0.28	766	32	10	3	0.51	0.28	1.22	0.37	5.19	9.7	8.4	34.4	6.46	0.94
S6	F202515	B578	47° 20' 00"S	169° 08' 00"E	143	F2	f	8	2.70	0.55	4060	25	8	2	0.34	0.28	0.46	0.32	2.76	10.7	11.8	34.7	5.82	0.7
S7	F202516	J1022	47° 29' 36"S	179° 19' 54"E	150	F2	f	7	2.14	0.34	11031	55	7	10	0.33	0.34	0.50	0.26	2.54	10.0	8.8	34.3	6.38	0.82
S8	F202517	D151	48° 12' 00"S	166° 38' 00"E	152	F2	f	7	2.24	0.37	17515	28	6	7	0.38	0.25	0.73	0.48	3.11	11.0	11.7	35.0	5.33	0.75
S9	F202518	J541	52° 27' 12"S	168° 58' 00"E	161	F2	f	5	1.79	0.31	8737	37	5	15	0.34	0.22	0.60	0.29	2.45	8.5	7.9	34.3	6.6	1.05
S10	F202519	B192	52° 27' 00"S	169° 21' 00"E	165	F2	f	2	1.33	0.42	3896	28	5	8	0.28	0.21	0.42	0.31	1.79	8.4	7.9	34.3	6.6	1.05
S11	F202520	F141	52° 38' 00"S	169° 23' 00"E	176	F2	f	8	2.22	0.34	989	29	2	2	0.26	0.24	0.32	0.27	1.47	8.4	7.9	34.3	6.59	1.07
S12	F202521	D73	50° 18' 00"S	166° 23' 30"E	177	F2	f	9	2.34	0.35	8224	17	5	2	0.41	0.50	0.62	0.44	2.95	9.7	8.3	34.4	6.4	0.9
S13	F202522	B589	48° 44' 00"S	166° 30' 00"E	187	F2	f	9	2.25	0.33	12847	40	7	5	0.32	0.26	0.53	0.35	1.95	11.0	11.3	35.0	5.31	0.79
S14	F202523	D32	52° 08' 00"S	168° 50' 00"E	188	F2	f	4	1.95	0.41	10019	22	14	8	0.33	0.24	0.54	0.43	2.05	8.5	7.9	34.3	6.59	1.01
S15	F202524	D35	52° 56' 24"S	169° 33' 00"E	188	F2	f	6	1.64	0.23	18626	60	14	21	0.25	0.21	0.32	0.30	1.30	8.4	7.9	34.3	6.59	1.1
S16	F202525	D210	49° 21' 30"S	171° 53' 00"E	353	E2	g	6	1.78	0.26	12192	29	11	14	0.36	0.33	0.58	0.38	1.22	9.3	7.1	34.4	6.3	0.81
S17	F202526	F138	52° 03' 00"S	170° 23' 00"E	353	E2	g	6	2.17	0.42	20370	73	3	16	0.29	0.31	0.40	0.41	0.87	8.3	7.4	34.4	6.28	1
S18	F202527	F106	49° 30' 00"S	172° 00' 00"E	371	E2	g	5	2.32	0.51	16535	69	10	30	0.31	0.28	0.31	0.16	0.93	9.2	6.9	34.4	6.22	0.82
S19	F202528	D175	50° 36' 30"S	167° 41' 00"E	426	E2	g	9	2.72	0.49	8923	88	5	25	0.24	0.34	0.25	0.27	0.55	9.6	8.4	34.5	5.9	0.89
S20	F202529	F145	53° 14' 00"S	171° 48' 00"E	435	E2	g	8	2.75	0.58	6190	86	3	34	0.18	0.18	0.21	0.15	0.35	7.8	7.3	34.4	6.33	1.14
S21	F202530	TAN0307/19	49° 30' 00"S	174° 30' 25"E	492	D6	d3	9	2.45	0.40	10397	87	4	68	0.19	0.19	0.21	0.16	0.32	8.9	6.9	34.4	5.77	0.88
S22	F202531	F120	48° 18' 00"S	179° 16' 00"E	494	D6	d3	12	2.71	0.42	13487	88	5	28	0.28	0.24	0.34	0.26	0.59	9.4	5.7	34.3	5.65	0.9
S23	F202532	T68	50° 00' 42"S	172° 00' 18"E	496	D6	d3	10	2.80	0.47	6592	88	4	71	0.21	0.22	0.25	0.13	0.39	8.8	6.8	34.4	5.8	0.85
S24	F202533	D211	48° 53' 00"S	172° 17' 30"E	519	D6	d3	9	2.54	0.44	12331	87	3	29	0.19	0.21	0.22	0.12	0.32	9.6	6.5	34.3	6.09	0.8
S25	F202534	F137	51° 42' 00"S	171° 31' 00"E	519	D6	d3	8	2.38	0.38	11351	90	4	53	0.20	0.26	0.21	0.28	0.35	8.5	6.9	34.4	5.84	0.98
S26	F202535	1120A	50° 03' 48"S	173° 22' 20"E	544	D6	d3	7	2.33	0.35	8960	88	4	48	0.19	0.20	0.22	0.12	0.30	8.6	6.6	34.4	5.96	0.88
S27	F202536	D203	51° 00' 00"S	169° 29' 30"E	655	D6	d3	10	2.62	0.39	10942	85	2	59	0.20	0.22	0.24	0.20	0.27	8.8	6.8	34.4	5.82	0.9
S28	F202537	T37	48° 59' 36"S	179° 21' 24"E	565	E2	g	7	2.45	0.50	2341	91	6	11	0.22	0.22	0.21	0.18	0.36	9.4	5.4	34.3	5.45	0.94
S29	F202538	F90	49° 30' 30"S	167° 40' 00"E	601	E2	g	14	2.96	0.50	2849	93	4	28	0.19	0.25	0.18	0.16	0.28	10.2	7.8	34.5	5.69	0.82
S30	F202539	D178	51° 43' 12"S	167° 49' 48"E	629	D6	d3	9	2.24	0.30	11342	95	5	57	0.19	0.18	0.23	0.20	0.26	9.0	6.6	34.4	5.49	0.99
S31	F202540	J482	49° 30' 00"S	169° 59' 48"E	638	D6	d3	9	2.53	0.42	12389	86	6	62	0.19	0.19	0.23	0.10	0.26	9.8	6.4	34.3	5.76	0.8
S32	F202541	F148	51° 43' 00"S	173° 32' 00"E	677	D6	d3	7	2.53	0.50	8550	91	3	32	0.18	0.17	0.21	0.15	0.22	8.3	5.8	34.3	5.48	1
S33	F202542	F99	48° 32' 00"S	168° 54' 30"E	706	D6	d3	9	2.65	0.47	10684	91	5	38	0.22	0.24	0.24	0.12	0.29	10.6	5.8	34.3	5.73	0.75
S34	F202543	E404	47° 20' 00"S	169° 44' 00"E	716	D6	d3	11	2.68	0.41	10553	88	4	18	0.24	0.26	0.25	0.18	0.33	10.7	5.4	34.3	5.57	0.71
S35	F202544	D160	49° 31' 30"S	166° 15' 30"E	722	E2	g	9	2.23	0.33	9588	81	3	4	0.32	0.33	0.47	0.33	0.50	10.3	7.2	34.5	5.38	0.85
S36	F202545	V1439	52° 54' 35"S	168° 07' 00"E	791	D6	d3	8	2.28	0.33	4733	89	5	81	0.19	0.18	0.23	0.16	0.21	8.5	5.8	34.4	5.1	1.12

Stn. No.	GNS/AM Cat. No.	Original Stn No.	Latitude	Longitude	Depth (m)	Ch. Ass.	Jac. Ass.	Species diversity			BF Abund (n/gsed)	PF %	FI	Mud %	Chl-ann	Chl-spr	Chl-sum	Seas Index	Jz	SST (˚C)	BTemp (˚C)	SAL (psu)	O_2 (mg/L)	P (µmole/l)
								α	H	E														
S37	F202546	F102	48° 39' 00"S	169° 51' 00"E	810	D6	d3	6	2.32	0.41	6393	88	5	56	0.22	0.23	0.25	0.19	0.25	10.3	5.2	34.3	5.32	0.76
S38	F202547	T73	50° 53' 48"S	173° 56' 48"E	850	D6	d3	9	2.87	0.59	3097	97	2	65	0.17	0.17	0.21	0.15	0.17	8.6	4.98	34.3	5.05	0.94
S39	F202548	I703	48° 10' 54"S	178° 15' 54"E	875	D5	d3	10	2.58	0.40	3586	96	4	62	0.24	0.22	0.26	0.19	0.27	9.3	4.1	34.3	4.92	0.88
S40	F202549	J1024	47° 33' 12"S	177° 59' 24"E	890	D5	d3	10	2.68	0.49	3266	95	3	31	0.25	0.23	0.33	0.19	0.28	9.8	4	34.3	4.91	0.83
S41	F202550	D169	50° 47' 30"S	163° 57' 30"E	896	B	a2	9	2.47	0.42	938	94	4	2	0.23	0.19	0.30	0.25	0.25	9.5	6.1	34.4	4.88	1.03
S42	F202551	S44	53° 45' 00"S	170° 31' 12"E	960	D6	d3	10	2.84	0.53	1853	96	3	61	0.19	0.15	0.25	0.18	0.17	7.9	5	34.4	4.93	1.21
S43	F202552	F128	49° 09' 00"S	177° 18' 00"E	978	D5	d3	10	2.62	0.44	1147	94	5	28	0.20	0.21	0.21	0.16	0.19	8.8	3.2	34.4	4.66	0.93
S44	F202553	E405	47° 20' 00"S	169° 55' 00"E	1004	D6	d3	12	2.79	0.44	5788	94	5	43	0.22	0.24	0.25	0.17	0.20	10.7	3.6	34.3	4.86	0.71
S45	F202554	F110	48° 07' 12"S	174° 01' 48"E	1100	D5	d3	8	2.45	0.45	7865	95	3	41	0.20	0.20	0.19	0.20	0.16	9.4	3.2	34.4	4.69	0.8
S46	F202555	H542	47° 53' 54"S	175° 24' 12"E	1169	D5	d3	10	2.76	0.49	2751	94	4	22	0.21	0.21	0.21	0.20	0.16	9.8	3.1	34.4	4.61	0.82
S47	F202556	E411	46° 38' 33"S	170° 59' 00"E	1244	D3	n.c.	9	2.37	0.35	2820	90	5	71	0.22	0.22	0.28	0.22	0.17	10.6	2.7	34.5	4.2	0.72
S48	F202557	F126	49° 48' 00"S	176° 01' 00"E	1256	B	a2	12	2.73	0.44	466	97	4	10	0.18	0.18	0.21	0.17	0.12	8.8	2.9	34.5	4.43	0.93
S49	F202558	F123	47° 38' 00"S	178° 57' 00"W	1280	B	a2	7	1.74	0.23	396	96	6	4	0.23	0.22	0.27	0.17	0.18	10.4	2.9	34.4	4.34	0.79
S50	F202559	H540	47° 54' 30"S	170° 56' 12"E	1304	C6	d3	6	2.18	0.42	2407	94	5	72	0.23	0.21	0.29	0.20	0.17	10.4	2.8	34.5	4.27	0.75
S51	F202560	TAN0307/9	47° 41' 56"S	171° 30' 17"E	1360	C6	e3	6	2.00	0.34	3117	95	5	81	0.22	0.20	0.27	0.23	0.15	10.2	2.6	34.5	4.1	0.75
S52	F202561	H564	47° 02' 36"S	174° 04' 42"E	1429	C6	d3	8	2.23	0.34	1388	96	2	82	0.23	0.20	0.24	0.21	0.16	9.9	2.6	34.5	4.19	0.77
S53	F202562	F115	49° 18' 30"S	179° 52' 01"E	1518	B	a2	8	2.18	0.34	484	96	5	4	0.20	0.21	0.23	0.16	0.12	9.0	2.5	34.6	4.1	0.95
S54	F202563	TAN0307/31	49° 19' 34"S	176° 10' 48"E	1552	B	a2	23	3.28	0.51	152	96	2	51	0.19	0.19	0.21	0.16	0.10	8.8	2.4	34.6	4.17	0.91
S55	F202564	J1026	47° 09' 06"S	176° 01' 30"E	1668	D5	nc	10	2.81	0.53	2515	96	5	13	0.24	0.22	0.26	0.28	0.14	9.8	2.4	34.6	4.16	0.79
S56	F202565	T54	46° 33' 48"S	173° 50' 12"E	1670	C6	d3	7	2.04	0.32	2986	93	4	76	0.25	0.20	0.29	0.29	0.15	10.4	2.5	34.6	4.11	0.75
S57	F202566	So82	55° 20' 05"S	166° 40' 04"E	1685	B	a2	9	2.48	0.40	-	98	2		0.19	0.16	0.24	0.18	0.10	6.8	2.6	34.6	4.17	1.46
S58	F202567	G704	46° 17' 00"S	172° 37' 00"E	1756	C6	nc	13	2.58	0.36	2700	91	4	67	0.32	0.21	0.34	0.33	0.21	10.5	2.4	34.6	4.13	0.74
S59	F202568	So88	55° 30' 06"S	165° 52' 14"E	2074	B	a2	11	2.59	0.42	-	99	2		0.19	0.17	0.23	0.21	0.08	6.6	2.4	34.7	4.18	1.5
S60	F202569	J1019	46° 59' 00"S	179° 58' 48"E	2390	C6	e2	14	2.91	0.49	2468	98	4	35	0.26	0.24	0.30	0.18	0.11	10.7	1.9	34.8	4.49	0.74
S61	F202570	H557	46° 48' 36"S	178° 00' 00"E	2765	C6	e2	15	2.74	0.36	2467	97	3	52	0.26	0.23	0.32	0.19	0.09	10.6	1.7	34.8	4.63	0.76
S62	F202571	H549	46° 51' 36"S	179° 10' 54"W	3287	C6	e2	11	2.38	0.34	1863	97	3	54	0.28	0.26	0.33	0.23	0.09	10.9	1.3	34.8	4.76	0.7
S63	F202572	So25	50° 39' 00"S	176° 22' 34"E	3452	A1	a1	13	2.93	0.51	108	99	4	10	0.18	0.17	0.20	0.12	0.04	8.4	1.2	34.7	4.74	0.99
S64	F202573	So98	55° 44' 56"S	165° 07' 56"E	4138	A1	a1	11	2.98	0.54	180	99	15	18	0.18	0.15	0.22	0.12	0.04	6.6	1.1	34.7	4.81	1.52
S65	F202574	ODP 1121B	50° 53' 52"S	176° 59' 52"E	4490	A1	a1	9	2.51	0.42	139	83	17	50	0.18	0.19	0.19	0.16	0.03	8.4	0.8	34.7	4.9	1.02
S66	F202575	Q585	49° 40' 12"S	178° 00' 00"W	4500	C7	a1	12	2.62	0.39	487	92	11	83	0.23	0.21	0.27	0.18	0.05	9.3	0.9	34.7	4.89	0.94
S67	F202576	So19	50° 51' 07"S	176° 53' 11"E	4530	A1	a1	10	2.27	0.32	373	82	58	53	0.18	0.19	0.19	0.17	0.03	8.4	0.8	34.7	4.9	1.02
S68	F202577	Q583	50° 30' 00"S	175° 00' 00"W	5000	A1	a1	4	1.53	0.29	420	17	64	84	0.24	0.21	0.25	0.18	0.05	9.6	0.9	34.7	4.9	0.97
W1	F202415	E887	36° 40' 00"S	173° 53' 00"E	379	NC	nc	15	3.02	0.51	125	42	1	70	0.48	0.63	0.29	0.28	1.74	18.3	10	34.8	3.7	0.29
W2	F202416	E469	37° 40' 00"S	173° 50' 00"E	1011	D1	e2	8	2.77	0.59	676	86	5	98	0.33	0.58	0.21	0.39	0.37	17.6	5.3	34.5	3.3	0.27
W3	F202417	E892	37° 20' 00"S	173° 35' 00"E	1226	D1	e1	8	2.72	0.58	274	63	7	98	0.30	0.52	0.18	0.34	0.27	17.6	4.1	34.5	3.2	0.28
W4	F202418	E465	37° 40' 00"S	173° 20' 00"E	1419	C3	e1	10	2.66	0.49	468	87	5	97	0.32	0.54	0.18	0.37	0.25	17.6	3.2	34.5	3	0.28
W5	F202419	E473	37° 20' 00"S	173° 05' 00"E	1545	C3	e1	10	2.58	0.45	461	84	6	95	0.30	0.52	0.17	0.38	0.21	17.6	3	34.6	2.9	0.29
W6	F202420	E476	37° 00' 00"S	172° 53' 00"E	1670	C3	e1	9	2.57	0.45	686	88	5	97	0.28	0.46	0.15	0.37	0.17	17.3	2.8	34.6	2.9	0.29
W7	F202421	B94	36° 48' 12"S	172° 12' 00"E	1825	C3	e1	6	2.45	0.55	627	91	6	93	0.26	0.43	0.15	0.39	0.14	17.7	2.6	34.6	2.9	0.3
W8	F202422	J51	36° 52' 00"S	170° 42' 00"E	2000	C3	e1	11	2.78	0.49	1149	96	4	89	0.21	0.33	0.13	0.32	0.10	17.5	2.4	34.6	2.8	0.31
W9	F202423	J48	36° 30' 00"S	170° 26' 00"E	2150	C3	e1	11	2.81	0.52	1312	96	5	92	0.27	0.32	0.13	0.33	0.13	17.5	2.4	34.6	2.8	0.32
W11	F202425	C288	38° 01' 48"S	174° 30' 24"E	60	G9	nc	7	2.41	0.47	357	20	6	2	0.63	0.75	0.35	0.26	16.83	16.9	13.8	35.2	4.4	0.27
W12	F202426	C293	38° 01' 12"S	173° 57' 36"E	238	G5	h3	9	2.55	0.41	26947	22	4	32	0.35	0.52	0.24	0.26	1.72	16.8	11.7	35.1	3.8	0.27
W13	F202427	E898	38° 00' 00"S	173° 53' 00"E	506	G	d1	12	2.75	0.41	1712	53	5	95	0.38	0.61	0.23	0.30	0.92	16.8	9	34.7	3.8	0.27
W14	F202428	E453	38° 00' 00"S	173° 50' 00"E	794	D7	e1	11	2.91	0.57	530	82	6	96	0.33	0.61	0.21	0.30	0.48	16.8	7	34.5	3.4	0.27
W15	F202429	E900	38° 01' 00"S	173° 38' 00"E	974	D1	e1	11	2.59	0.37	419	73	6	98	0.34	0.60	0.21	0.35	0.41	16.8	5.4	34.5	3.3	0.27

Stn.	GNS/AM	Original	Latitude	Longitude	Depth	Ch.	Jac.	Species diversity			BF	PF	FI	Mud	Chl-	Chl-	Chl-	Seas	Jz	SST	BTemp	SAL	O_2	P
No.	Cat. No.	Stn No.			(m)	Ass.	Ass.	α	H	E	Abund (n/gsed)	%		%	ann	spr	sum	Index		(˚C)	(˚C)	(psu)	(mg/L)	(µmole/l)
W16	F202430	E446	38° 10' 00"S	172° 50' 00"E	1417	D1	e1	10	2.72	0.52	512	83	8	93	0.29	0.50	0.19	0.34	0.22	16.7	3.2	34.5	3	0.27
W18	F202432	C271	38° 20' 00"S	174° 11' 48"E	91	G9	nc	10	2.38	0.36	95	13	3	1	0.38	0.52	0.26	0.30	5.10	16.9	13.4	35.2	4.3	0.26
W19	F202433	C275	38° 20' 00"S	173° 43' 30"E	137	G6	h3	12	3.05	0.56	5468	51	5	47	0.33	0.51	0.24	0.26	2.76	16.8	12.9	35.2	3.8	0.27
W23	F202437	C358	38° 40' 00"S	173° 47' 30"E	121	G5	h3	7	2.45	0.45	1814	37	7	33	0.34	0.47	0.25	0.23	3.29	16.8	12.9	35.2	3.8	0.26
W24	F202438	B657	38° 37' 00"S	173° 07' 00"E	155	G5	h3	10	2.89	0.60	3562	48	5	37	0.34	0.57	0.23	0.30	2.55	16.8	12.9	35.2	3.8	0.27
W25	F202439	E441	38° 30' 00"S	172° 50' 00"E	498	D8	d3	10	2.64	0.42	3205	83	2	77	0.33	0.67	0.23	0.37	0.78	16.7	9	34.7	3.8	0.27
W26	F202440	E904	38° 30' 00"S	172° 24' 00"E	1244	C3	e1	12	2.84	0.52	264	76	7	97	0.30	0.49	0.22	0.32	0.27	16.7	4.1	34.5	3.2	0.27
W27	F202441	Q248	39° 55' 48"S	173° 09' 24"E	109	G3	h3	8	2.53	0.45	365	39	5	64	0.55	0.68	0.66	0.21	7.55	15.8	13.4	35.2	4.3	0.27
W28	F202442	G20	39° 32' 00"S	172° 48' 00"E	154	G5	h3	9	2.30	0.36	6397	26	6	51	0.42	0.60	0.35	0.27	3.49	16.0	12.9	35.2	3.8	0.27
W29	F202443	H112	39° 52' 00"S	172° 37' 12"E	194	G5	h3	11	2.93	0.52	2533	42	6	97	0.41	0.57	0.38	0.21	2.71	16.0	12	35.2	3.8	0.27
W30	F202444	C169	39° 40' 00"S	172° 25' 00"E	234	G5	h3	14	2.90	0.45	2165	54	5	86	0.38	0.57	0.32	0.25	2.01	16.0	11.7	35.1	3.8	0.27
W31	F202445	C625	39° 20' 00"S	172° 03' 00"E	276	G5	h3	14	3.06	0.54	3507	58	6	69	0.35	0.60	0.29	0.30	1.52	16.0	11.2	35.0	3.7	0.28
W32	F202446	B306	39° 28' 00"S	171° 39' 30"E	541	D2	d1	15	3.18	0.56	4268	84	2	92	0.36	0.61	0.28	0.35	0.79	16.1	8.6	34.6	3.8	0.28
W33	F202447	F736	39° 20' 00"S	171° 37' 00"E	746	D7	d1	14	3.02	0.51	697	88	4	97	0.39	0.62	0.25	0.35	0.65	16.1	7.2	34.5	3.5	0.28
W34	F202448	F840	39° 05' 00"S	171° 06' 00"E	850	D7	e1	12	3.13	0.65	805	92	1	91	0.30	0.51	0.23	0.35	0.39	16.1	6.8	34.5	3.4	0.29
W35	F202449	F730	38° 55' 00"S	171° 35' 00"E	1025	D1	e1	8	2.76	0.61	537	89	4	94	0.34	0.54	0.22	0.37	0.39	16.7	5.3	34.5	3.3	0.28
W36	F202450	F733	38° 53' 00"S	171° 50' 00"E	1120	D1	e1	8	2.59	0.49	1200	89	5	95	0.33	0.63	0.21	0.37	0.34	16.7	4.2	34.5	3.2	0.28
W37	F202451	F728	38° 38' 00"S	171° 48' 00"E	1233	D1	e1	15	3.22	0.66	610	96	3	95	0.29	0.50	0.19	0.34	0.26	16.7	4.1	34.5	3.2	0.28
W38	F202452	F6	38° 18' 00"S	171° 30' 00"E	1518	D1	nc	8	2.57	0.50	317	96	2	95	0.28	0.48	0.18	0.38	0.19	16.7	3	34.6	2.9	0.29
W39	F202453	G831	37° 45' 00"S	171° 24' 18"E	1748	C3	e1	11	2.72	0.47	458	93	7	97	0.26	0.42	0.17	0.37	0.15	17.2	2.8	34.6	2.9	0.29
W40	L13021	N550	40° 20' 00"S	174° 30' 00"E	109	G3	h3	8	2.78	0.57	-	15	-	74	0.55	0.69	0.60	0.15	7.57	15.2	13.4	35.2	4.3	0.26
W41	L13022	N551	40° 19' 42"S	174° 39' 00"E	105	G3	h3	9	2.71	0.48	-	16	-	63	0.55	0.70	0.53	0.17	7.76	15.2	13.4	35.2	4.3	0.26
W42	L13025	N554	40° 14' 54"S	174° 35' 12"E	98	G3	h3	9	2.67	0.48	-	5	-	60	0.52	0.66	0.53	0.18	7.68	15.2	13.4	35.2	4.3	0.26
W43	L13028	P614	40° 10' 24"S	174° 35' 00"E	90	G3	h1	13	2.90	0.47	-	10	-	55	0.54	0.69	0.55	0.18	8.82	15.2	13.4	35.2	4.3	0.26
W44	L13024	N553	40° 15' 00"S	174° 45' 00"E	87	G3	h1	12	2.82	0.51	-	20	-	60	0.51	0.61	0.47	0.16	8.46	15.2	13.6	35.2	4.4	0.26
W45	L13017	K784	40° 19' 48"S	175° 00' 00"E	85	G3	e1	12	3.06	0.61	-	16	-	67	0.86	0.65	0.49	0.26	18.73	15.3	13.6	35.2	4.4	0.26
W46	L13027	P613	40° 10' 48"S	174° 45' 42"E	78	G3	h1	14	3.07	0.54	-	13	-	27	0.50	0.61	0.45	0.15	9.11	15.2	13.6	35.2	4.4	0.26
W47	L13023	N552	40° 14' 36"S	174° 55' 00"E	77	G3	h1	12	3.08	0.60	-	5	-	45	0.53	0.62	0.45	0.17	10.13	15.2	13.6	35.2	4.4	0.26
W48	L13030	W113	40° 06' 54"S	174° 30' 00"E	76	G3	h1	17	3.20	0.55	-	15	-	30	0.52	0.64	0.50	0.16	9.90	15.2	13.6	35.2	4.4	0.26
W49	L13014	K768	40° 06' 54"S	174° 35' 24"E	72	G3	h1	18	3.32	0.62	-	0	-	36	0.51	0.60	0.48	0.13	10.20	15.2	13.8	35.2	4.4	0.26
W51	L13015	K769	40° 03' 36"S	174° 41' 24"E	57	G3	h1	15	3.01	0.48	-	0	-	24	0.81	0.89	0.55	0.30	25.56	15.2	13.8	35.2	4.4	0.26
W52	L13016	K778	40° 09' 48"S	174° 55' 18"E	55	G3	h1	18	3.19	0.54	-	3	-	27	1.03	1.07	0.57	0.13	37.97	15.2	13.8	35.2	4.4	0.26
W53	L13019	N306	40° 06' 36"S	174° 54' 06"E	50	G1	nc	14	3.21	0.65	-	1	-	3	0.67	0.76	0.45	0.24	21.95	15.2	13.8	35.2	4.4	0.26
W54	F202620	E774	42° 00' 00"S	169° 15' 00"E	1168	C6	e2	11	2.30	0.32	5402	92	5	83	0.31	0.40	0.28	0.26	0.29	15.4	4.2	34.5	3.2	0.35
W55	F202621	E773	42° 00' 00"S	169° 54' 18"E	968	D7	e2	13	2.93	0.55	5575	97	5	84	0.31	0.44	0.27	0.21	0.35	15.4	5.5	34.5	3.3	0.33
W56	F202622	D223	41° 10' 00"S	170° 14' 24"E	770	D7	d1	12	2.61	0.38	5923	90	3	74	0.30	0.46	0.26	0.28	0.42	15.9	7	34.5	3.4	0.3
W57	F202623	E772	42° 00' 00"S	170° 16' 24"E	748	D7	d1	15	2.92	0.44	12836	92	4	85	0.36	0.47	0.25	0.29	0.58	15.4	7.2	34.5	3.5	0.32
W58	F202624	D221	40° 06' 00"S	171° 16' 24"E	688	D7	d1	11	2.42	0.32	3395	86	3	85	0.34	0.53	0.31	0.30	0.58	15.7	7.9	34.5	3.6	0.29
W59	F202625	D222	40° 38' 00"S	170° 46' 24"E	651	D7	d1	9	2.62	0.39	30303	93	3	83	0.32	0.50	0.28	0.36	0.55	15.9	8.1	34.6	3.7	0.29
W60	F202626	S386	41° 20' 04"S	170° 40' 42"E	515	D2	d1	13	3.04	0.52	5876	88	3	56	0.32	0.53	0.25	0.26	0.70	15.9	9	34.7	3.8	0.3
W61	F202627	E771	42° 00' 00"S	170° 30' 30"E	508	D2	d1	15	3.26	0.60	14342	85	4	40	0.31	0.47	0.26	0.26	0.68	15.4	9	34.7	3.8	0.32
W62	F202628	E486	40° 05' 00"S	171° 55' 24"E	369	G7	h3	17	3.11	0.48	8223	64	7	41	0.36	0.56	0.31	0.28	1.15	15.7	10.3	34.9	3.7	0.28
W63	F202629	P192	40° 20' 28"S	171° 43' 42"E	325	G7	h3	12	2.95	0.44	17200	65	5	59	0.36	0.61	0.31	0.32	1.35	15.7	11.2	35.0	3.7	0.28
W64	F202630	P655	42° 20' 00"S	170° 38' 00"E	249	G	h3	14	2.96	0.49	2346	80	9	21	0.35	0.62	0.29	0.28	1.65	15.4	11.7	35.1	3.8	0.32
W65	F202631	H830	42° 01’ 02”S	171° 04’ 24”E	154	G2	h3	11	2.74	0.48	125	28	6	79	0.91	1.01	0.96	0.15	11.27	15.4	12.9	35.2	3.8	0.3

APPENDIX II. Details of additional qualitative deep-water faunal samples

Used for species frequency, duration and biogeography analyses.

Area	Cat. No.	NIWA Stn.	Depth	Latitude	Longitude	Location detail
North Cape	F201019		150 m			
North Cape	F201517		133 m			
Poor Knights Islands	F201049		120 m			
Poor Knights Islands	L17748		110 m	35˚ 30’S	174˚ 45’E	Mestayer collection
Poor Knights Islands	L17749		156 m	35˚ 40’S	174˚ 52’E	Mestayer collection, 16 km SE of islands
Hen & Chickens Islands	F201048		60 m			
Hen & Chickens Islands	F201050		77 m			
Little Barrier Island	F201354		77 m	36˚ 12’S	175˚ 04’E	
Little Barrier Island	L7932		55 m	36˚ 12’S	175˚ 05’E	Mestayer collection, 10 km W of island
Great Barrier Island	AU17804		96 m	36˚ 06’S	175˚ 31’E	NE of Rakitu Island
Great Barrier Island	AU17805		131 m	36˚ 02’S	175˚ 41’E	NE of Rakitu Island
Great Barrier Island	AU17806		146 m	36˚ 06’S	175˚ 44’E	NE of Rakitu Island
Great Barrier Island	AU17807		125 m	36˚ 06’S	175˚ 40’E	NE of Rakitu Island
Great Barrier Island	AU17808		144 m	36˚ 09’S	175˚ 46’E	E of Rakitu Island
Great Barrier Island	AU17809		98 m	36˚ 07’S	175˚ 34’E	E of Rakitu Island
Great Barrier Island	AU17810		86 m	36˚ 06’S	175˚ 31’E	NE of Rakitu Island
Great Barrier Island	AU17811		70 m	36˚ 07’S	175˚ 30’E	N of Rakitu Island
Great Barrier Island	L17753		201 m	~36˚ 00’S	175˚38’E	Mestayer collection
Great Barrier Island	F201389		500 m			
Great Barrier Island	F201390		750 m			
Cuvier Island	L8083		71 m	36˚ 26’S	175˚ 40’E	Mestayer collection, 10 km W of island
Cuvier Island	L17741		73 m	36˚ 29’S	175˚ 46’E	Mestayer collection, 6.5 km S of island
Cuvier Island	L17742		70 m	36˚ 30’S	175˚ 46’E	Mestayer collection, 8 km S of island
Cuvier Island	L17743		73 m	36˚ 29’S	175˚ 50’E	Mestayer collection, 8 km SE of island
Cuvier Island	L17744		60 m	36˚ 26’S	175˚ 35’E	Mestayer collection, 16 km W of island
Cuvier Island	L17745		73 m	~36˚ 21’S	175˚ 40’E	Mestayer collection, 15 km NW of island
Cuvier Island	L17746		70 m	36˚ 26’S	175˚ 40’E	Mestayer collection, 10 km W of island
Cuvier Island	L17747		70 m	36˚ 26’S	175˚ 41’E	Mestayer collection, 8 km W of island
Mayor Island	F201042		200 m			
Hawkes Bay		F601	375 m	40˚ 50’S	176˚ 44’E	30 km E of Castlepoint
Hawkes Bay		F861	329 m	40˚ 01’S	177˚ 22’E	30 km SE of Cape Kidnappers
Greymouth	F201288		610 m			
Snares Islands	F202072		100 m	46˚ 35’S	166˚ 52’E	
Auckland Islands	AU18457	J526	59 m	50º 51’S	166º 06’E	Carnley Harbour
Auckland Islands	AU18458	J515	54 m	50º 43’S	166º 07’E	Norman Inlet
Auckland Islands	AU18459	J512	59 m	50º 41’S	166º 12’E	Smith Harbour
Auckland Islands	F201015		300 m			
Auckland Islands	F201028		400 m			
Auckland Islands	F202511	J522	80 m	50º 53’S	166º 09’E	Carnley Harbour

APPENDIX III. Census data (relative abundance of benthic foraminifera)

Used in deep-sea quantitative ecologic distribution analyses.

This data is available for download from http://data.gns.cri.nz/paperdata/index.jsp

APPENDIX IV. Composite sample localities used for biogeographic and other analyses

New Zealand composite localities from which all benthic foraminiferal species were recorded for the species frequency, duration and biogeographic analyses (Figs 67, 73-79).

Sample repositories:

F	Institute of Geological and Nuclear sciences Ltd, Lower Hutt, New Zealand
L	Marine Departments, Auckland War Memorial Museum, Auckland, New Zealand
NIWA	National Institute for Water and Atmospheric Research, Wellington, New Zealand
UCF	Department of Geology, University of Canterbury, Christchurch, New Zealand

DEEP-WATER (>50 m) COMPOSITE LOCALITIES

1. North Cape mid abyssal
1 sample; 3000-4000 m depth; N1 (Hayward *et al.* 2006c)

2. North Cape upper abyssal
2 samples; 2000-3000 m depth; N8, N9 (Hayward *et al.* 2006c)

3. North Cape mid bathyal
1 sample; 600-1000 m depth; N21 (Hayward *et al.* 2006c)

4. North Cape uppermost bathyal
3 samples; 200-400 m depth; N29, N33, N36 (Hayward *et al.* 2006c)

5. North Cape mid shelf
2 samples; 50-100 m depth; F201019, 517

6. Cavalli Islands lower bathyal
1 sample; 1000-2000 m depth; N14 (Hayward *et al.* 2006c)

7. Cavalli Islands mid bathyal
1 sample; 600-1000 m depth; N22 (Hayward *et al.* 2006c)

8. Cavalli Islands upper bathyal
2 samples; 400-600 m depth; N24, N28 (Hayward *et al.* 2006c)

9. Cavalli Islands uppermost bathyal
2 samples; 200-400 m depth; N34, N37 (Hayward *et al.* 2006c)

10. Cavalli Islands outer shelf
2 samples; 100-200 m depth; N42, N48 (Hayward *et al.* 2006c)

11. Doubtless Bay mid shelf
1 sample; 50-100 m depth; N55 (Hayward *et al.* 2006c)

12. Poor Knights lower bathyal
3 samples; 1000-2000 m depth; N10, N12, N16 (Hayward *et al.* 2006c)

13. Poor Knights mid bathyal
2 samples; 600-1000 m depth; N17, N19 (Hayward *et al.* 2006c)

14. Poor Knights upper bathyal
1 sample; 400-600 m depth; N26 (Hayward *et al.* 2006c)

15. Poor Knights uppermost bathyal
1 sample; 200-400 m depth; N30 (Hayward *et al.* 2006c)

16. Poor Knights outer shelf
3 samples; 100-200 m depth; L17748-9, F201049

17. Poor Knights mid shelf
2 samples; 50-100 m depth; N70, N72 (Hayward *et al.* 2006c)

18. Chickens Islands mid bathyal
2 samples; 600-1000 m depth; N23, F201390 (Hayward *et al.* 2006c)

19. Chickens Islands uppermost bathyal
2 samples; 200-400 m depth; N32, N35 (Hayward *et al.* 2006c)

20. Chickens Islands outer shelf
5 samples; 100-200 m depth; N39, N40, N44, N45, N47 (Hayward *et al.* 2006c)

21. Chickens Islands mid shelf
9 samples; 50-100 m depth; N50, N54, N66-8, L7932, F201048, F201050, F201354 (Hayward *et al.* 1984, 2006c)

22. Great Barrier upper bathyal
2 samples; 400-600 m depth; N25, F201389 (Hayward *et al.* 2006c)

23. Great Barrier outer shelf
9 samples; 100-200 m depth; N38, N41, N43, N46, L17753, AU17805-8 (Hayward *et al.* 2006c)

24. Great Barrier mid shelf
18 samples; 50-100 m depth; N51-3, N56-65, N71, AU17804, AU17809-11 (Hayward & Grenfell 1994, Hayward *et al.* 2006c)

25. Cuvier inshore upper abyssal
2 samples; 2000-3000 m depth; N4, N7 (Hayward *et al.* 2006c)

26. Cuvier Island lower bathyal
3 samples; 1000-2000 m depth; N11, N13, N15 (Hayward *et al.* 2006c)

27. Cuvier Island mid bathyal
2 samples; 600-1000 m depth; N18, N20 (Hayward *et al.* 2006c)

28. Cuvier Island upper bathyal
1 sample; 400-600 m depth; N27 (Hayward *et al.* 2006c)

29. Cuvier Island uppermost bathyal
1 sample; 200-400 m depth; N31 (Hayward *et al.* 2006c)

30. Cuvier Island mid shelf
9 samples; 50-100 m depth; N49, L17741-8, L8083 (Hayward *et al.* 2006c)

31. Mayor Island uppermost bathyal
1 sample; 200-400 m depth; F201042

32. Whale Island outer shelf
1 sample; 100-200 m depth; N75 (Hayward *et al.* 2006c)

33. Cuvier offshore upper abyssal
2 samples; 2000-3000 m depth; N5, N6 (Hayward *et al.* 2006c)

34. Cuvier offshore mid abyssal
1 sample; 3000-4000 m depth; N3 (Hayward *et al.* 2006c)

35. Great Barrier mid abyssal
1 sample; 3000-4000 m depth; N2 (Hayward *et al.* 2006c)

36. East Cape upper abyssal
2 samples; 2000-3000 m depth; N73, N74 (Hayward *et al.* 2006c)

37. Kermadec Trench lower abyssal
1 sample; 4000-5000 m depth; N76

38. Kaipara uppermost bathyal
1 sample; 200-400 m depth; W1 (Hayward *et al.* 2003)

39. Kaipara lower bathyal
2 samples; 1000-2000 m depth; W6, W7 (Hayward *et al.* 2003)

40. Kaipara upper abyssal
2 samples; 2000-3000 m depth; W8, W9 (Hayward *et al.* 2003)

41. Raglan mid shelf
1 sample; 50-100 m depth; W11 (Hayward *et al.* 2003)

42. Raglan uppermost bathyal
1 sample; 200-400 m depth; W12 (Hayward *et al.* 2003)

43. Raglan upper bathyal
1 sample; 400-600 m depth; W13 (Hayward *et al.* 2003)

44. Raglan mid bathyal
2 samples; 600-1000 m depth; W14, W15 (Hayward *et al.* 2003)

45. Raglan lower bathyal
4 samples; 1000-2000 m depth; W2-5 (Hayward *et al.* 2003)

46. Urenui mid shelf
1 sample; 50-100 m depth; W18 (Hayward *et al.* 2003)

47. Urenui outer shelf
3 samples; 100-200 m depth; W19, W23, W24 (Hayward *et al.* 2003)

48. Urenui upper bathyal
1 sample; 400-600 m depth; W25 (Hayward *et al.* 2003)

49. Urenui lower bathyal
3 samples; 1000-2000 m depth; W16, W26, W39 (Hayward *et al.* 2003)

50. Egmont outer shelf
3 samples; 100-200 m depth; W27, W28, W29 (Hayward *et al.* 2003)

51. Egmont uppermost bathyal
2 samples; 200-400 m depth; W30, W31 (Hayward *et al.* 2003)

52. Egmont upper bathyal
1 sample; 400-600 m depth; W32 (Hayward *et al.* 2003)

53. Egmont mid bathyal
2 samples; 600-1000 m depth; W33, W34 (Hayward *et al.* 2003)

54. Egmont lower bathyal
4 samples; 1000-2000 m depth; W35-8 (Hayward *et al.* 2003)

55. Farewell uppermost bathyal
2 samples; 200-400 m depth; W62, W63

56. Farewell mid bathyal
1 sample; 600-1000 m depth; W58

57. Westport upper bathyal
1 sample; 400-600 m depth; W60

58. Westport mid bathyal
2 samples; 600-1000 m depth; W56, W59

59. Greymouth outer shelf
1 sample; 100-200 m depth; W65

60. Greymouth uppermost bathyal
1 sample; 200-400 m depth; W64

61. Greymouth upper bathyal
1 sample; 400-600 m depth; W61

62. Greymouth mid bathyal
3 samples; 600-1000 m depth; W55, W57, F201288

63. Greymouth lower bathyal
1 sample; 1000-2000 m depth; W54

64. Wanganui mid shelf
14 samples; 50-100 m depth; W40-W53 ((Hayward *et al.* 1997a)

65. Hawkes Bay uppermost bathyal
2 samples; 200-400 m depth; NIWA F601, NIWA F861 (Lewis 1979)

66. Hawkes Bay upper abyssal
1 sample; 2000-3000 m depth; E68

67. Hawkes Bay mid abyssal
3 samples; 3000-4000 m depth; E19-21 (Hayward *et al.* 2001, 2002)

68. Hawkes Bay lower abyssal
2 samples; 4000-5000 m depth; E22, E67 (Hayward *et al.* 2001, 2002)

69. Banks Peninsula mid shelf
2 samples; 50-100 m depth; E1, F201032 (Hayward *et al.* 2001, 2002)

70. West Chatham Rise outer shelf
2 samples; 100-200 m depth; E9, E10 (Hayward *et al.* 2001, 2002)

71. West Chatham Rise uppermost bathyal
3 samples; 200-400 m depth; E2, E3, E11 (Hayward *et al.* 2001, 2002)

72. West Chatham Rise upper bathyal
1 sample; 400-600 m depth; E4 (Hayward *et al.* 2001, 2002)

73. West Chatham Rise mid bathyal
1 sample; 600-1000 m depth; E5 (Hayward *et al.* 2001, 2002)

74. West Chatham Rise lower bathyal
2 samples; 1000-2000 m depth; E6, E7 (Hayward *et al.* 2001, 2002)

75. West Chatham Rise upper abyssal
1 sample; 2000-3000 m depth; E8 (Hayward *et al.* 2001, 2002)

76. Central Chatham Rise upper bathyal
3 samples; 400-600 m depth; E33, E34, E63 (Hayward *et al.* 2001, 2002)

77. North central Chatham Rise mid bathyal
3 samples; 600-1000 m depth; E12, E13, E62 (Hayward *et al.* 2001, 2002)

78. North central Chatham Rise lower bathyal
3 samples; 1000-2000 m depth; E14, E17, E18 (Hayward *et al.* 2001, 2002)

79. North central Chatham Rise upper abyssal
1 sample; 2000-3000 m depth; E61 (Hayward *et al.* 2001, 2002)

80. East Chatham Rise upper abyssal
1 sample; 2000-3000 m depth; E32 (Hayward *et al.* 2001, 2002)

81. Chatham Islands mid shelf
1 sample; 50-100 m depth; E23 (Hayward *et al.* 2001, 2002)

82. Chatham Islands outer shelf
1 sample; 100-200 m depth; E24 (Hayward *et al.* 2001, 2002)

83. Chatham Islands uppermost bathyal
1 sample; 200-400 m depth; E25 (Hayward *et al.* 2001, 2002)

84. Chatham Islands mid bathyal
2 samples; 600-1000 m depth; E26, E27 (Hayward *et al.* 2001, 2002)

85. Chatham Islands lower bathyal
1 sample; 1000-2000 m depth; E28 (Hayward *et al.* 2001, 2002)

86. Chatham Islands upper abyssal
1 sample; 2000-3000 m depth; E29 (Hayward *et al.* 2001, 2002)

87. Chatham Islands mid abyssal
2 samples; 3000-4000 m depth; E30, E31 (Hayward *et al.* 2001, 2002)

88. South Chatham Islands lower abyssal
1 sample; 4000-5000 m depth; E42 (Hayward *et al.* 2001, 2002)

89. South Chatham Rise mid bathyal
1 sample; 600-1000 m depth; E35 (Hayward *et al.* 2001, 2002)

90. South Chatham Rise lower bathyal
5 samples; 1000-2000 m depth; E36, E37, E38, E64, E65 (Hayward *et al.* 2001, 2002)

91. South Chatham Rise upper abyssal
2 samples; 2000-3000 m depth; E39, E40 (Hayward *et al.* 2001, 2002)

92. South Chatham Rise mid abyssal
1 sample; 3000-4000 m depth; E41 (Hayward *et al.* 2001, 2002)

93. Canterbury Bight outer shelf
1 sample; 100-200 m depth; E44 (Hayward *et al.* 2001, 2002)

94. Canterbury Bight uppermost bathyal
2 samples; 200-400 m depth; E45, E46 (Hayward *et al.* 2001, 2002)

95. Canterbury Bight upper bathyal
1 sample; 400-600 m depth; E47 (Hayward *et al.* 2001, 2002)

96. Canterbury Bight mid bathyal
1 sample; 600-1000 m depth; E48 (Hayward *et al.* 2001, 2002)

97. Canterbury Bight lower bathyal
3 samples; 1000-2000 m depth; E49-51 (Hayward *et al.* 2001, 2002)

98. Bounty Trough lower bathyal
2 samples; 1000-2000 m depth; E52, E53 (Hayward *et al.* 2001, 2002)

99. Bounty Trough upper abyssal
5 samples; 2000-3000 m depth; E54, E55, E66, S60, S61 (Hayward *et al.* 2001, 2002, 2007b)

100. Bounty Trough mid abyssal
2 samples; 3000-4000 m depth; E57, S62 (Hayward *et al.* 2001, 2002, 2007b)

101. Bounty Trough lower abyssal
1 sample; 4000-5000 m depth; E58 (Hayward *et al.* 2001, 2002)

102. Dunedin lower bathyal
5 samples; 1000-2000 m depth; S44, S47, S50, S51, S58 (Hayward *et al.* 2007b)

103. North Campbell Plateau lower bathyal
5 samples; 1000-2000 m depth; S45, S46, S52, S55, S56 (Hayward *et al.* 2007b)

104. Bounty Island mid bathyal
3 samples; 600-1000 m depth; S39, S40, S43 (Hayward *et al.* 2007b)

105. Bounty Island outer shelf
1 sample; 100-200 m depth; S7 (Hayward *et al.* 2007b)

106. Bounty Island upper bathyal
2 samples; 400-600 m depth; S22, S28 (Hayward *et al.* 2007b)

107. East Bounty Island lower bathyal
2 samples; 1000-2000 m depth; S49, S53 (Hayward *et al.* 2007b)

108. Bollons Seamount lower abyssal
2 samples; 4000-5000 m depth; S66, S68 (Hayward *et al.* 2007b)

109. Snares Island mid shelf
1 sample; 50-100 m depth; F202072 (Hayward *et al.* 2007c)

110. Stewart Island outer shelf
4 samples; 100-200 m depth; S4, S6, S8, S13 (Hayward *et al.* 2007b)

111. Stewart Island mid bathyal
4 samples; 600-1000 m depth; S31, S33, S34, S37 (Hayward *et al.* 2007b)

112. Pukaki Seamount mid shelf
1 sample; 50-100 m depth; S82 (Hayward *et al.* 2007b)

113. Pukaki Seamount uppermost bathyal
2 samples; 200-400 m depth; S16, S18 (Hayward *et al.* 2007b)

114. Pukaki Seamount upper bathyal
4 samples; 400-600 m depth; S21, S23, S24, S26 (Hayward *et al.* 2007b)

115. South-west Bounty Island lower bathyal
2 samples; 1000-2000 m depth; S48, S54 (Hayward *et al.* 2007b)

116. East Campbell Plateau mid abyssal
1 sample; 3000-4000 m depth; S63 (Hayward *et al.* 2007b)

117. East Campbell Plateau lower abyssal
2 samples; 4000-5000 m depth; S65, S67 (Hayward *et al.* 2007b)

118. South-west Campbell Island mid bathyal
2 samples; 600-1000 m depth; S32, S38 (Hayward *et al.* 2007b)

119. Campbell Island upper bathyal
2 samples; 400-600 m depth; S20, S25 (Hayward *et al.* 2007b)

120. Auckland Islands mid shelf
6 samples; 50-100 m depth; J512, 515, 522, 526, S1, S2 (Hayward et al., 2007b, c)

121. Auckland Islands outer shelf
2 samples; 100-200 m depth; S5, S12 (Hayward *et al.* 2007b)

122. Auckland Islands uppermost bathyal
2 samples; 200-400 m depth; F201015, 28 (Hayward et al., 2007b)

123. Auckland Islands upper bathyal
2 samples; 400-600 m depth; S19, S27 (Hayward *et al.* 2007b)

124. Auckland Islands mid bathyal
3 samples; 600-1000 m depth; S29, S35, S41 (Hayward *et al.* 2007b)

125. Campbell Island outer shelf
5 samples; 100-200 m depth; S9, S10, S11, S14, S15 (Hayward *et al.* 2007b)

126. Campbell Island uppermost bathyal
1 sample; 200-400 m depth; S17 (Hayward *et al.* 2007b)

127. Campbell Island mid bathyal
3 samples; 600-1000 m depth; S30, S36, S42 (Hayward *et al.* 2007b)

128. Far South lower bathyal
1 sample; 1000-2000 m depth; S57 (Hayward *et al.* 2007b)

129. Far South upper abyssal
1 sample; 2000-3000 m depth; S59 (Hayward *et al.* 2007b)

130. Far South lower abyssal
1 sample; 4000-5000 m depth; S64 (Hayward *et al.* 2007b)

SHALLOW-WATER (<50 m) COMPOSITE LOCALITIES (from Hayward et al., 1999)

131. Kermadec Islands
5 samples; HT-30 m depth; F202268, 69, L451, 1599, 10926

132. Three Kings Islands-Far North
8 samples
Three Kings -1 sample; 10 m depth; F202038
Parengarenga Harbour - 4 samples; HT-2 m depth; F201892, 93, 937, 43
Tapotupotu Bay estuary - 2 samples; HT; F202120, 21
Ahipara Reef - 1 sample; MT; F202117

133. Cavalli Islands
55 samples; 0-41 m depth; F201712-66 (Hayward 1982a)

134. Bay of Islands
11 samples; HT-7 m depth; F201774, 87, 96, 99, 802, 05, 09-11, 13, 14 (Hayward 1981)

135. Helena Bay
29 samples
Taiwawe Bay - 20 samples; 1-10.5 m depth; F201957-76 (Reid & Hayward 1997)
Owai Estuary - 9 samples; HT-LT; F201948-56 (Hayward 1993)

136. Poor Knights Islands-Tutukaka Harbour
6 samples
Poor Knights - 1 sample; 20 m depth; F201844
Tutukaka Harbour - 5 samples; 1-10 m depth; F201839-43 (Brook *et al.* 1981)

137. Chickens Islands
15 samples; 5-50 m depth; F201916-F201930 (Hayward *et al.* 1984)

138. North-east Great Barrier Island
27 samples; 1-50 m depth; F201848, 50, 51, 53, 54, 56, 58, 60, 63, 72-75, 78, 202040-1, 43, 45, 46, 48, 49, 51, 53-55, 57, 62 (Hayward & Grenfell 1994)

139. West Great Barrier Island
24 samples; MT-35 m depth; L2803, 07, 09-12, 15, 16, 18-20, 27, 28, 30-32, 35, 37, 38, 40-44 (Hayward & Grenfell 1994)

140. Pakiri-Little Barrier Island
6 samples
Pakiri - 1 sample; 40 m depth; L14171 (Morley *et al.* 1996)
Little Barrier - 5 samples; 4-50 m depth; F201907-11 (Hayward 1982b)

141. Whangateau Harbour-Kawau Island
2 samples
Whangateau Harbour - 1 sample; LT; F201353
Kawau Island - 1 sample; 10m depth; F201817

142. Waitemata Harbour
72 samples
Orakei Basin - 2 samples; HT-1 m depth; L509, 95.
Parnell Reef - 2 samples; LT; F201346, 47
Upper Waitemata - 68 samples; HT-8 m depth; L598-600, 04-06, 08-10, 61, 62, 839-48, 9819, 21, 30, 34, 36, 38, 40, 43, 45, 12001-25, 27 (Hayward *et al.* 1997b)

143. Cuvier Island-Cooks Beach
9 samples
Cuvier - 8 samples; 6-37 m depth; L17744, 46, F201833-38 (Hayward & Grace 1981)
Cooks Beach - 1 sample; MT; F202267

144. Whale Island
5 samples; 4-10 m depth; F202203-7 (Hayward 1990b)

145. Hawkes Bay
10 samples
South Hawkes Bay - 5 samples; 18-50 m depth; NIWA (Lewis 1979)
Castlepoint - 3 samples; LT-50 m depth; F201340, 881, 82

146. Kawerua- Maunganui Bluff.
5 samples
Kawerua - 4 samples; MT-1 m; F201680-83, 895 (Hayward 1979)
Maunganui Bluff - 1 sample; 87 m depth; F201009 (Hedley *et al.* 1965)

147. Kaipara
4 samples
Kaipara Harbour - 3 samples; HT-LT; L596, 97, F201987
offshore - 1 sample; 85 m depth; F201391

148. Manukau Harbour
4 samples; 0-6 m depth; F201372, 77, 421, 505 (Hulme 1964)

149. Raglan - Kawhia Harbours- Urenui
4 samples
Raglan - 2 samples; MT-LT; F202088, 91
Kawhia - 2 sample; MT-HT; F201192, 202094
Urenui - 4 samples; LT-22 m depth; F202085, L24013, 22, 23, 25

150. Patea River estuary - Wanganui
Patea - 2 samples; MT-LT; F202083, 84
Wanganui offshore - 16 samples; 10-49 m; L13001-7, 9-13, 19, 20, 26, 29 (Hayward et al., 1997a)

151. Manawatu Coast- Kapiti Island
5 samples; 50-130 m depth; F201274, 75, 78, 81, 82 (Vella 1957)
1 sample; 38 m depth; F201982

152. Pauatahanui Inlet
45 samples; HT-10 m depth; F201992-202037 (Hayward & Triggs 1994)

153. Marlborough Sounds
25 samples; 0.5-42 m depth; F201000, 202108, 12, L617-20, 22, 24-29, 31-35, 37-39, 41, 42, 46 (Hayward *et al.* 1997a)

154. Kaikoura Coast-Banks Peninsula
13 samples
Kaikoura - 9 samples; HT-94 m depth; F202261, UCF (Cameron 1995)
Lyttleton Harbour - 1 sample; HT; F202260
Akaroa Harbour - 3 samples; MT; F201887-88, 202259

155. Oparara Lagoon
11 samples; HT-MT; L647, 49-58 (Hayward & Hollis 1994)

156. Milford Sound-George Sound-Jacksons Bay
5 samples
Milford Sound - 3 samples; MT-120 m; F202245, NIWA A325-27 (Kustanowich 1965)
George Sound -1 sample; ? depth: F201169
Jacksons Bay – 1 sample; MT; AU16142

157. Dusky Sound
2 samples; 60 m depth; F201071, 101

158. Purakanui - Otago Heads - Clutha River mouth
54 samples
Purakanui Inlet - 52 samples; HT-1 m depth; L6701-48, 10649-52 (Hayward *et al.* 1996)
Otago Heads - 2 samples; LT-100 m depth; F201008, 202065
1 sample; 32 m depth; F201160

159. Stewart Island- Foveaux Strait
59 samples
Foveaux Strait - 2 samples; LT-25 m depth; F201210, 202075 (Hornibrook in Fleming 1952)
Port Pegasus - 57 samples; HT-45 m depth; L9674, F202271-75, 77, 78, 280-329 (Hayward *et al.* 1994)

160. Chatham Island
19 samples; 1-35 m depth; F201913, 14, L14036, 42, 55, 59-61, 63, 64, 83-91 (Hayward & Grenfell 1999)

161. Auckland Islands
20 samples; 0-80 m depth; AU18098-105, 18455-61, F201002, 6-7, 201162, F202511, L6184 (Hayward et al., 2007c)

162. Campbell Island
21 samples; 0-40 m depth; AU18107-16, 20-27, AU18462-4, F201105 (Hayward et al., 2007c)

APPENDIX V. Foraminifera recorded in this study from deep-water (>50 m) from around New Zealand

Includes rare species only recorded in extra qualitative picks from east of central New Zealand (Appendix 2 in Hayward *et al.* 2001).

List includes references to published figures that portray their features.

Plate and figure numbers in bold refer to illustrations in this publication.

Class Foraminiferida

Order Allogromiida

Placopsilinella aurantiaca Earland 1934. Loeblich & Tappan 1987, pl. 10, fig. 4. **Pl. 1, Fig. 1**

Order Astrorhizida

Bathysiphon alba (Heron-Allen & Earland 1932), pl.1, figs 16-18 (as *Hippocrepinella*)
Bathysiphon argenteus Heron-Allen & Earland 1913. Cushman 1918, pl. 12, figs 1-3. **Pl. 1, Figs 2-3**
Bathysiphon filiformis M. Sars 1872. Jones 1994, pl. 26, figs 15, 17-20. **Pl. 1, Figs 4-5**
Bathysiphon saeva (Saidova 1975). Saidova 1975, pl. 93, fig. 22 (as *Rhabdammina*).
Botellina labyrinthica Brady 1881. Jones 1994, pl. 29, figs 8-18. **Pl. 1, Figs 6-7**
Crithionina hispida Flint 1899. Cushman 1910, fig. 63.
Hyperammina cylindrica Parr 1950. Jones 1994, Pl. 23, figs 4, 7. **Pl. 1, Figs 8-9**
Hyperammina elongata Brady 1878. Jones 1994, pl. 23, fig. 8.
Hyperammina laevigata Wright 1891. Jones 1994, pl. 23, figs 9-10. **Pl. 1, Figs 10-11**
Hyperammina novaezealandiae Heron-Allen & Earland, 1922. Loeblich & Tappan 1994, pl. 1, figs 9-12. **Pl. 1, Figs 12-13**
Jullienella zealandica Hayward & Gordon 1984. Hayward & Gordon 1984, fig. 2, pl. 1 & 2. **Pl. 2, Figs 1-2**
Lagenammina arenulata (Skinner 1961). Jones 1994, pl. 30, fig. 5. **Pl. 1, Figs 24-25**
Lagenammina bulbosa (Chapman & Parr 1937, pl. 10, fig. 42). **Pl. 1, Figs 26-27**
Lagenammina difflugiformis (Brady 1879). Jones 1994, pl. 30, figs 1-3. **Pl. 1, Figs 28-29**
Lagenammina spiculata (Skinner 1961). Jones 1994, pl. 30, fig. 4. **Pl. 1, Fig. 30**
Marsipella cylindrica Brady 1882. Jones 1994, pl. 24, figs 20-22.
Marsipella elongata Norman 1878. Jones 1994, pl. 24, figs. 10-19. **Pl. 1, Fig. 17**
Psammophax consociata Rhumbler, in Wiesner 1931. Loeblich & Tappan 1987, pl. 19, figs 4-6.
Psammosphaera fusca Schulze 1875. Jones 1994, pl. 18, figs 2-3. **Pl. 1, Fig. 15**
Psammosphaera parva Flint 1899. Cushman 1918, pl. 12, figs 4-6. **Pl. 1, Fig. 16**
Psammosphaera rustica Heron-Allen & Earland 1912. Loeblich & Tappan 1987, pl. 43, figs 1-7 (as *Aggerostramen rusticum*)
Psammosphaera testacea Flint 1899. Cushman 1918, pl. 15, figs 1-3.
Rhabdammina abyssorum M. Sars 1869. Jones 1994, pl. 21, figs 1-8, 10-13.
Rhabdammina antarctica Saidova 1975, pl. 2, fig. 1. **Pl. 1, Figs 18-19**
Rhabdammina discreta Brady 1881. Jones 1994, pl. 22, figs 7-10. **Pl. 1, Fig. 20**
Rhabdammina major de Folin 1887. Gooday 1986, pl.2, figs 1-6. **Pl. 1, Figs 21-22**
Rhizammina algaeformis Brady 1879. Jones 1994, pl. 28, figs 1-11. **Pl. 1, Fig. 23**
Rhizammina sp.
Saccammina sphaerica Brady 1871. Jones 1994, pl. 18, figs 11-15. **Pl. 1, Figs 31-32**
Saccorhiza ramosa (Brady 1879). Loeblich & Tappan 1994, pl. 1, figs 4-5. **Pl. 1, Fig. 14**
Storthosphaera albida Schulze 1875. Jones 1994, pl. 25, figs 15-17.
Technitella legumen Norman 1878. Jones 1994, pl. 25, figs 8-10. **Pl. 1, Figs 33-34**
Tholosina vesicularis (Brady 1879). Jones 1994, pl. 35, figs 18-19.

Order Lituolida

Adercotryma glomeratum (Brady 1878). Jones 1994, pl. 34, figs 15-18. **Pl. 2, Figs 20-21**
Alveolophragmium zealandicum Vella 1957. Saidova 1975, pl. 23, fig. 6. **Pl. 2, Figs 25-26**
Ammobaculites agglutinans (d'Orbigny, 1846). Jones 1994, pl. 32, figs 19-20, 24-26. **Pl. 4, Figs 21-22**
Ammobaculites crassiformis Zheng 1988. Loeblich & Tappan 1994, pl. 7, figs 8-11.
Ammobaculites filiformis (Earland 1934). Jones 1994, pl. 32, figs 22-23. **Pl. 4, Figs 23-24**
Ammobaculites microformis Saidova 1970. Saidova 1975, pl. 98, fig. 6.
Ammobaculites paradoxus Clark 1994. Clark 1994, pl. 1, figs 5-22. **Pl. 4, Figs 25-26**
Ammobaculites villosus Saidova 1975. Loeblich & Tappan 1994, pl. 7, figs 12-15.

Ammodiscus exsertus Cushman 1910. Saidova 1975, pl. 17, fig. 8. **Pl. 2, Figs 3-4**
Ammodiscus gullmarensis Höglund 1947. Loeblich & Tappan 1994, pl. 3, figs 11-15. **Pl. 2, Figs 5-6**
Ammodiscus mestayeri Cushman 1919, pl. 74, figs 1-2. **Pl. 2, Figs 7-8**
Ammodiscus pacificus Cushman & Valentine1930, pl.1, fig.1.
Ammodiscus planorbis Höglund 1947, pl. 28, figs 13-16. **Pl. 2, Figs 9-10**
Ammodiscus profundissimus Saidova 1970. Saidova 1975, pl. 18, fig. 2. **Pl. 2, Fig**
Ammolagena clavata (Jones & Parker, 1860). Loeblich & Tappan 1994, pl. 4, figs 1-4. **Pl. 2, Figs 13-14**
Ammomarginulina ensis Wiesner 1931. Loeblich & Tappan 1987, pl. 60, fig. 7. **Pl. 4, Figs 27-28**
Ammoscalaria georgescotti Hayward n.sp. Jones 1994, pl. 33, figs 7, 9-11 (as *Ammobaculites* sp.nov.). **Pl. 3, Figs 8-12**
Ammoscalaria tenuimargo (Brady 1882). Hayward *et al.* 1999, pl. 1, figs 17-18.
Ammovertellina prima Suleymanov 1959. Loeblich & Tappan 1987, pl. 39, figs 1-7.
Buzasina galeata (Brady 1881). Jones 1994, pl. 40, figs 19-23. **Pl. 3, Figs 20-21**
Buzasina ringens (Brady 1879). Jones 1994, pl. 40, figs 17-18.
Cribrostomoides crassimargo (Norman 1892). Loeblich & Tappan 1994, pl. 10, figs 1-3 (as *Labrospira*). **Pl. 3, Figs 22-23**
Cribrostomoides jeffreysi (Williamson 1858). Hayward *et al.* 1999, pl. 1, figs 23-24. **Pl. 3, Figs 24-25**
Cribrostomoides spiculolega (Parr 1950). Loeblich & Tappan 1994, pl. 10, figs 4-5 (as *Labrospira spiculotesta*). **Pl. 3, Figs 26-27**
Cribrostomoides subglobosus (Cushman 1910). Jones 1994, pl. 34, figs 8-10. **Pl. 3, Figs 28-29**
Cribrostomoides subtrullissatus (Parr 1950). Saidova 1975, pl. 23, fig. 8 (as *Cyclammina*).
Cribrostomoides wiesneri (Parr 1950). Yassini & Jones 1995, figs 80,85. **Pl. 4, Figs 1-2**
Cyclammina cancellata Brady 1879. Jones 1994, pl. 37, figs 8-16.
Cyclammina pusilla Brady 1881. Jones 1994, pl. 37, figs 20-23. **Pl. 3, Figs 1-2**
Cyclammina trullissata (Brady 1879). Jones 1994, pl. 40, figs 13,16. **Pl. 3, Figs 3-4**
Cystammina pauciloculata (Brady 1879). Jones 1994, pl. 41, fig. 1. **Pl. 2, Fig. 22**
Discammina compressa (Goes 1882). Jones 1994, pl. 33, figs 26-28. **Pl. 3, Figs 5-7**
Eratidus foliaceus (Brady 1881). Jones 1994, pl. 33, figs 20-25. **Pl. 4, Figs 29-30**
Gaudryina convexa (Karrer 1865). Hayward *et al.* 1999, pl. 2, figs 14-15. **Pl. 4, Figs 50-51**
Gaudryina quadrangularis Bagg 1908. Loeblich & Tappan 1994, pl. 17, figs 22-23. **Pl. 4, Figs 52-53**
Globotextularia anceps (Brady 1884). Jones 1994, pl. 35, figs 12-15.
Glomospira gordialis (Jones & Parker 1860). Jones 1994, pl. 38, figs 7-9. **Pl. 2, Figs 15-16**
Haplophragmoides pusillus Collins 1974. Loeblich & Tappan 1994, pl. 7, figs 1-3.
Haplophragmoides neobradyi Uchio 1960, pl. 7, figs 15-16. **Pl. 4, Figs 3-4**
Haplophragmoides sphaeriloculum Cushman 1910. Hess & Kuhnt 1996, pl. 3, figs 12-13.
Hormosina globulifera Brady 1879. Jones 1994, pl. 39, figs 1-4,6.
Hormosina pilulifera (Brady 1884). Jones 1994, pl. 30, figs 18-20. **Pl. 4, Figs 4-8**
Hormosinella distans (Brady 1881). Jones 1994, pl. 31, figs 18-22. **Pl. 4, Figs 9-10**
Hormosinella guttifera (Brady 1881). Jones 1994, pl. 31, figs 10-15. **Pl. 4, Figs 11-12**
Labrospira sp.
Liebusella goësi Höglund 1947, pl.14, figs. 4-8. **Pl. 3, Fig. 13**
Liebusella improcera Loeblich & Tappan 1994, pl. 30, figs 1-3, pl. 49, figs 5-6.
Liebusella soldanii (Jones & Parker 1860). Jones 1994, pl. 32, figs 12-18. **Pl. 3, Figs 14-15**
Nouria polymorphinoides Heron-Allen & Earland 1914. Hayward *et al.* 1999, pl. 1, figs 9-10.
Parvigenerina arenacea (Heron-Allen & Earland, 1922). Loeblich & Tappan 1987, pl. 123, figs 13-16. **Pl. 4, Figs 31-32**
Recurvoidatus parcus Saidova 1970. Saidova 1975, pl. 21, figs 8-9. **Pl. 2, Fig. 23**
Recurvoides contortus Earland 1934. Loeblich & Tappan 1994, pl. 12, figs 1-14. **Pl. 2, Fig. 24**
Reophax dentaliniformis Brady 1881. Jones 1994, pl. 30, figs 21-22. **Pl. 4, Fig. 13**
Reophax hispidulus Cushman 1920, pl. 5, fig.7. **Pl. 4, Figs 14-15**
Reophax nodulosus Brady 1879. Jones 1994, pl. 31, figs 6-9. **Pl. 4, Figs 16-17**
Reophax pseudodistans Cushman 1919, pl.75, fig.1.
Reophax spiculifer Brady. Jones 1994, pl. 31, figs 16-17. **Pl. 4, Figs 18-19**
Reophax subfusiformis Earland 1933. Hayward *et al.* 1999, pl. 1, figs 15-16. **Pl. 4, Fig. 20**
Rhumblerella humboldti (Todd & Brönnimann 1957). Loeblich & Tappan 1994, pl. 20, figs 1-7. **Pl. 3, Figs 16-17**
Ruakituria pseudorobusta Kennett 1967. Loeblich & Tappan 1987, pl. 153, figs 10-13.
Spiroplectammina carteri Hayward n.sp. Jones 1994, pl. 45, figs 25-27 (as *S. biformis*). **Pl. 4, Figs 33-37**
Spiroplectinella proxispira (Vella 1957). Hayward *et al.* 1999, pl. 2, figs 9-11. **Pl. 4, Figs 38-40**
Spirotextularia fistulosa (Brady 1884). Hayward *et al.* 1999, pl. 2, figs 12-13. **Pl. 4, Figs 41-43**

Textulariella barretti (Parker & Jones 1876). Loeblich & Tappan 1987, pl. 154, figs 5-6. **Pl. 4, Figs 44-47**
Tolypammina horrida Cushman, 1919, pl. 74, fig. 5. **Pl. 2, Fig. 17**
Usbekistania charoides (Jones & Parker 1860). Jones 1994, pl. 38, figs 10-16. **Pl. 2, Figs 18-19**
Verneuilinulla propinqua (Brady 1884). Jones 1994, pl. 47, figs 8-12. **Pl. 3, Figs 18-19**

Order Trochamminida
Alterammina alternans (Earland 1934). Brönnimann & Whittaker, 1988, figs 45-46. **Pl. 5, Figs 1-4**
Paratrochammina bartrami (Hedley *et al.* 1967). Hayward *et al.* 1999, pl. 2, figs 1-3.
Paratrochammina challengeri Brönnimann & Whittaker 1988. Loeblich & Tappan 1994, pl. 22, figs 7-12. **Pl. 5, Figs 5-7**
Paratrochammina simplissima (Cushman & McCulloch 1939). Loeblich & Tappan 1994, pl. 24, figs 1-12. **Pl. 5, Figs 8-10**
Polystomammina nitida (Brady 1881). Jones 1994, pl. 41, figs 5-6. **Pl. 5, Figs 11-13**
Portatrochammina bipolaris Brönnimann & Whittaker. Jones 1994, pl.35, figs 6a-c.
Portatrochammina sorosa (Parr 1950). Hayward *et al.* 1999, pl.2, figs 4-5.
Pseudotrochammina dehiscens (Frerichs 1969). Loeblich & Tappan 1987, pl. 132, figs 6-11.
Rotaliammina sigmoidea Wells 1985, figs. 5d-i,11d,e,g.
Tritaxis fusca (Williamson 1858). Jones 1994, pl. 49, fig. 13. **Pl. 5, Figs 14-16**
Trochammina tasmanica Parr 1950. Saidova 1975, pl. 27, fig. 7. **Pl. 5, Figs 17-19**
Trochamminella conica (Parker & Jones 1865). Jones 1994, pl. 49, figs 15b, 16.
Trochamminopsis xishaensis (Zheng 1979). Loeblich & Tappan 1994, pl. 27, figs 1-3.

Order Textulariida
Cylindroclavulina bradyi (Cushman 1911). Jones 1994, pl. 48, figs 32-38. **Pl. 6, Figs 37-40**
Dorothia scabra (Brady 1884). Jones 1994, pl. 44, figs 12-13. **Pl. 5, Figs 20-22**
Eggerella bradyi (Cushman 1911). Loeblich &Tappan 1994, pl. 28, figs 9-14. **Pl. 5, Figs 23-24**
Karreriella bradyi (Cushman 1911). Loeblich & Tappan 1994, pl. 30, figs 8-9. **Pl. 5, Figs 25-27**
Karreriella novangliae (Cushman 1922). Jones 1994, pl. 46, figs 8-11.
Karreriella sp.
Karrerulina conversa (Grzybowski 1901). Jones 1994, pl. 46, figs 17-19. **Pl. 6, Figs 6-7**
Martinottiella communis (d'Orbigny 1846). Jones 1994, pl. 48, figs 1-2, 4-8. **Pl. 6, Figs 1-3**
Martinottiella omnia Saidova 1975. Saidova 1975, pl. 33, figs 3-4. **Pl. 6, Figs 4-5**
Planctostoma luculenta (Brady 1884). Jones 1994, pl. 43, figs 5-8.
Pseudoclavulina serventyi Chapman & Parr 1935. Jones 1994, pl. 48, figs 14-16. **Pl. 6, Figs 8-10**
Siphotextularia blacki Vella 1957. Hayward *et al.* 1999, pl. 2, figs 16-18. **Pl. 6, Figs 11-13**
Siphotextularia flintii (Cushman 1911). Loeblich & Tappan 1994, pl. 41, figs 8-15. **Pl. 6, Figs 14-15**
Siphotextularia foliosa Zheng 1988. Loeblich & Tappan 1994, pl. 42, figs 1-6. **Pl. 6, Figs 16-18**
Siphotextularia fretensis Vella 1957. Loeblich & Tappan 1994, pl. 41, figs 1-4. **Pl. 6, Figs 22-23**
Siphotextularia mestayerae Vella 1957. Hayward *et al.* 1999, pl. 2, figs 19-21. **Pl. 6, Figs 19-21**
Siphotextularia rolshauseni Phleger &Parker 1951. Jones 1994, pl. 43, fig. 11. **Pl. 6, Figs 24-25**
Textularia candeiana d'Orbigny 1839. Hayward *et al.* 1999, pl. 2, figs 24-26.
Textularia earlandi Parker 1952. Hayward *et al.* 1999, pl. 2, figs 22-23.
Textularia lythostrota (Schwager 1866). Gupta 1994, pl. 1, figs 4, 15. **Pl. 6, Figs 26-29**
Textularia pseudogramen Chapman & Parr 1937. Hayward *et al.* 1999, pl. 2, figs 27-29. **Pl. 6, Figs 30-32**
Textularia stricta Cushman 1911. Loeblich & Tappan 1994, pl. 38, figs 1-9. **Pl. 6, Figs 33-36**
Textularia subantarctica Vella 1957. Loeblich & Tappan 1994, pl. 39, figs 1-5.

Order Spirillinida
Mychostomina revertens (Rhumbler 1906). Hayward *et al.* 1999, pl. 3, figs 3-4.
Patellina corrugata Williamson 1858. Hayward *et al.* 1999, pl. 3, figs 11-13.
Planispirillina denticulata (Brady). Barker 1960, pl. 85, fig. 17.
Spirillina denticulogranulata Chapman 1907. Hayward *et al.* 1999, pl. 3, figs 5-6.
Spirillina novaezealandiae Chapman 1909, pl. 17, figs.4-5.
Spirillina vivipara Ehrenberg 1843. Hayward *et al.* 1999, pl. 3, fig. 7.

Order Miliolida
Cornuloculina inconstans (Brady 1879). Jones 1994, pl. 12, figs 5, 7-8.
Cornuloculina margaritifera (Heron-Allen & Earland, 1922), pl. 1, figs 9-12.
Cornuspira carinata (Costa 1856). Jones 1994, pl. 11, fig. 4.
Cornuspira expansa Chapman 1915, pl.1, fig.3.

Cornuspira foliacea (Philippi 1844). Hayward *et al.* 1999, pl. 3, figs 14-15.
Cornuspira lacunosa Brady 1884. Jones 1994, pl. 113, fig. 21.
Cornuspira planorbis Schultze 1854. Loeblich &Tappan 1994, pl. 56, figs 1-7.
Cornuspirella diffusa (Heron-Allen & Earland 1913). Hayward *et al.* 1999, pl. 3, figs 17-18.
Discospirina aff. *italica* (Costa 1856). Jones 1994, pl. 15, figs 6-7.
Inaequalina disparilis (Terquem 1878). Hayward *et al.* 1999, pl. 6, figs 1-3. **Pl. 9, Figs 25-29**
Massilina granulocostata (Germeraad 1946). Hayward *et al.* 1999, pl. 3, figs 22-23.
Miliolinella subrotunda (Montagu 1808). Hayward *et al.* 1999, pl. 3, fig. 24. **Pl. 7, Figs 1-3**
Miliolinella vigilax Vella 1957. Hayward *et al.* 1999, pl. 3, fig. 25.
Nubecularia sp.
Nummoloculina contraria (d'Orbigny 1846). Jones 1994, pl. 11, figs 10-11. **Pl. 7, Figs 4-6**
Nummulopyrgo globulus (Hofker 1976). Loeblich & Tappan 1994, pl. 65, figs 8-16. **Pl. 9, Figs 30-32**
Pseudoflintina triquetra (Brady 1879). Hayward *et al.* 1999, pl.4, figs 9-10.
Pyrgo clypeata (d'Orbigny 1846). Papp & Schmidt 1985, pl. 82, figs 4-6. **Pl. 7, Figs 7-10**
Pyrgo comata (Brady 1881). Jones 1994, pl. 3, fig. 9. **Pl. 7, Figs 11-12**
Pyrgo depressa (d'Orbigny 1826). Hayward *et al.* 1999, pl. 4, figs 5-6. **Pl. 7, Figs 13-14**
Pyrgo inornata (d'Orbigny 1846). Papp & Schmid 1985, pl. 84, figs 1-3. **Pl. 7, Figs 15-19**
Pyrgo murrhina (Schwager 1866). Loeblich &Tappan 1994, pl. 91, figs 11-15. **Pl. 7, Figs 20-23**
Pyrgo oligocenica Cushman 1935. Hayward *et al.* 1999, pl. 4, figs 3-4 (as *P. comata*).
Pyrgo ringens (Lamarck 1804). Gudmundsson 1998, figs 14l-n. **Pl. 8, Figs 1-4**
Pyrgo serrata (Bailey 1861). Loeblich & Tappan 1994, pl. 92, figs 3-6. **Pl. 8, Figs 5-6**
Pyrgo tasmanensis Vella 1957. Loeblich & Tappan 1994, pl. 94, figs 15-16. **Pl. 8, Figs 7-8**
Pyrgo williamsoni (Silvestri, 1923). Jones 1994, pl. 2, fig. 9 (as *P. elongata*).
Pyrgoella sphaera (d'Orbigny 1839). Jones 1994, pl. 2, fig. 4. **Pl. 8, Figs 9-11**
Quinqueloculina agglutinans d'Orbigny 1839. Hayward *et al.* 1999, pl. 4, figs 11-12.
Quinqueloculina auberiana d'Orbigny 1839. Hayward *et al.* 1999, pl. 4, figs 13-14. **Pl. 8, Figs 12-14**
Quinqueloculina sp. aff. *bicornis* (Walker & Jacob 1798). Hayward *et al.* 1999, pl. 4, figs 15-17.
Quinqueloculina bicostoides Vella 1957. Hayward *et al.* 1999, pl. 4, figs 18-20.
Quinqueloculina boueana d'Orbigny 1846. Papp & Schmid 1985, pl. 96, figs 8-9. **Pl. 8, Figs 15-17**
Quinqueloculina carinatastriata (Wiesner 1912). Hayward *et al.* 1999, pl. 5, figs 14-15 (as *Q. tenagos*).
Quinqueloculina cooki Vella 1957. Hayward *et al.* 1999, pl. 4, figs 21-22.
Quinqueloculina delicatula Vella 1957. Hayward *et al.* 1999, pl. 4, figs 23-24.
Quinqueloculina incisa Vella 1957. Hayward *et al.* 1999, pl. 4, figs 25-26.
Quinqueloculina oblonga (Montagu 1803). Hayward *et al.* 1999, pl. 4, figs 27-28.
Quinqueloculina parvaggluta Vella 1957. Hayward *et al.* 1999, pl. 5, figs 1-2. **Pl. 8, Figs 18-19**
Quinqueloculina rebeccae Vella 1957. Hayward *et al.* 1999, pl. 5, figs 3-5.
Quinqueloculina seminula (Linnaeus 1758). Hayward *et al.* 1999, pl. 5, figs 9-10. **Pl. 8, Figs 20-22**
Quinqueloculina suborbicularis d'Orbigny 1826. Hayward *et al.* 1999, pl. 5, figs 6-8. **Pl. 8, Figs 23-25**
Quinqueloculina subpolygona Parr 1945. Hayward *et al.* 1999, pl. 5, figs 11-13. **Pl. 9, Figs 1-4**
Quinqueloculina venusta Karrer 1868. Jones 1994, pl. 5, fig. 7. **Pl. 9, Figs 5-7**
Sigmoilina sigmoidea (Brady 1884). Jones 1994, pl. 2, figs 1-3. **Pl. 9, Figs 8-9**
Sigmoilopsis elliptica (Galloway & Wissler 1927). Hayward *et al.* 1999, pl. 5, figs 16-18. **Pl. 9, Figs 10-11**
Sigmoilopsis finlayi Vella 1957. Saidova 1975, pl. 46, fig. 7.
Sigmoiliopsis schlumbergeri (Silvestri 1904). Jones 1994, pl. 8, figs 1-4. **Pl. 9, Figs 12-16**
Sigmoilopsis wanganuiensis Vella 1957. Hayward *et al.* 1999, pl. 5, figs 19-20. **Pl. 9, Figs 17-18**
Siphonaperta crassa Vella 1957, pl.4, figs.62,64-66.
Spiroloculina antillaruma d'Orbigny 1839. Hayward *et al.* 1999, pl. 6, figs 4-5.
Spiroloculina carinata Fornasini 1905. Hayward *et al.* 1999, pl. 6, figs 6-7.
Spiroloculina communis Cushman & Todd 1944. Hayward *et al.* 1999, pl. 6, figs 8-9. **Pl. 10, Figs 1-5**
Spiroloculina novozelandica Cushman & Todd 1944, pl. 4, fig. 23. **Pl. 10, Figs 6-10**
Spiroloculina subaequa Mc Culloch 1977. Hayward *et al.* 1999, pl. 6, figs 10-11.
Spirosigmoilina pusilla (Earland 1934). Jones 1994, pl. 10, figs 9-10. **Pl. 9, Figs 19-20**
Spirosigmoilina tenuis (Czjzek 1848). Hayward *et al.* 1999, pl. 5, figs 21-22. **Pl. 9, Figs 21-22**
Triloculina chrysostoma (Chapman 1909). Hayward *et al.* 1999, pl. 5, figs 27-28.
Triloculina insignis (Brady 1881). Hayward *et al.* 1999, pl. 5, figs 23-24.
Triloculina striatotrigonula Parr 1941. Hayward *et al.* 1999, pl. 5, figs 25-26.
Triloculina tricarinata d'Orbigny 1826. Hayward *et al.* 1999, pl. 5, figs 29-30. **Pl. 9, Figs 23-24**
Triloculina trigonula (Lamarck 1804). Hayward *et al.* 1999, pl. 5, figs 31-32.
Triloculinella hornibrooki (Vella 1957). Hayward *et al.* 1999, pl. 5, figs 33-35.
Webbina sp.

Order Lagenida

Amphicoryna georgechapronierei Yassini & Jones 1995. Hayward *et al.* 1999, pl. 6, figs 38-39. **Pl. 13, Figs 17-18**

Amphicoryna hirsuta f. *hirsuta* (d'Orbigny 1826). Loeblich &Tappan 1994, pl. 116, figs 7-8 (as *Nodosaria*). **Pl. 13, Fig. 19**

Amphicoryna hirsuta f. *sublineata* (Brady 1884). Jones 1994, pl. 63, figs 19-22 (as *A. sublineata*). **Pl. 13, Fig. 20**

Amphicoryna leurodeira Loeblich &Tappan 1994, pl. 127, figs 19-24.

Amphicoryna scalaris (Batsch 1798). Jones 1994, pl. 65, figs 7-9.

Amphicoryna separans (Brady 1884). Jones 1994, pl. 64, figs 16-19. **Pl. 13, Figs 21-22**

Astacolus crepidulus (Fichtel & Moll 1798). Hayward *et al.* 1999, pl. 6, figs 28-29. **Pl. 13, Figs 23-24; Pl. 14, Figs 1-2**

Astacolus insolitus (Schwager 1866). Hayward *et al.* 1999, pl. 6, fig. 30.

Astacolus neolatus Vella 1957, pl. 7, figs 143, 146-148.

Botuloides pauciloculus Zheng 1979. Jones 1994, pl. 61, figs 23-24 (as *Glandulonodosaria calomorpha*). **Pl. 12, Figs 27-28**

Cushmanina striatopunctata (Parker & Jones 1865). Jones 1994, pl. 58, figs 37,40. **Pl. 10, Figs 11-13**

Cushmanina spp.

Dentalina acuta (d'Orbigny 1846). Papp & Schmid 1985, pl.18, figs 1-6.

Dentalina cuvieri (d'Orbigny 1826). Loeblich &Tappan 1987, pl. 439, fig. 19. **Pl. 12, Figs 29-30**

Dentalina decepta Bagg 1912, pl.1, fig.3.

Dentalina mutabilis Costa 1855. Hayward 2002, pl.2, figs 30-32 (as *Dentalina flintii*).

Dentalina mutsui Hada 1913. Loeblich &Tappan 1994, pl. 113, figs 20-22.

Enantiodentalina muraii Uchio 1953. Loeblich &Tappan 1994, pl. 115, figs 7-10.

Exsculptina eccentrica (Sidebottom 1912) pl. 16, figs 5-6 (as *Lagena stelligera* var. *eccentrica*). **Pl. 10, Figs 14-15**

Exsculptina exsculpta (Brady 1881). Jones 1994, pl. 58, fig. 1, pl. 61, fig. 5. **Pl. 10, Figs 16-17**

Exsculptina spp.

Favulina favosopunctata (Brady 1881). Jones 1994, pl. 58, fig. 35 (as *Oolina favosopunctata*). **Pl. 10, Figs 18-19**

Favulina hexagona (Williamson, 1848). Hayward *et al.* 1999, pl. 8, fig. 2 (as *Oolina hexagona*). **Pl. 10, Figs 20-21**

Favulina hexagoniformis (McCulloch, 1977) pl. 54, fig. 19. **Pl. 10, Figs 22-23**

Favulina melo (d'Orbigny 1839). Hayward *et al.* 1999, pl. 8, fig. 3 (as *Oolina melo*).

Favulina melosquamosa (McCulloch, 1977) pl. 54, figs 26-28. **Pl. 10, Figs 24-25**

Favulina squamosa (Montagu 1803). Jones 1994, pl. 58, figs 28-32 (as *Oolina squamosa*).

Favulina vadosa (McCulloch, 1977) pl. 54, figs 21,23,24. **Pl. 10, Figs 26-27**

Favulina spp.

Fissurina annectens (Burrows & Holland, 1895). Hayward *et al.* 1999, pl. 7, fig. 16 (as *F. claricurta*).

Fissurina bispinosa (Heron-Allen & Earland 1932), pl. 11, figs 1-2. **Pl. 10, Figs 28-29**

Fissurina clathrata (Brady 1884). Hayward *et al.* 1999, pl. 7, fig. 17.

Fissurina aff. *fimbriata* (Brady 1881). Jones 1994, pl. 60, figs 26-27. **Pl. 10, Figs 30-31**

Fissurina laevigata Hayward *et al.* 1999, pl. 7, figs 18-19.

Fissurina laureata (Heron-Allen & Earland 1932). Yassini & Jones 1995, figs 412,416 (as *F. rugosocarinata*). **Pl. 10, Figs 32-33**

Fissurina lucida (Williamson 1848). Hayward *et al.* 1999, pl. 7, figs 20-21.

Fissurina marginata (Montagu 1803). Hayward *et al.* 1999, pl. 7, figs 22-23.

Fissurina orbignyana Seguenza 1862. Hayward *et al.* 1999, pl. 7, fig. 24.

Fissurina cf. *southbayensis* McCulloch 1977. Hayward *et al.* 1999, pl. 7, figs 25-26.

Fissurina spinosa (Sidebottom, 1912). Loeblich & Tappan 1994, pl. 157, figs 1-11. **Pl. 10, Figs 34-35**

Fissurina spp.

Francuscia extensa (Cushman, 1923). Jones 1994, pl. 73, figs 18-19. **Pl. 13, Figs 1-2**

Frondicularia compta Brady 1879. Jones 1994, pl. 65, fig. 19. **Pl. 12, Figs 31-33**

Galwayella trigonomarginata (Parker & Jones 1865). Jones 1994, pl. 61, fig. 12. **Pl. 11, Figs 1-2**

Glandulina ovula d'Orbigny 1846. Jones 1994, pl. 61, figs 17-22. **Pl. 12, Figs 1-2**

Glandulina sp.

Globulina minuta (Roemer 1838). Jones 1994, pl.71, fig.16.

Grigelis neopyrula (McCulloch 1981), pl.28, figs 24-25.

Grigelis orectus Loeblich & Tappan 1994. Hayward *et al.* 1999, pl. 6, figs 14-15.

Grigelis semirugosa (d'Orbigny 1846). Jones 1994, pl. 63, figs 23-27.

Guttulina bartschi Cushman & Ozawa 1930. Hayward *et al.* 1999, pl. 7, fig. 8.

Guttulina irregularis (d'Orbigny 1846). Hayward *et al.* 1999, pl. 7, figs 10-11.

Guttulina ovata (d'Orbigny 1826). Jones 1994, pl.72, figs 7-8.

Guttulina regina (Brady, Parker & Jones 1870). Jones 1994, pl.73, figs 11-13 (as *Globulina regina*).

Guttulina yabei Cushman & Ozawa 1929. Hayward *et al.* 1999, pl. 7, fig. 12.

Hemirobulina angistoma (Stache, 1864). Jones 1994, pl. 65, figs 5-6 (as *Marginulina obesa*). **Pl. 13, Figs 25-27**
Hemirobulina hydropica (Hornibrook 1961) pl. 5, figs 74-75,79-80. **Pl. 13, Figs 28-30**
Homalohedra liratiformis (McCulloch 1977), pl. 53, figs 25,32. **Pl. 11, Figs 3-4**
Homalohedra spp.
Hyalinonetrion gracillima (Seguenza 1862). Jones 1984, pl. 5, figs 18-20. **Pl. 12, Figs 5-6**
Laculatina quadrilatera (Earland, 1934), pl. 7, figs 10-11. **Pl. 11, Figs 5-6**
Laevidentalina advena (Cushman). Jones 1994, pl. 63, fig. 1. **Pl. 12, Figs 34-35**
Laevidentalina ariena Patterson & Pettis 1986. Jones 1994, pl. 62, figs 27-31.
Laevidentalina badenensis (d'Orbigny, 1846). Hayward *et al.* 1999, pl. 6, figs 18-19 (as *L. filiformis*). **Pl. 12, Figs 36-39**
Laevidentalina elegans (d'Orbigny 1846). Jones 1994, pl. 62, figs 25-26. **Pl. 12, Figs 40-42**
Laevidentalina haueri (Neugeboren, 1856). Hayward *et al.* 1999, pl. 6, figs 16-17 (as *L. bradyensis*). **Pl. 12, Figs 43-47**
Laevidentalina inornata (d'Orbigny 1846). Hayward *et al.* 1999, pl. 6, figs 22-23 (as *L. subemaciata*). **Pl. 12, Figs 48-52**
Laevidentalina sidebottomi Cushman 1923. Loeblich & Tappan 1994, pl. 113, figs 13-19. **Pl. 12, Figs 53-56**
Laevidentalina spp.
Lagena crenata Parker & Jones 1865. Jones 1994, pl. 57, figs 15, 21. **Pl. 12, Figs 7-10**
Lagena hispida Reuss 1863. Hayward *et al.* 1999, pl. 7, figs 1-2.
Lagena hispidula Cushman 1913. Jones 1994, pl. 56, figs 10-11. **Pl. 12, Figs 11-12**
Lagena laevicostatiformis McCulloch 1981. Hayward *et al.* 1999, pl. 7, fig. 3.
Lagena oceanica Albani 1974. Loeblich & Tappan 1994, pl. 144, figs 4-7 (as *Pygmaeoseistron oceanicum*). **Pl. 12, Figs 13-14**
Lagena peculiariformis Albani & Yassini 1989. Yassini & Jones 1995, figs 334-337,339. **Pl. 12, Figs 15-16**
Lagena spicata Cushman & McCulloch 1950. Hayward *et al.* 1999, pl. 7, figs 4-5.
Lagena spiratiformis McCulloch 1981. Hayward *et al.* 1999, pl. 7, figs 6-7.
Lagena tokiokai Uchio 1962. Loeblich & Tappan 1994, pl. 140, figs 6-9. **Pl. 12, Figs 17-18**
Lagena spp.
Lagenosolenia confossa (McCulloch 1977). Hayward *et al.* 1999, pl. 7, figs 27-28. **Pl. 11, Figs 7-8**
Lagenosolenia falcata (Chaster 1892), pl. 1, fig. 7. **Pl. 11, Figs 9-10**
Lagenosolenia spp.
Lagnea honshuensis (McCulloch 1977), pl. 51, fig. 2 (as *Lagenosolenia lagenoides honshuensis*). **Pl. 11, Figs 11-12**
Lagnea neosigmoidella (McCulloch 1977), pl. 51, fig . 9 (as *Lagenosolina neosigmoidella*). **Pl. 11, Figs 13-14**
Lagnea spp.
Laryngosigma aff. *compacta* McCulloch 1977, pl. 86, figs 9-11, 22-24, 32-34.
Lenticulina anaglypta Loeblich & Tappan 1987, pl. 449, figs 7-8. **Pl. 13, Figs 31-32; Pl. 14, Figs 3-4**
Lenticulina antarctica Parr 1950, pl. 11, fig. 11. **Pl. 14, Figs 5-6**
Lenticulina australis Parr 1950. Hayward *et al.* 1999, pl. 6, figs 31-32. **Pl. 13, Figs 33-34; Pl. 14, Figs 7-8**
Lenticulina calcar (Linnaeus 1758). Jones 1994, pl. 70, figs 9-12. **Pl. 14, Figs 9-10; Pl. 15, Figs 1-2**
Lenticulina cultrata (Montfort 1808). Loeblich & Tappan 1987, pl. 446, figs 9-10. **Pl. 14, Figs 11-12**
Lenticulina denticulifera (Cushman, 1913). Jones 1994, pl. 70, figs 7-8. **Pl. 14, Figs 13-14**
Lenticulina erratica Hornibrook 1961. Hayward *et al.* 1999, pl. 6, figs 33-34.
Lenticulina foliata (Stache 1865). Hornibrook et al. 1989, fig. 19:18. **Pl. 14, Figs 15-16**
Lenticulina formosa (Cushman 1923). Jones 1994, pl. 70, figs 13-14. **Pl. 14, Figs 17-18; Pl. 15, Figs 3-4**
Lenticulina gibba (d'Orbigny 1839). Jones 1994, pl. 69, figs 8-9. **Pl. 14, Figs 19-20**
Lenticulina limbosa (Reuss 1863). Yassini & Jones 1994, fig. 726. **Pl. 14, Figs 21-22**
Lenticulina orbicularis (d'Orbigny 1826). Jones 1994, pl. 69, fig. 17. **Pl. 14, Figs 23-24**
Lenticulina subgibba Parr 1950. Hayward *et al.* 1999, pl. 6, fig. 35. **Pl. 14, Figs 25-26; Pl. 15, Figs 5-6**
Lenticulina submamilligera (Cushman, 1917). Jones 1994, pl. 70, figs 17-18. **Pl. 14, Figs 27-28; Pl. 15, Figs 7-8**
Lenticulina suborbicularis Parr 1950. Loeblich & Tappan 1994, pl. 123, figs 1-9. **Pl. 14, Figs 29-30**
Lenticulina tasmanica Parr 1950. Jones 1994, pl. 69, figs 9-12 (as *L. atlantica*). **Pl. 14, Figs 31-32**
Lingulina grandis Cushman 1917, pl. 43, fig. 1. **Pl. 12, Figs 57-58**
Marginulina striata d'Orbigny 1852. Loeblich & Tappan 1994, pl. 131, figs 14-20. **Pl. 15, Figs 9-11**
Marginulinopsis bradyi (Goës, 1894). Jones 1994, pl. 65, figs 11-12. **Pl. 15, Fig. 12**
Marginulinopsis tenuis (Bornemann 1855). Jones 1994, pl. 66, figs 21-23. **Pl. 15, Figs 13-14**
Mucronina aff. *advena* (Cushman 1923). Loeblich & Tappan 1987, pl. 444, figs 7-9. **Pl. 12, Figs 59-61**
Neolenticulina variabilis (Reuss 1850). Hayward *et al.* 1999, pl. 6, figs 36-37 (as *N. peregrina*). **Pl. 14, Figs 33-34; Pl. 15, Figs 15-16**
Nodosaria inflexa Reuss 1866. Hayward *et al.* 1999, pl. 6, figs 20-21 (as *Laevidentalina inflexa*).
Nodosaria nebulosa (Ishizaki 1943). Hayward *et al.* 1999, pl. 6, fig. 27.

Nodosaria subsoluta (Cushman 1923). Jones 1994, pl. 62, figs 13-16 (as *Dentalina subsoluta*).
Oolina borealis Loeblich & Tappan 1954. Hayward *et al.* 1999, pl. 8, fig. 1.
Oolina emaciata (Reuss 1863). Reuss 1863. White 1928, pl. 29, fig. 8.
Oolina felsinea (Fornasini 1894). Jones 1994, pl.56, fig. 4 (as *Parafissurina felsinea*).
Oolina globosa (Montagu 1803). Yassini & Jones 1995, figs 369-370
Oolina lineata (Williamson 1848). Loeblich & Tappan 1987, pl. 463, figs 10-11. **Pl. 11, Figs 15-16**
Oolina setosa (Earland 1934). Hermelin 1989, pl. 10, fig. 6.
Oolina stelligera (Brady 1881). Jones 1994, pl. 57, figs 17, 35-36. **Pl. 11, Figs 17-19**
Oolina tasmanica Parr 1950. Hayward *et al.* 1999, pl. 8, fig. 4.
Oolina spp.
Palliolatella bradyiformis McCulloch 1977, pl. 61, fig. 14. **Pl. 11, Figs 20-21**
Palliolatella lacunata paucialveolata Albani & Yassini 1989. Hayward *et al.* 1999, pl. 7, figs 31-32.
Palliolatella quadrirevertens (McCulloch 1977). Hayward *et al.* 1999, pl. 7, figs 29-30 (as *Lagenosolina quadrirevertens*).
Palliolatella spp.
Parafissurina lateralis (Cushman 1913). Jones 1994, pl.56, figs 17-18. **Pl. 11, Figs 22-23**
Parafissurina ventricosa (Silvestri 1904b), fig. 6.
Parafissurina spp.
Planularia spinipes (Cushman 1913). Hayward *et al.* 1999, pl. 6, figs 40-41 (as *P. australis*). **Pl. 15, Figs 17-19**
Procerolagena distomamargaritifera (Parker & Jones 1865). Jones 1994, pl. 58, fig. 16. **Pl. 12, Figs 19-20**
Procerolagena meridionalis (Wiesner 1931). Jones 1994, pl. 58, fig. 19. **Pl. 12, Figs 21-24**
Procerolagena multilatera (McCulloch 1977). Loeblich & Tappan 1994, Pl. 144, fig. 8. **Pl. 12, Figs 25-26**
Procerolagena spp.
Pseudofissurina spp.
Pseudonodosaria brevis (d'Orbigny 1846). Loeblich & Tappan 1994, pl. 117, figs 1-6 (as *P. discreta*). **Pl. 12, Figs 62-63**
Pyramidulina cf. *doliolaris* Parr 1950, pl.12, fig.2, as *Nodosaria.*
Pyramidulina pauciloculata Cushman & Grey 1946. Yassini & Jones 1995, figs 656-657 (as *Vaginulina* cf. *advena pauciloculata*).
Pyramidulina spp.
Pyrulina angusta (Egger 1857). Jones 1994, pl. 72, figs 1-2. **Pl. 13, Figs 3-4**
Pyrulina fusiformis (Roemer 1838). Jones 1994, pl. 72, fig. 4. **Pl. 13, Figs 5-8**
Pyrulina gutta (d'Orbigny 1839). Jones 1994, pl.71, fig.14.
Ramulina globulifera Brady 1879. Jones 1994, pl. 76, figs 22-28. **Pl. 13, Fig. 9**
Reussoolina strangeri Loeblich & Tappan 1994, pl. 142, figs 9-10.
Saracenaria altifrons (Parr 1950). Jones 1994, pl. 114, fig. 17. **Pl. 15, Figs 20-24**
Saracenaria italica Defrance 1824.Jones 1994, pl. 68, figs 18, 20-23. **Pl. 15, Figs 25-27**
Saracenaria latifrons (Brady 1884). Hayward *et al.* 1999, pl. 6, figs 44-45. **Pl. 15, Figs 28-34**
Saracenaria spinosa Eichenberg 1935. Hayward *et al.* 1999, pl. 6, figs 42-43 (as *S. italica*). **Pl. 16, Figs 1-2**
Seabrookia pellucida Brady 1890. Loeblich & Tappan 1994, pl. 170, figs 1-9. **Pl. 12, Figs 3-4**
Sigmoidella elegantissima (Brady, Parker & Jones 1870). Jones 1994, pl. 72, fig.12-15. **Pl. 13, Figs 10-13**
Sigmoidella pacifica Cushman & Ozawa 1928. Loeblich & Tappan 1987, pl. 459, figs 5-7. **Pl. 13, Figs 14-16**
Vaginulina inflata Parr 1950, pl. 11, figs 21-22. **Pl. 16, Fig. 3**
Vaginulina spinigera Brady 1881. Jones 1994, pl. 67, figs 13-14. **Pl. 15, Figs 4-7**
Vaginulina sp.
Vaginulinopsis gnamptina Loeblich & Tappan, 1994, pl. 132, figs 11-16. **Pl. 16, Figs 8-11**
Vaginulinopsis sublegumen Parr 1950. Jones 1994, pl. 66, fig.13.
Vaginulinopsis tasmanica Parr 1950. Jones 1994, pl. 67, fig. 7. **Pl. 16, Figs 12-15**
Vasicostella rara (McCulloch 1977), pl. 52, fig. 2 (as *Lagenosolenia*). **Pl. 11, Figs 24-25**
Vasicostella squamosoalata (Brady 1881). Jones 1994, pl.60, fig. 23. **Pl. 11, Figs 26-29**
Ventrosoma scaphaeformis (Parr 1950), pl. 10, figs 1-3 (as *Parafissurina*). **Pl. 11, Figs 30-31**
Ventrosoma unguis (Heron-Allen & Earland 1913), pl. 7, figs 1-3 (as *Lagena*). **Pl. 11, Figs 32-33**
Wiesnerina baccata (Heron-Allen & Earland 1929). Hayward *et al.*, pl.7, fig.15, as *Fissurina.*
Wiesnerina scarabaeus (Heron-Allen & Earland 1922), pl. 6, figs 20-23. **Pl. 11, Fig. 34**

Order Robertinida

Hoeglundina elegans (d'Orbigny 1826). Hayward *et al.* 1999, pl. 8, figs 5-7. **Pl. 16, Figs 16-21**
Robertinoides oceanicus (Cushman & Parker 1947). Jones 1994, pl. 50, fig. 19. **Pl. 16, Figs 22-24**

Order Buliminida

Abditodentrix pseudothalmanni (Boltovskoy & Guissani de Kahn 1981). Loeblich & Tappan, 1994, pl. 218, figs 1-2. **Pl. 17, Figs 11-12**

Bolivina alata (Seguenza 1862). Jones 1994, pl. 53, figs 2-4. **Pl. 16, Figs 25-26**

Bolivina cacozela Vella 1957. Hayward *et al.* 1999, pl. 8, figs 8-9. **Pl. 16, Figs 27-28**

Bolivina compacta Sidebottom 1905. Hayward *et al.* 1999, pl. 8, figs 10-11. **Pl. 16, Figs 29-30**

Bolivina earlandi Parr 1950, pl. 12, fig.16. **Pl. 16, Figs 31-33**

Bolivina glutinata Egger 1893. Hayward *et al.* 1999, pl. 8, fig. 16.

Bolivina neocompacta McCulloch 1981. Hayward *et al.* 1999, pl. 8, figs 12-13.

Bolivina pseudolobata Yassini & Jones 1995, fig. 555. **Pl. 16, Figs 34-36**

Bolivina pseudoplicata Heron-Allen & Earland 1930. Hayward *et al.* 1999, pl. 8, figs 14-15.

Bolivina pusilla Schwager 1866. Kawagata 1999, fig. 4 (2a, b). **Pl. 16, Figs 37-38**

Bolivina pygmaea (Brady 1881). Jones 1994, pl. 53, figs 5-6. **Pl. 16, Figs 39-40**

Bolivina robusta Brady 1881. Jones 1994, pl. 53, figs 7-9. **Pl. 16, Figs 41-42**

Bolivina seminuda Cushman 1911. Kawagata 1999, fig. 4:4. **Pl. 17, Figs 1-3**

Bolivina spathulata (Williamson 1858). Hayward *et al.* 1999, pl. 8, fig. 17. **Pl. 17, Figs 4-5**

Bolivina striatula Cushman 1922. Hayward *et al.* 1999, pl. 8, fig. 21.

Bolivina variabilis (Williamson 1858). Loeblich & Tappan, 1994, pl. 216, figs 7-15. **Pl. 17, Figs 6-10**

Bolivinita quadrilatera (Schwager 1866). Jones 1994, pl. 42, figs 8-12. **Pl. 17, Figs 13-16**

Bulimina elongata d'Orbigny 1826. Hayward *et al.* 1999, pl. 9, figs 6-7.

Bulimina exilis Brady 1884. Vella 1957, pl.8, figs 164-165.

Bulimina marginata f. acaenapeza Loeblich & Tappan, 1994. Loeblich & Tappan, 1994, pl. 243, figs 1-6. **Pl. 17, Figs 17-18**

Bulimina marginata f. *acanthia* Costa 1856. Hayward *et al.* 1999, pl. 9, figs 16-17. **Pl. 17, Fig. 19**

Bulimina marginata f. *aculeata* d'Orbigny 1826. Hayward *et al.* 1999, pl. 9, figs 10-12. **Pl. 17, Figs 20-22**

Bulimina marginata f. *marginata* d'Orbigny 1826. Hayward *et al.* 1999, pl. 9, figs 13-15. **Pl. 17, Figs 23-24**

Bulimina striata d'Orbigny 1826. Loeblich & Tappan, 1994, pl. 242, figs 8-14. **Pl. 17, Figs 25-27**

Bulimina subornata Brady 1884. Jones 1994, pl. 51, fig. 6.

Bulimina truncana Gümbel 1868. Hayward *et al.* 2002, pl. 1, figs 9-10. **Pl. 17, Figs 28-29**

Buliminella elegantissima d'Orbigny 1839. Hayward *et al.* 1999, pl. 9, figs 18-19.

Buliminoides williamsoniana (Brady 1881). Hayward *et al.* 1999, pl. 13, fig. 10.

Cassidella bradyi (Cushman 1922). Jones 1994, pl. 52, fig. 9. **Pl. 20, Figs 12-14**

Cassidulina angulosa Cushman 1933. Loeblich & Tappan, 1994, pl. 221, figs 1-4.

Cassidulina carinata Silvestri 1896. Hayward *et al.* 1999, pl. 8, figs 23-24. **Pl. 17, Figs 39-41**

Cassidulina reniforme Nørvangi 1945. Nomura 1999, fig. 18, 18a-c, 19a-c, 30-3. **Pl. 18, Figs 1-3**

Cassidulina spiniferiformis McCulloch 1977, pl.164, figs 9a-b. **Pl. 18, Figs 4-5**

Ehrenbergina aspinosa Parr 1950. Eade 1967b, fig.7 (4-6), fig.8 (1-2). **Pl. 18, Figs 6-8**

Ehrenbergina carinata Eade 1967b, fig.8 (9), fig.9 (1-4). **Pl. 18, Figs 9-11**

Ehrenbergina aff. crassitrigona Nomura 1999, Fig.29 (1a-c, 2a-c, 3a-c), 30 (10).

Ehrenbergina glabra Heron-Allen & Earland 1922. Hayward *et al.* 2007, pl.1, figs.6-7. **Pl. 18, Figs 12-14**

Ehrenbergina hystrix Brady 1881. Jones 1994, pl. 55, figs 8-11. **Pl. 18, Figs 15-18**

Ehrenbergina mestayeri Cushman 1922. Hayward *et al.* 1999, pl. 8, figs 26-27. **Pl. 19, Figs 1-3**

Ehrenbergina trigona (Goës 1896). Eade 1967b, fig.8 (8). **Pl. 19, Figs 4-6**

Elongobula iphigeneae Revets 1993. Hayward *et al.* 1999, pl. 13, fig. 11.

Evolvocassidulina belfordi Nomura 1983. Hayward *et al.* 2001, fig.14HH-II. **Pl. 19, Figs 7-9**

Evolvocassidulina bradyi (Norman 1881). Hayward & Buzas 1979, p.55, pl.14, fig.179. **Pl. 19, Figs 10-11**

Evolvocassidulina orientalis (Cushman 1922). Hayward *et al.* 1999, pl. 8, fig. 28. **Pl. 19, Figs 12-13**

Evolvocassidulina tenuis (Phleger & Parker 1961). Eade 1967b, fig.3 (3-4).

Favocassidulina australis Eade 1967b, fig.2 (2-3), fig.3 (1-2). **Pl. 19, Figs 14-15**

Francesita advena (Cushman 1922). Loeblich & Tappan 1987, pl. 581, figs 1-7. **Pl. 20, Figs 10-11**

Fursenkoina acuta (d'Orbigny 1846). Papp & Schmidt 1985, pl.75, figs 1-6.

Fursenkoina complanata (Egger 1893). Jones 1994, pl. 52, figs 1-3. **Pl. 20, Figs 15-16**

Fursenkoina schreibersiana (Czjzek 1848). Hayward *et al.* 1999, pl. 9, fig. 29. **Pl. 20, Figs 17-19**

Globobulimina pacifica Cushman 1927. Jones 1994, pl. 50, figs 7-10. **Pl. 17, Figs 30-32**

Globobulimina turgida (Bailey 1851). Hayward *et al.* 1999, pl. 9, figs 20-21. **Pl. 17, Figs 33-34**

Globocassidulina canalisuturata Eade 1967. Hayward *et al.* 1999, pl. 8, figs 29-30. **Pl. 19, Figs 16-18**

Globocassidulina crassa (d'Orbigny 1839). Jones 1994, pl. 54, fig. 4 (as *Cassidulina crassa*). **Pl. 19, Figs 19-21**

Globocassidulina decorata (Sidebottom 1910). Loeblich & Tappan, 1994, pl. 222, figs 14-19.

Globocassidulina elegans (Sidebottom 1910). Loeblich & Tappan, 1994, pl. 223, figs 1-6.

Globocassidulina minuta (Cushman 1933). Hayward *et al.* 1999, pl. 8, figs 31-32. **Pl. 19, Figs 22-24**

Globocassidulina producta (Chapman & Parr 1937). Eade 1967b, fig.4 (5).
Globocassidulina spherica Eade 1967b, fig.7 (1-3). **Pl. 20, Figs 1-3**
Globocassidulina subglobosa (Brady 1881). Loeblich & Tappan 1987, pl. 557, figs 18-23. **Pl. 20, Figs 4-6**
Islandiella sp.
Neouvigerina ampullacea (Brady 1884). Loeblich & Tappan, 1994, pl. 246, figs 9-19.
Neouvigerina hispida (Schwager 1866). Jones 1994, pl. 75, figs 6-9. **Pl. 21, Figs 4-5**
Neouvigerina interrupta (Brady 1879). Loeblich & Tappan, 1994, pl. 246, figs 5-8. **Pl. 21, Figs 6-8**
Neouvigerina proboscidea (Schwager 1866). Hayward *et al.* 1999, pl. 9, fig. 22. **Pl. 21, Figs 9-11**
Paracassidulina sagamiensis (Asano & Nakamura 1937). Hayward *et al.* 2007b, pl.1, figs.11-12. **Pl. 20, Figs 7-9**
Praeglobobulimina pupoides (d'Orbigny 1846). Jones 1994, pl. 50, figs 14-15. **Pl. 17, Figs 35-36**
Praeglobobulimina spinescens (Brady 1884). Loeblich & Tappan 1987, pl. 571, figs 13-16. **Pl. 17, Figs 36-37-38**
Pseudobrizalina lobata (Brady 1881). Jones 1994, pl. 53, figs 22-23. **Pl. 20, Figs 24-15**
Rutherfordoides rotundata (Parr 1950). Jones 1994, pl. 52, figs 10-11(as *Fursenkoina*). **Pl. 20, Figs 20-23**
Saidovina karreriana (Brady 1881). Hayward *et al.* 1999**, p**l. 9, fig. 3. **Pl. 20, Figs 26-28**
Sigmavirgulina tortuosa (Brady 1881). Hayward *et al.* 1999, pl.9, figs 30-31.
Siphogenerina collumellaris (Brady 1881). Jones 1994, pl. 75, figs 15-17. **Pl. 20, Figs 29-30**
Siphogenerina dimorpha (Parker & Jones 1865). Jones 1994, pl. 76, figs 1-3. **Pl. 20, Figs 31-32**
Siphogenerina raphana (Parker & Jones 1865). Hayward *et al.* 1999**,** pl. 9, fig. 4.
Siphogenerina semistriata (Schubert 1911), figs 10a-b.
Spiroloxostoma glabra (Millett 1903). Hayward *et al.* 1999**,** pl. 9, fig. 5. **Pl. 21, Figs 1-3**
Trifarina angulosa (Williamson 1858) *s.l.* Hayward *et al.* 1999**,** pl. 9, figs 23-24. **Pl. 21, Figs 12-15**
Trifarina bradyi Cushman 1923. Jones 1994, pl. 67, figs 1-3. **Pl. 21, Figs 16-17**
Trifarina gracilis (Vella 1957), pl. 8, fig. 167.
Trifarina occidentalis (Cushman 1923). Hayward *et al*. 2002, pl. 1, figs 18-19. **Pl. 21, Figs 18-20**
Trifarina pacifica (Albani 1974). Hayward *et al.* 1999**,** pl. 9, figs 25-26.
Uvigerina hornibrooki Boersma 1984. Boersma 1985, pl. 18, fig. 1. **Pl. 21, Figs 21-23**
Uvigerina mediterranea s.l. Hofker 1932. Cimerman & Langer 1991, pl. 65, figs 7-9. **Pl. 21, Figs 24-26**
Uvigerina peregrina Cushman 1923.Hayward *et al*. 2002, pl. 1, figs 20-22. **Pl. 21, Figs 27-31**
Virgulopsis turris (Heron-Allen & Earland 1922). Hayward *et al.* 1999, pl. 8, fig. 33.

Order Rotaliida
Acervulina inhaerens Schulze 1854. Hayward *et al.* 1999, pl. 15, figs 2-3.
Alabaminella weddellensis (Earland 1936). Loeblich & Tappan 1987, pl. 593, figs 18-20. **Pl. 25, Figs 20-22**
Alexanderina viejoensis McCulloch 1977. Loeblich & Tappan 1987, pl. 626, figs 17-19.
Anomalinoides colligerus (Chapman & Parr 1937). Jones 1994, pl. 94, figs 2-3.
Anomalinoides glabratus (Cushman 1924). Hayward *et al.* 2001, fig.15A-B (as *A. tasmanica*). **Pl. 28, Figs 4-6**
Anomalinoides semicribratus (Beckmann 1954). Loeblich & Tappan 1987, pl.722, figs 1-7. **Pl. 28, Figs 7-9**
Anomalinoides sphericus (Finlay 1940). Hayward *et al.* 1999, pl. 15, figs 27-29. **Pl. 28, Figs 10-12**
Anomalinoides tasmanica (Parr 1950). Hayward *et al*. 2001, fig. 15A-B.
Astrononion novozealandicum Cushman & Edwards 1937. Hayward *et al.* 1999, pl. 15, figs 8-9. **Pl. 28, Figs 13-16**
Astrononion stelligerum (d'Orbigny 1839). Jones 1994, pl. 109, figs 3-4.
Baggina sp.
Biarritzina proteiformis (Goës 1882). Loeblich & Tappan 1994, pl. 331, figs 4-8. **Pl. 32, Figs 18-19**
Cancris oblongus (Williamson 1858). Jones 1994, pl. 106, fig. 5. **Pl. 30, Figs 10-15**
Carpentaria monticularis Carter 1877. Jones 1994, pl. 98, figs 13, 15-16 and pl. 99, figs 1-5. **Pl. 33, Figs 1-2**
Chilostomella oolina Schwager 1878. Jones 1994, pl. 55, figs 12-14, 17-18. **Pl. 21, Figs 32-35**
Chilostomella ovoidea Reuss 1850. Jones 1994, pl. 55, figs 15-16, 19-23. Pl. **21, Figs 36-40**
Cibicides bradyi (Trauth 1918). Jones 1994, pl.95, figs 5a-c as *Gyroidina*. **Pl. 22, Figs 1-3**
Cibicides corticatus Earland 1934. Hayward *et al.* 1999, pl. 14, figs 19-21.
Cibicides deliquatus Finlay 1940. Hornibrook *et al.* 1989, p.89, figs 22a-b.
Cibicides dispars (d'Orbigny 1839). Hayward *et al.* 1999, pl. 14, figs 22-24. **Pl. 22, Figs 4-9**
Cibicides fumeus (Saidova 1975), pl.64, fig.5 as *Cibicidoides.*
Cibicides grosseperforatus (Van Morkhoven & Berggren) in Van Morkhoven *et al.* 1986, p.103, figs 1a-c, as *Cibicidoides*.
Cibicides lobatulus (Walker & Jacob 1798). Jones 1994, pl. 115, figs 4-5. **Pl. 22, Figs 10-12**
Cibicides pachyderma (Rzehak 1886). Jones 1994, pl. 94, fig. 9 as *Cibicidoides*. **Pl. 22, Figs 13-15**
Cibicides planus Saidova 1975, pl. 72, fig. 7.
Cibicides refulgens de Montfort 1808. Jones 1994, pl. 92, figs 7-9. **Pl. 22, Figs 16-21**
Cibicides robertsonianus (Brady 1881). Jones 1994, pl. 95, fig. 4 as *Cibicidoides*. **Pl. 23, Figs 1-3**
Cibicides subhaidingeri (Parr 1950). Jones 1994, pl. 95, fig. 7 as *Cibicidoides*. **Pl. 23, Figs 4-8**

Cibicides temperatus Vella 1957, pl. 9, figs 201-203. **Pl. 23, Figs 9-13**
Cibicides tesnersianus (Saidova 1975), pl.64, fig.6, pl.107, fig.5, as *Cibicidoides.*
Cibicides variabilis (d'Orbigny 1826). Boltovskoy *et al.* 1980, pl.9, figs 12-17. **Pl. 23, Figs 14-16**
Cibicides wuellerstorfi (Schwager 1866). Jones 1994, pl. 93, figs 8-9 as *Cibicidoides*. **Pl. 23, Figs 17-22**
Colonimilisea coronata (Heron-Allen & Earland 1932). Hayward *et al.* 1999, pl.13, figs 23-25.
Cymbaloporetta bradyi (Cushman 1915). Hayward *et al.* 1999, pl. 14, figs 28-29.
Discanomalina coronata (Parker & Jones 1857). Jones 1994, pl. 97, figs 1-2. **Pl. 26, Figs 7-8**
Discanomalina semipunctata (Bailey 1851). Jones 1994, pl. 97, figs 3-6. **Pl. 26, Figs 9-12**
Discorbinella bertheloti (d'Orbigny 1839). Hayward *et al.* 1999, pl. 14, figs 1-3. **Pl. 24, Figs 4-6**
Discorbinella complanata (Sidebottom 1918). Hayward *et al.* 1999, pl. 14, figs 4-6. **Pl. 24, Figs 7-9**
Discorbinella deflata (Finlay 1940). Hayward *et al.* 1999, pl. 14, figs 7-9.
Discorbinella subcomplanata (Parr 1950). Hayward *et al.* 1999, pl. 14, figs 10-12. **Pl. 24, Figs 10-12**
Discorbinella timida Hornibrook 1961. Hayward *et al.* 1999, pl. 14, figs 13-15. **Pl. 24, Figs 13-15**
Discorbinella vitrevoluta (Hornibrook 1961). Hayward *et al.* 1999, pl. 14, figs 16-18.
Discorbitina pustulata (Heron-Allen & Earland 1913). Hayward *et al.* 1999, pl. 13, figs 26-28.
Dyocibicides sp.
Eilohedra vitrea (Parker 1953). Hayward *et al.* 1999, pl. 13, figs 14-16. **Pl. 31, Figs 1-5**
Elphidium advenum f. *limbatum* (Chapman 1907). Hayward *et al.* 1999, pl. 17, figs 1-2.
Elphidium charlottense (Vella 1957). Hayward *et al.* 1999, pl. 17, figs 6-8.
Elphidium excavatum f. *clavatum* Cushman 1930. Hayward *et al.* 1999, pl. 17, figs 11-12.
Elphidium novozealandicum Cushman 1936. Hayward *et al.* 1999, pl. 17, figs 23-24.
Eoeponidella pulchella (Parker 1952b), pl. 6, figs 18-20 as *Pninaella.*
Epistominella exigua (Brady 1884). Hayward *et al.* 2007b, pl. 1, figs 16-18. **Pl. 31, Figs 6-10**
Eponides repandus (Fichtell & Moll 1798). Jones 1994, pl. 104, fig. 19.
Evolutononion shansiense (Wang 1964). Loeblich & Tappan 1994, pl. 342, figs 13-14.
Gavelinopsis hamatus Vella 1957. Hayward *et al.* 1999, pl. 10, figs 12-14.
Gavelinopsis praegeri (Heron-Allen & Earland 1913). Hayward *et al.* 1999, pl. 10, figs 15-17. **Pl. 31, Figs 14-21**
Glabratella margaritaceus (Earland 1933). Hayward *et al.* 1999, pl. 11, figs 26-27.
Gypsina vesicularis (Parker & Jones 1860). Hayward *et al.* 1999, pl. 15, fig. 4.
Gyroidina danvillensis Howe & Wallace 1932. Hayward & Buzas 1979, pl. 18, figs 224-225. **Pl. 26, Figs 13-15**
Gyroidina kawagatai (Ujiie 1995), pl. 14, fig. 3. **Pl. 26, Figs 16-18**
Gyroidina orbicularis d'Orbigny 1826. Jones 1994, pl. 115, fig. 6. **Pl. 27, Figs 1-6**
Gyroidina soldanii d'Orbigny 1826. Jones 1994, pl. 107, figs 7. **Pl. 27, Figs 7-12**
?Hanzawaia grossepunctata (Earland 1934). Loeblich & Tappan 1994, pl. 364, figs 9-13, pl. 365, figs 1-13.
Hanzawaia cf. *wilcoxensis* (Cushman & Pontin 1932), pl.9, fig.6 (as cf. *Valvulineria wilcoxensis*). **Pl. 27, Figs 13-17**
Haynesina depressula (Walker & Jacob 1798). Hayward *et al.* 1999, pl. 15, figs 10-11.
Heronallenia gemmata Earland 1934, pl.8, figs 28-29.
Heronallenia lingulata (Burrows & Holland 1895). Hayward *et al.* 1999, pl. 13, figs 4-6.
Heronallenia nodulosa (McCulloch 1977), pl. 125, figs 15-16 (as *Planoheronallenia*).
Heronallenia pulvinulinoides (Cushman 1915). Hayward *et al.* 1999, pl. 13, figs 7-9.
Heronallenia translucens Parr 1945, p.211, pl.9, fig.15-16. **Pl. 27, Figs 18-20**
Heronallenia unguiculata Loeblich & Tappan 1994, pl. 295, figs 8-10. **Pl. 28, Figs 1-3**
Hyalinea asiana Huang 1972, pl. 1, figs 1-4.
Ioanella tumidula (Brady 1884). Jones 1994, pl. 95, fig. 8. **Pl. 26, Figs 1-3**
Karreria maoria (Finlay 1939). Hayward *et al.* 1999, pl. 15, fig. 30.
Laminononion tumidum (Cushman & Edwards 1937). Jones 1994, pl.109, fig.5.
Laticarinina altocamerata (Heron-Allen & Earland 1922).Loeblich & Tappan 1987, pl. 631, figs 5-7. **Pl. 24, Figs 16-18**
Laticarinina pauperata (Parker & Jones 1865) Jones 1994, pl. 104, figs 3-11. **Pl. 24, Figs 19-21**
Melonis affinis (Reuss 1851). Jones 1994, pl. 109, figs 8-9. **Pl. 28, Figs 17-18**
Melonis pompilioides (Fichtel & Moll 1798). Jones 1994, pl. 109, figs 10-11. **Pl. 28, Figs 19-20**
Neoconorbina terquemi (Rzehak 1888). Jones 1994, pl.88, figs 5-8.
Neoeponides schrebersii (d'Orbigny 1846). Jones 1994, pl. 115, fig. 1. **Pl. 24, Figs 1-3**
Nonion pacificum (Cushman 1924). Loeblich & Tappan 1994, pl. 342, figs 8-12. **Pl. 28, Figs 21-22; Pl. 29, Figs 1-2**
Nonionella auris (d'Orbigny 1839). Hayward *et al.* 2001, figs 16I-K. **Pl. 29, Figs 3-5**
Nonionella magnalingua Finlay 1940. Hayward *et al.* 1999, pl. 15, figs 12-13. **Pl. 29, Figs 6-8**
Nonionellina flemingi (Vella 1957). Hayward *et al.* 1999, pl. 15, figs 14-15. **Pl. 29, Figs 9-10**
Nonionoides grateloupi (d'Orbigny 1826). Loeblich & Tappan 1994, pl. 342, figs 1-5. **Pl. 29, Figs 11-14**
Nonionoides turgida (Williamson 1858). Hayward *et al.* 1999, pl. 15, figs 16-17.
Notorotalia aucklandica Vella 1957. Hayward *et al.* 1999, pl. 16, figs 13-15. **Pl. 25, Figs 1-3**

Notorotalia depressa Vella 1957. Hayward *et al.* 1999, pl. 16, figs 16-18. **Pl. 25, Figs 4-6**
Notorotalia finlayi Vella 1957. Hayward *et al.* 1999, pl. 16, figs 19-21.
Notorotalia hornibrooki Hayward *et al.* 1999, pl. 16, figs 31-33.
Notorotalia olsoni Vella 1957. Hayward *et al.* 1999, pl. 16, figs 25-27.
Notorotalia profunda Vella 1957. Hayward *et al.* 1999, pl. 16, figs 28-30. **Pl. 25, Figs 7-9**
Notorotalia zelandica Finlay 1939. Hayward *et al.* 1999, pl. 16, figs 34-36. **Pl. 25, Figs 10-12**
Nuttallides bradyi (Earland 1934). Loeblich & Tappan 1987, pl. 669, figs 17-20. **Pl. 25, Figs 13-15**
Nuttallides umbonifera (Cushman 1933). Hayward et al. 2007, pl. 1, figs 19-20. **Pl. 25, Figs 16-19**
Oridorsalis umbonatus (Reuss 1851). Hayward *et al.* 1999, pl. 15, figs 24-26. **Pl. 30, Figs 3-6**
Osangularia bengalensis (Schwager 1866). Jones 1994, pl. 96, fig. 3. **Pl. 30, Figs 7-9**
Parrelloides hyalinus (Hofker 1951). Loeblich & Tappan 1994, pl. 301, figs 10-12, pl. 302, figs 1-7.
Patellinella inconspicua (Brady 1884). Hayward *et al.* 1999, pl. 9, figs 34-35.
Pileolina calcarata (Heron-Allen & Earland 1922). Hayward *et al.* 1999, pl. 12, figs 1-3.
Pileolina harmeri (Heron-Allen & Earland 1922). Hayward *et al.* 1999, pl.12, figs 7-9.
Pileolina patelliformis (Brady 1884). Hayward *et al.* 1999, pl. 12, figs 10-12.
Pileolina radiata Vella 1957. Hayward *et al.* 1999, pl. 12, figs 13-15.
Pileolina zealandica Vella 1957. Hayward *et al.* 1999, pl. 12, figs 16-18.
Planodiscorbis rarescens (Brady 1884). Jones 1994, pl. 90, figs 2-3. **Pl. 32, Figs 1-6**
Planoglabratella opercularis (d'Orbigny 1839). Hayward *et al.* 1999, pl. 13, figs 1-3.
Planorbulina acervalis Brady 1884. Jones 1994, pl.92, fig.4.
Planulina ariminensis (d'Orbigny 1826). Jones 1994, pl. 93, figs 10-11. **Pl. 30, Figs 19-22**
Planulina renzi Cushman & Stainforth 1945. Hornibrook *et al.* 1989, fig. 20:15.
Planulina sinuosa (Sidebottom 1918), pl.6, figs 22-25 as *Anomalina*.
Planulina aff. *subinflata* Bandy 1949, pl.18, fig.1.
Planulina sp.
Planulinoides biconcavus (Parker & Jones 1826). Hayward *et al.* 1999, pl. 13, figs 17-19.
Planulinoides norcotti Hedley, Hurdle & Burdett 1967. Hayward *et al.* 1999, pl.13, figs 20-22.
Porogavelinella ujiiei Kawagata 1999. Kawagata 1999, figs 11(1-6). **Pl. 26, Figs 4-6**
Pullenia bulloides (d'Orbigny 1846). Jones 1994, pl. 84, figs 12-13. **Pl. 29, Figs 15-17**
Pullenia quinqueloba Reuss (1851). Jones 1994, pl. 84, figs 14-15. **Pl. 29, Figs 18-20**
Pullenia salisburyi Stewart & Stewart 1930. Yassini & Jones 1995, figs 938-939. **Pl. 29, Figs 21-24**
Pulleniella asymmetrica Ujiie 1990. Kawagata 1999, figs 9(7a,b). **Pl. 30, Figs 1-2**
Quadrimorphina laevigata (Phleger & Parker 1951). Loeblich & Tappan 1994, pl. 353, figs 1-9 as *Q. pescicula*. **Pl. 31, Figs 11-13**
Rosalina bradyi (Cushman 1915). Hayward *et al.* 1999, pl. 11, figs 1-3.
Rosalina irregularis (Rhumbler 1906). Hayward *et al.* 1999, pl. 11, figs 4-5. **Pl. 32, Figs 7-11**
Rosalina paupereques Vella 1957. Hayward *et al.* 1999, pl. 11, figs 6-8.
Rosalina vitrizea Hornibrook 1961. Hayward *et al.* 1999, pl. 11, figs 9-11.
Rupertina pustulosa Hatta 1992. Hayward *et al.* 1999, pl. 15, fig. 1. **Pl. 33, Figs 3-5**
Siphonina bradyana Cushman 1927. Loeblich & Tappan 1994, pl. 298, figs 1-9.
Siphonina tubulosa Cushman 1924. Hayward *et al.* 1999, pl. 13, figs 12-13.
Sphaeroidina bulloides d'Orbigny 1826. Hayward *et al.* 1999, pl. 11, figs 15-16. **Pl. 32, Figs 12-13**
Spirotectina crassa Saidova 1975. Loeblich & Tappan 1987, pl. 696, figs 9-13. **Pl. 32, Figs 14-17**
Stomatorbina concentrica (Parker & Jones 1864). Hayward *et al.* 1999, pl. 10, figs 7-8.
Subanomalina guadalupensis McCulloch 1977. Loeblich & Tappan 1987, pl. 693, figs 9-11.
Valvulineria minuta (Schubert 1904). Jones 1994, pl. 91, fig. 4. **Pl. 30, Figs 16-18**
Virgulopsis turris (Heron-Allen & Earland 1922). Hayward *et al.* 1999, pl.8, fig.33.
Zeaflorilus parri (Cushman 1936). Hayward *et al.* 1999, pl. 15, figs 18-20.

APPENDIX VI. Updates and corrections to the species names given in Hayward et al's (1999) Monograph on New Zealand shallow-water foraminifera.

Hayward et al. (1999) name	Name accepted here
Order Miliolida	
Cornuspira involvens (Reuss 1850)	*Cornuspira planorbis* Schultze 1854
Miliolinella subrotundata (Montagu 1808)	*Miliolinella subrotunda* (Montagu 1808)
Pyrgo anomala Schlumberger 1891	*Pyrgo inornata* (d'Orbigny 1846)
Pyrgo comata (Brady 1881)	*Pyrgo oligocenica* Cushman 1935
Pyrgo guerreri (Silvestri 1900)	*Pyrgo clypeata* (d'Orbigny 1846)
Quinqueloculina tenagos Parker 1962	*Quinqueloculina carinatastriata* (Wiesner 1912)
Order Lagenida	
Fissurina baccata (Heron-Allen & Earland 1922)	*Wiesnerina baccata* (Heron-Allen & Earland 1922)
Fissurina claricurta McCulloch 1977	*Fissurina annectens* (Burrows & Holland 1895)
Lagenosolenia quadrirevertens (McCulloch 1977)	*Palliolatella quadrirevertens* (McCulloch 1977)
Laevidentalina bradyensis (Dervieux 1894)	*Laevidentalina haueri* (Neugeboren 1856)
Laevidentalina filiformis (d'Orbigny 1826)	*Laevidentalina badenensis* (d'Orbigny 1846)
Laevidentalina inflexa (Reuss 1866)	*Nodosaria inflexa* Reuss 1866
Laevidentalina subemaciata (Parr 1950)	*Laevidentalina inornata* (d'Orbigny 1846)
Oolina hexagona (Williamson 1848)	*Favulina hexagona* (Williamson 1848)
Oolina melo d'Orbigny 1839	*Favulina melo* (d'Orbigny 1839)
Neolenticulina peregrina (Schwager 1866)	*Neolenticulina variabilis* (Reuss 1850)
Planularia australis Chapman 1941	*Planularia spinipes* (Cushman 1913)
Pyramidulina perversa (Schwager 1866)	*Pyramidulina* n.sp.
Saracenaria italica Defrance 1824	*Saracenaria spinosa* Eichenberg 1935
Sigmoidella kagaensis Cushman & Ozawa 1928	*Sigmoidella pacifica* Cushman & Ozawa 1928
Order Buliminida	
Bolivina spinescens Cushman 1911	*Bolivina pseudolobata* Yassini & Jones 1995
Bolivina subexcavata Cushman & Wickenden 1929	*Bolivina variabilis* (Williamson 1858)
Cassidulina laevigata d'Orbigny 1826	*Casidulina carinata* Silvestri 1896
Uvigerina bradyana Fornasini 1900	*Uvigerina peregrina* Cushman 1923
Order Rotaliida	
Cibicides marlboroughensis Vella 1957	*Cibicides dispars* (d'Orbigny 1839)

APPENDIX VII. Glossary of abbreviations used in this monograph

AABW	Antarctic Bottom Water
AAIW	Antarctic Intermediate Water
Alpha, α	Fischer Alpha Index of species richness (Hayeck & Buzas 1997)
AU	Prefix of sample catalog numbers held by University of Auckland, Geology Dept.
BDG	Biodiversitygram of Hayek & Buzas (2006)
BFOI	Benthic Foraminiferal Oxygen Index of Kaiho (1994)
BWH	Prefix of specimen catalog numbers figured using SEM and held on stubs in collection of GNS Science, Lower Hutt
CC	Correlation Coefficient
CCD	Carbonate compensation depth
CPDW	Circumpolar Deep Water
CSW	Circumpolar Surface Water
DC	D'Urville Current
DCCA	Detrended Canonical Correspondence Analysis
DECORANA	Detrended Correpondence Analysis
DSDP	Deep Sea Drilling Project
DWBC	Deep Western Boundary Current
E	Evenness measure of species distribution
EAUC	East Auckland Current
ECC	East Cape Current
F	Prefix of sample catalog numbers held by GNS Science, Lower Hutt
FI	Planktic foraminiferal Fragmentation Index of dissolution of Le & Shackleton (1992)
FP	Prefix of figured specimen catalog numbers held by GNS Science, Lower Hutt
H	Shannon Information Function for species diversity (Shannon 1948)
IGNS	Institute of Geological and Nuclear Sciences, Lower Hutt, New Zealand
Jz	Proxy for organic carbon flux to the sea floor of Berger & Wefer (1990)
L	Prefix of sample catalog numbers held by Auckland War Memorial Museum
lCPDW	Lower Circumpolar Deep Water
MAT	Modern Analogue Technique
MD	Prefix of MV Marion Dufresne core site
NADW	North Atlantic Deep Water
NIWA	National Institute of Water and Atmosphere, Wellington, New Zealand
ODP	Ocean Drilling Programme
OMZ	Oxygen Minimum Zone
RR	Prefix of MV Roger Revelle core site
SAF	Subantarctic Front (or Convergence)
SAMW	Subantarctic Mode Water
SAW	Subantarctic Surface Water
SC	Southland Current
Seas	Proxy for seasonality of ocean primary production, modified after Berger & Wefer (1990)
SHE	SHE Analysis of community diversity of Buzas & Hayek (1996)
SHEBI	SHE Analysis performed for biofacies identification of Buzas & Hayek (2005)
SHECSI	SHE Analysis performed for community structure identification of Buzas & Hayek (2005)
SST	Sea-surface temperature
STF	Subtropical front (or Convergence)
STW	Subtropical Surface Water
TF	Prefix of type specimen catalog numbers held by GNS Science, Lower Hutt
uCPDW	Upper Circumpolar Deep Water
USNM	Prefix of specimen catalog numbers held by Smithsonian Institution, Washington, DC
WAC	West Auckland Current
WC	West Coast Current

Plates 1–33

Plate 1

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1	***Placopsilinella aurantiaca*** Earland, 1934. BWH137/39, F202369, Hikurangi Plateau, 3654 m.	**p.124**
2-3	***Bathysiphon argenteus*** Heron-Allen & Earland, 1913. BWH184/10, NIWA F592, off southern Hawke Bay, 2432 m. Scale Bar: 20 & 100 µm.	**p.125**
4-5	***Bathysiphon filiformis*** M. Sars, 1872. BWH179/5, F201517, off North Cape, 133 m. Scale Bar: 200 & 500 µm.	**p.125**
6-7	***Botellina labyrinthica*** Brady, 1881. BWH158/3, AU17811, off Great Barrier Island, 70 m. Scale Bar: 500 µm & 1 mm.	**p.125**
8-9	***Hyperammina cylindrica*** Parr, 1950. BWH180/8, F201517, off North Cape, 133 m. Scale Bar: 100 & 500 µm.	**p.125**
10-11	***Hyperammina laevigata*** Wright, 1891. BWH180/11, L17747, Bay of Plenty, off Cuvier Island, 70 m. Scale Bar: 100 µm & 1 mm.	**p.126**
12-13	***Hyperammina novaezealandiae*** Heron-Allen & Earland, 1922. BWH158/7, AU17811, off Great Barrier Island, 70 m. Scale Bar: 200 µm & 1 mm.	**p.126**
14	***Saccorhiza ramosa*** (Brady, 1879). BWH156/9, F202456, Havre Trough, 3091 m. Scale Bar: 500 µm.	**p.126**
15	***Psammosphaera fusca*** Schulze, 1875. BWH181/13, F201390, off Great Barrier Island, 750 m. Scale Bar: 200 µm.	**p.126**
16	***Psammosphaera parva*** Flint, 1899. BWH185/10, F201706, off North Cape, 907 m.	**p.127**
17	***Marsipella elongata*** Norman, 1878. BWH137/12, F202356, Chatham Rise, 1324 m.	**p.127**
18-19	***Rhabdammina antarctica*** Saidova, 1975. BWH181/7, F202457, Bay of Plenty, 2810 m. Scale Bar: 100 & 200 µm.	**p.127**
20	***Rhabdammina discreta*** Brady, 1881. BWH181/6, F202422, New Caledonia Basin, 2000 m.	**p.127**
21-22	***Rhabdammina major*** de Folin, 1887. Multifocus image, FP5204, F201517, off North Cape, 133 m. Scale Bar: 1 mm.	**p.128**
23	***Rhizammina algaeformis*** Brady, 1879. BWH181/8, ODP 1120C-1H-1, 0-2 cm, Pukaki Rise, 544 m.	**p.128**
24-25	***Lagenammina arenulata*** (Skinner, 1961). BWH179/37, ODP 1124B-1H-1, 0-2 cm, Hikurangi Plateau, 3967 m.	**p.128**
26-27	***Lagenammina bulbosa*** (Chapman & Parr, 1937). BWH181/19, ODP 1123B-1H-1, 0-2 cm, Chatham Rise, 3290 m.	**p.128**
28-29	***Lagenammina difflugiformis*** (Brady, 1879). BWH179/38, F202421, New Caledonia Basin, 1825 m.	**p.128**
30	***Lagenammina spiculata*** (Skinner, 1961). BWH137/35, F202384, Chatham Rise, 1300 m.	**p.129**
31-32	***Saccammina sphaerica*** Brady, 1871. BWH137/18, ODP 1125A-1H-1, 4-6 cm, Chatham Rise, 1365 m.	**p.129**
33-34	***Technitella legumen*** Norman, 1878. BWH180/17, F201517, off North Cape, 133 m.	**p.129**

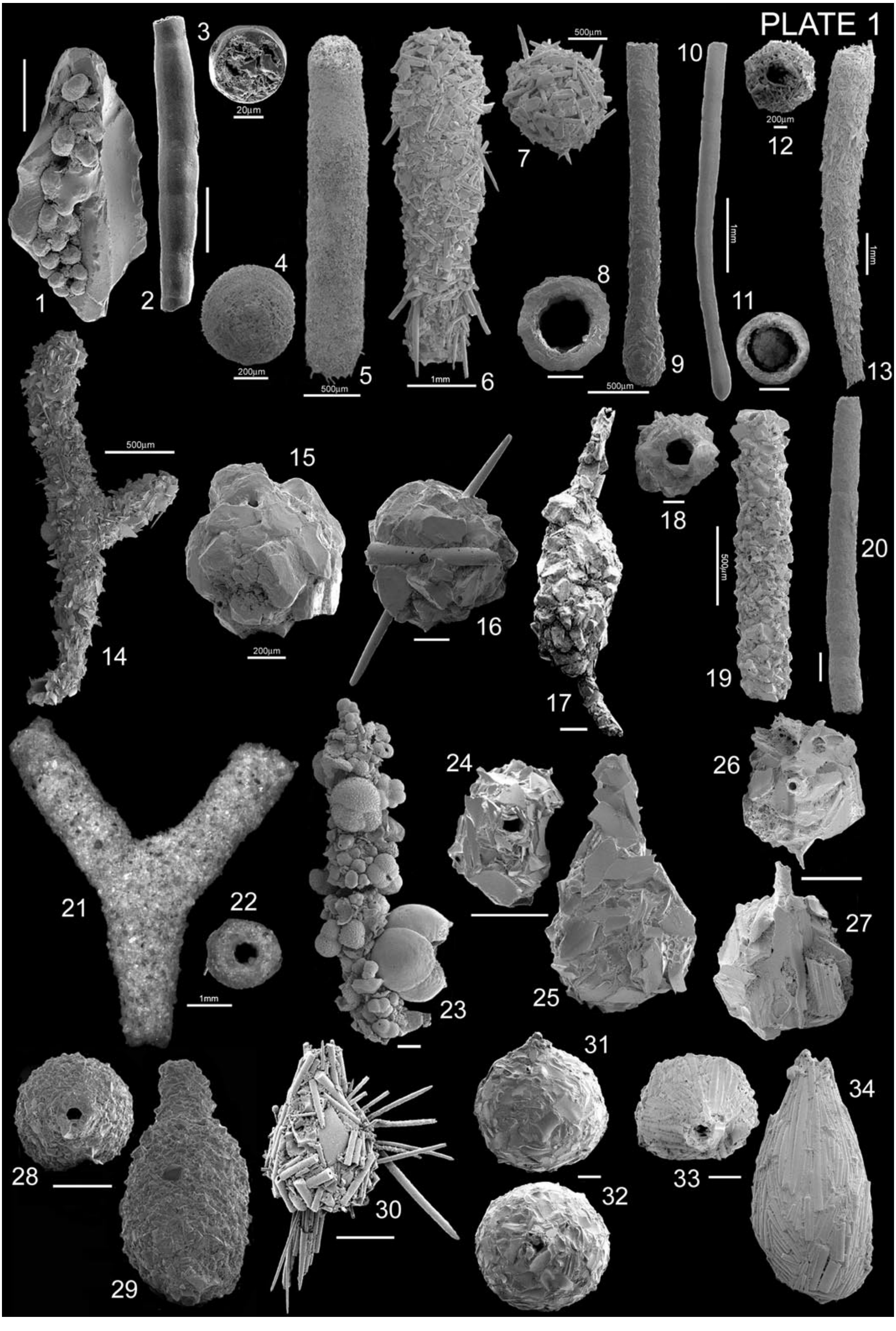
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Plate 2

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1-2	***Jullienella zealandica*** Hayward & Gordon, 1984. Slide: TF1602/3, NIWA E794, off South Westland, 1350-1400 m. Scale Bar: 10 mm.	**p.129**
3-4	***Ammodiscus exsertus*** Cushman, 1910. BWH180/12, F201255, Chatham Rise, 361 m. Scale Bar: 500 µm.	**p.130**
5-6	***Ammodiscus gullmarensis*** Höglund, 1948. BWH192/32, NIWA Stn F599, off southern Hawke Bay, 1240 m.	**p.130**
7-8	***Ammodiscus mestayeri*** Cushman, 1919. BWH159/3, F202496, off Great Barrier Island, 146 m. Scale Bar: 1 mm.	**p.130**
9-10	***Ammodiscus planorbis*** Höglund, 1947. BWH180/13, NIWA Stn F861, off Hawke Bay, 329 m. Scale Bar: 200 µm.	**p.130**
11-12	***Ammodiscus profundissimus*** Saidova, 1970. BWH180/10, F202615, Hikurangi Plateau, 4394 m.	**p.130**
13-14	***Ammolagena clavata*** (Jones & Parker, 1860). BWH180/16, F201390, off Great Barrier Island, 750 m. Scale Bar: 200 µm.	**p.130**
15-16	***Glomospira gordialis*** (Jones & Parker, 1860). BWH136/4, ODP 1123B-1H-1, 7-9 cm, Chatham Rise, 3290 m.	**p.131**
17	***Tolypammina horrida*** Cushman, 1919. BWH181/21, F201517, off North Cape, 133 m. Scale Bar: 500 µm.	**p.131**
18-19	***Usbekistania charoides*** (Jones & Parker, 1860). BWH137/17, F202369, Hikurangi Plateau, 3654 m.	**p.131**
20	***Adercotryma glomeratum*** (Brady, 1878). BWH137/2, F202369, Hikurangi Plateau, 3654 m.	**p.131**
21	***Adercotryma glomeratum*** (Brady, 1878). BWH137/1, F202369, Hikurangi Plateau, 3654 m.	**p.131**
22	***Cystammina pauciloculata*** (Brady, 1879). BWH137/29, F202369, Hikurangi Plateau, 3654 m.	**p.132**
23	***Recurvoidatus parcus*** Saidova, 1970. BWH137/45, F202369, Hikurangi Plateau, 3654 m.	**p.132**
24	***Recurvoides contortus*** Earland, 1934. BWH137/36, ODP 1124B-1H-1, 8-10cm, Hikurangi Plateau, 3967 m.	**p.132**
25-26	***Alveolophragmium zealandicum*** Vella, 1957. BWH156/10, AU17811, off Great Barrier Island, 70 m.	**p.133**

PLATE 2

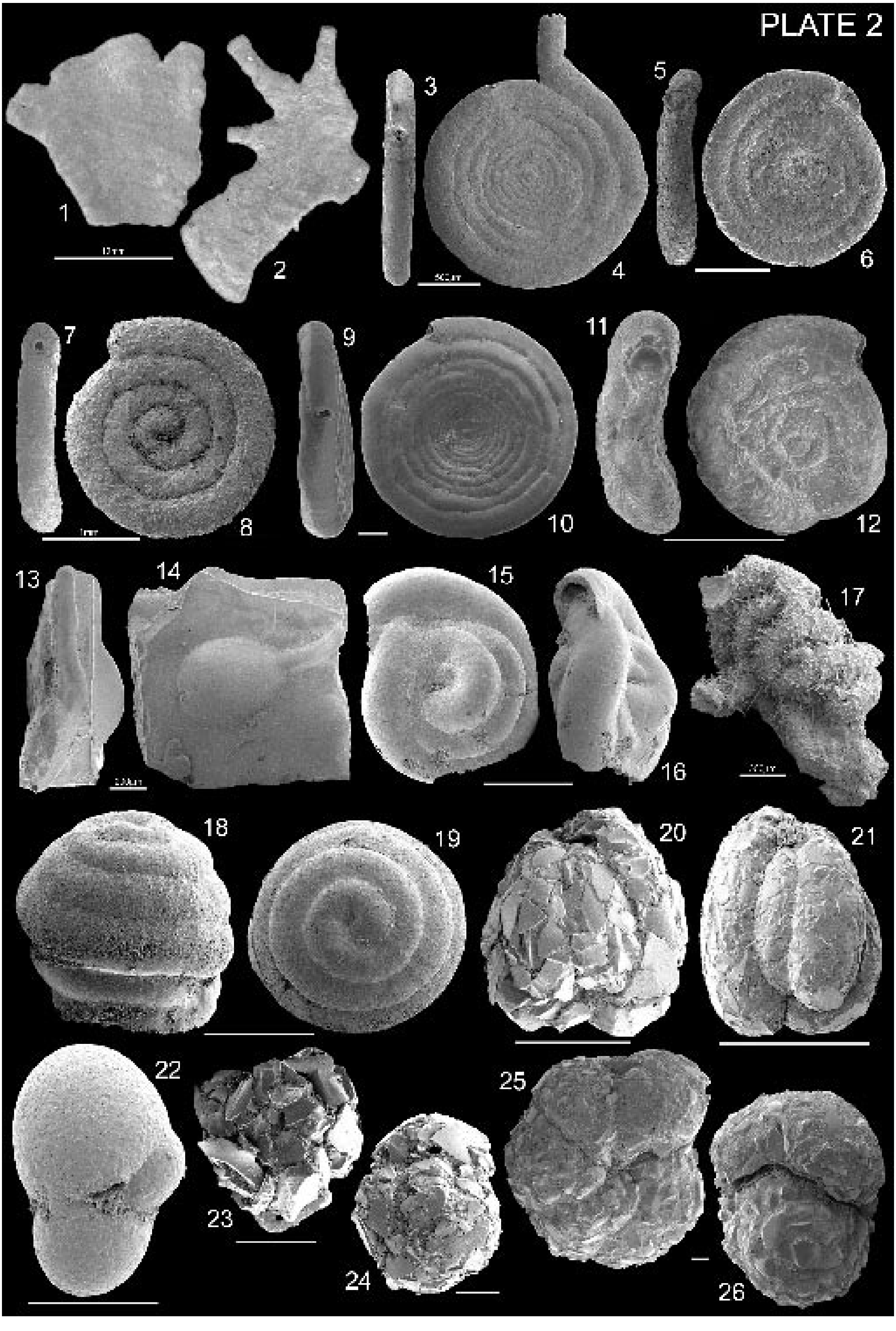
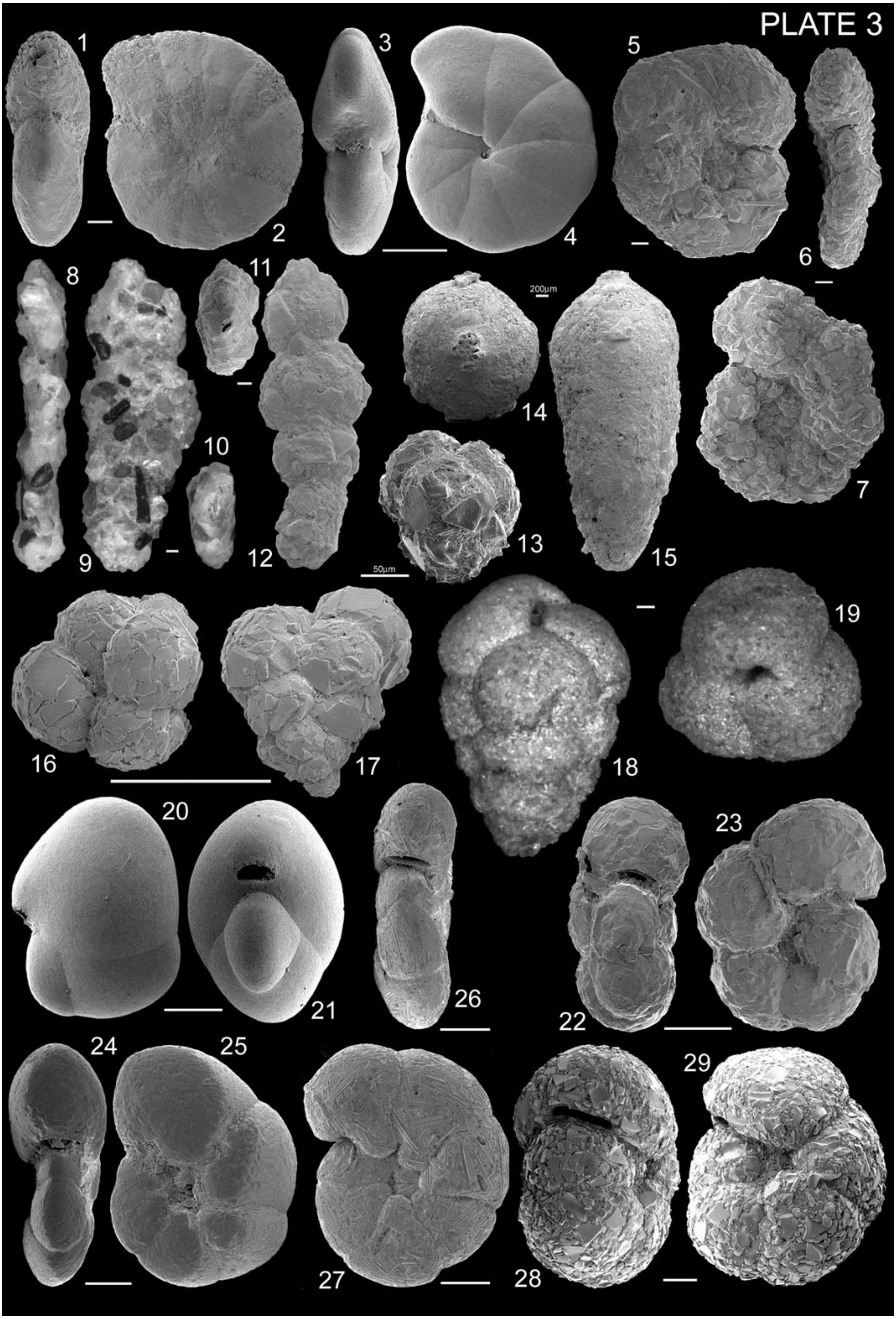


Plate 3

(Unless otherwise specified all scale bars = 100 μm)

Figs		
1-2	***Cyclammina pusilla*** Brady, 1881. BWH181/12, F202364, Chatham Rise, 1637 m.	**p.133**
3-4	***Cyclammina trullissata*** (Brady, 1879). BWH136/2, ODP 1123B-1H-1, 7-9 cm, Chatham Rise, 3290 m.	**p.133**
5	***Discammina compressa*** (Goës, 1882). BWH180/2, F202530, Pukaki Rise, 492 m.	**p.134**
6-7	***Discammina compressa*** (Goës, 1882). BWH180/3. F202530, Pukaki Rise, 492 m.	**p.134**
8-10	***Ammoscalaria georgescotti*** Hayward n.sp. Multifocus image, F201517, off North Cape, 133 m. HOLOTYPE, TF1665/1.	**p.134**
11-12	***Ammoscalaria georgescotti*** Hayward n.sp. F201517, off North Cape, 133 m. PARATYPE, TF1665/2.	**p.134**
13	***Liebusella goësi*** Höglund, 1947. BWH179/22, NIWA Stn F673, off Hawke Bay, 1419 m. Scale Bar: 50 μm.	**p.134**
14-15	***Liebusella soldanii*** (Jones & Parker, 1860). BWH185/1, F201517, off North Cape, 133 m. Scale Bar: 200 μm.	**p.135**
16-17	***Rhumblerella humboldti*** (Todd & Brönnimann, 1957). BWH181/1, F202615, Hikurangi Plateau, 4394 m.	**p.135**
18-19	***Verneuilinulla propinqua*** (Brady, 1884). Multifocus image, FP5205, ODP 1123B-1H-1, 7-9 cm, Chatham Rise, 3290 m. Scale Bar: 200 μm.	**p.135**
20-21	***Buzasina galeata*** (Brady, 1881). BWH137/4, ODP 1124B-1H-1, 4-6 cm, Hikurangi Plateau, 3967 m.	**p.135**
22-23	***Cribrostomoides crassimargo*** (Norman, 1892). BWH192/34, NIWA Stn F636, off southern Hawke Bay, 71 m.	**p.136**
24-25	***Cribrostomoides jeffreysi*** (Williamson, 1858). BWH195/6, L17748, east of Northland, off Poor Knights Islands, 110 m.	**p.136**
26-27	***Cribrostomoides spiculolega*** (Parr, 1950). BWH169/11, F201106, Enderby Island, Auckland Islands, 10 m.	**p.136**
28	***Cribrostomoides subglobosus*** (Cushman, 1910). BWH136/14, F202378, northeast of Chatham Island, 3550 m.	**p.136**
29	***Cribrostomoides subglobosus*** (Cushman, 1910). BWH136/13, F202378, northeast of Chatham Island, 3550 m.	**p.136**

PLATE 3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200µm
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Plate 4

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1-2	***Cribrostomoides wiesneri*** (Parr, 1950). BWH137/27, F202369, Hikurangi Plateau, 3654 m.	**p.137**
3-4	***Haplophragmoides neobradyi*** Uchio, 1960. BWH185/11, F202618, Kermadec Ridge, 2427 m.	**p.137**
5-6	***Hormosina pilulifera*** (Brady, 1884). BWH159/1, AU17808, off Great Barrier Island, 144 m. Scale Bar: 200 µm.	**p.137**
7-8	***Hormosina pilulifera*** (Brady, 1884). BWH158/6, NIWA Stn P525, off North Cape, 380 m. Scale Bar: 200 µm.	**p.137**
9-10	***Hormosinella distans*** (Brady, 1881). BWH181/16, ODP 1123B-1H-1, 0-2 cm, Chatham Rise, 3290 m.	**p.137**
11-12	***Hormosinella guttifera*** (Brady, 1881). BWH191/24, ODP 1123B-1H-1, 0-2 cm, Chatham Rise, 3290 m.	**p.137**
13	***Reophax dentaliniformis*** Brady, 1881. BWH136/6, F202356, Chatham Rise, 1324 m.	**p.138**
14-15	***Reophax hispidulus*** Cushman, 1920. BWH181/2, F202395, South Canterbury Bight, 1130 m.	**p.138**
16-17	***Reophax nodulosus*** Brady, 1879. BWH181/10, F202378, northeast of Chatham Island, 3550 m.	**p.138**
18	***Reophax spiculifer*** Brady, 1879. BWH136/27, L17748, east of Northland, off Poor Knights Islands, 110 m. Scale Bar: 200 µm.	**p.138**
19	***Reophax spiculifer*** Brady, 1879. BWH136/28, L17748, east of Northland, off Poor Knights Islands, 110 m. Scale Bar: 200 µm.	**p.138**
20	***Reophax subfusiformis*** Earland, 1933. BWH137/40, F202361, Chatham Rise, 285 m. Scale Bar: 200 µm.	**p.139**
21-22	***Ammobaculites agglutinans*** (d'Orbigny, 1846). BWH195/2, F201019, off North Cape, 150 m.	**p.139**
23-24	***Ammobaculites filiformis*** (Earland, 1934). BWH179/29, F202616, off Hawke Bay, 2317 m. Scale Bar: 50 µm.	**p.139**
25-26	***Ammobaculites paradoxus*** Clark, 1994. BWH137/26, F202378, northeast of Chatham Island, 3550 m. Scale Bar: 50 &100 µm.	**p.139**
27-28	***Ammomarginulina ensis*** Wiesner, 1931. BWH137/7, ODP 1124B-1H-1, 4-6 cm, Hikurangi Plateau, 3967 m.	**p.139**
29-30	***Eratidus foliaceus*** (Brady, 1881). BWH179/35, ODP 1123C-1H-1, 0-2 cm, Chatham Rise, 3290 m.	**p.140**
31-32	***Parvigenerina arenacea*** (Heron-Allen & Earland, 1922). BWH180/15, F201042, Bay of Plenty, off Mayor Island, 200 m. Scale Bar: 50 µm.	**p.140**
33-34	***Spiroplectammina carteri*** Hayward n.sp. F202369, Hikurangi Plateau, 3654 m. PARATYPE, TF1666/2. Scale Bar: 50 µm.	**p.140**
35-37	***Spiroplectammina carteri*** Hayward n.sp. Multifocus image, F202615, Hikurangi Plateau, 4394 m. HOLOTYPE, TF1666/1.	**p.140**
38-40	***Spiroplectinella proxispira*** (Vella, 1957). BWH195/12, L17748, east of Northland, off Poor Knights Islands, 110 m.	**p.141**
41-42	***Spirotextularia fistulosa*** (Brady, 1884). BWH128/37, F201844, east of Northland, off Poor Knights Islands, 20 m.	**p.141**
43	***Spirotextularia fistulosa*** (Brady, 1884). BWH128/36, F201844, east of Northland, off Poor Knights Islands, 20 m.	**p.141**
44-45	***Textulariella barrettii*** (Jones & Parker, 1876). BWH185/13, F201517, off North Cape, 133 m.	**p.141**
46-47	***Textulariella barrettii*** (Jones & Parker, 1876). BWH185/12, F201517, off North Cape, 133 m. Scale Bar: 200 µm.	**p.141**
48-49	***Gaudryina convexa*** (Karrer, 1865). BWH137/32, F202371, off Chatham Islands, 91 m. Scale Bar: 0.2 mm.	**p.142**
50-51	***Gaudryina convexa*** (Karrer, 1865). BWH130/32, L14055, Chatham Islands, 35 m.	**p.142**
52-53	***Gaudryina quadrangularis*** Bagg, 1908. BWH179/28, F202501, east of Northland, off Cavalli Islands, 108 m.	**p.142**

PLATE 4

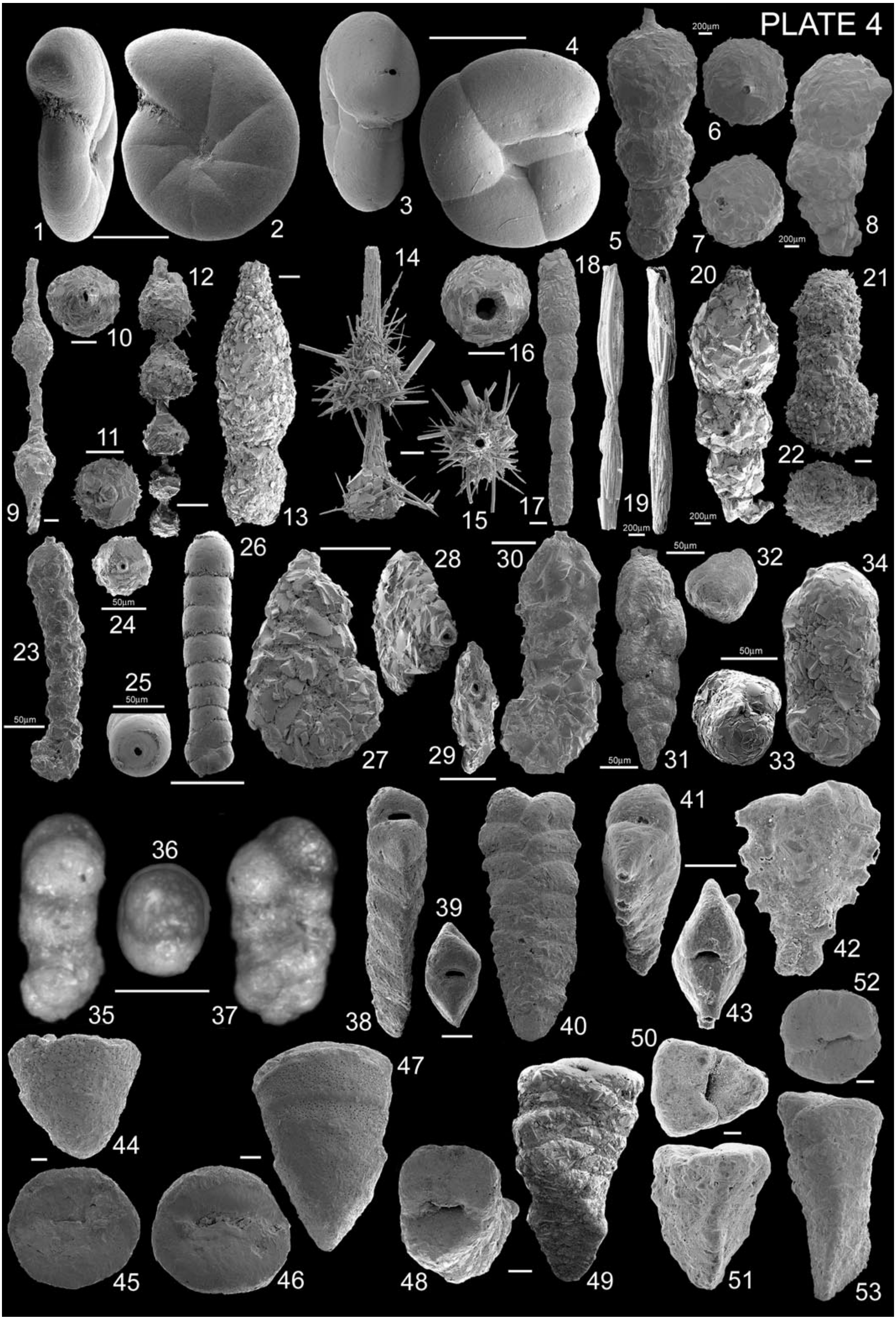
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Plate 5

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1-2	***Alterammina alternans*** (Earland, 1934). BWH179/14, F202618, Kermadec Ridge, 2175 m.	**p.142**
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5	***Paratrochammina challengeri*** Brönnimann & Whittaker, 1988. BWH136/7, ODP 1124B-1H-1, 4-6 cm, Hikurangi Plateau, 3967 m.	**p.143**
6	***Paratrochammina challengeri*** Brönnimann & Whittaker, 1988. BWH136/9, ODP 1124B-1H-1, 4-6 cm, Hikurangi Plateau, 3967 m.	**p.143**
7	***Paratrochammina challengeri*** Brönnimann & Whittaker, 1988. BWH136/12, F202389, Chatham Rise, 4680 m.	**p.143**
8-9	***Paratrochammina simplissima*** (Cushman & McCulloch, 1948). BWH179/24, ODP 1124B-1H-1, 0-2 cm, Hikurangi Plateau, 3967 m. Scale Bar: 20 µm.	**p.143**
10	***Paratrochammina simplissima*** (Cushman & McCulloch, 1948). BWH179/23, ODP 1124B-1H-1, 0-2 cm, Hikurangi Plateau, 3967 m. Scale Bar: 20 µm.	**p.143**
11-13	***Polystomammina nitida*** (Brady, 1881). BWH193/12, F202360, Chatham Rise, 121 m.	**p.143**
14	***Tritaxis fusca*** (Williamson, 1858). BWH181/14, F201288, West Coast, off Greymouth, 610 m.	**p.143**
15-16	***Tritaxis fusca*** (Williamson, 1858). BWH194/24, F201288, West Coast, off Greymouth, 610 m.	**p.143**
17	***Trochammina tasmanica*** Parr, 1950. BWH179/25, ODP 1124B-1H-1, 0-2 cm, Hikurangi Plateau, 3967 m. Scale Bar: 50 µm.	**p.144**
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20-21	***Dorothia scabra*** (Brady, 1884). BWH180/4, F202440, offshore Taranaki, 1244 m.	**p.144**
22	***Dorothia scabra*** (Brady, 1884). BWH137/25, F202370, Hikurangi Plateau, 4096 m.	**p.144**
23-24	***Eggerella bradyi*** (Cushman, 1911). BWH137/33, F202376, Chatham Rise, 1128 m.	**p.144**
25-27	***Karreriella bradyi*** (Cushman, 1911). Multifocus image, FP5206, F202473, east of Great Barrier Island, 754 m.	**p.145**

PLATE 5

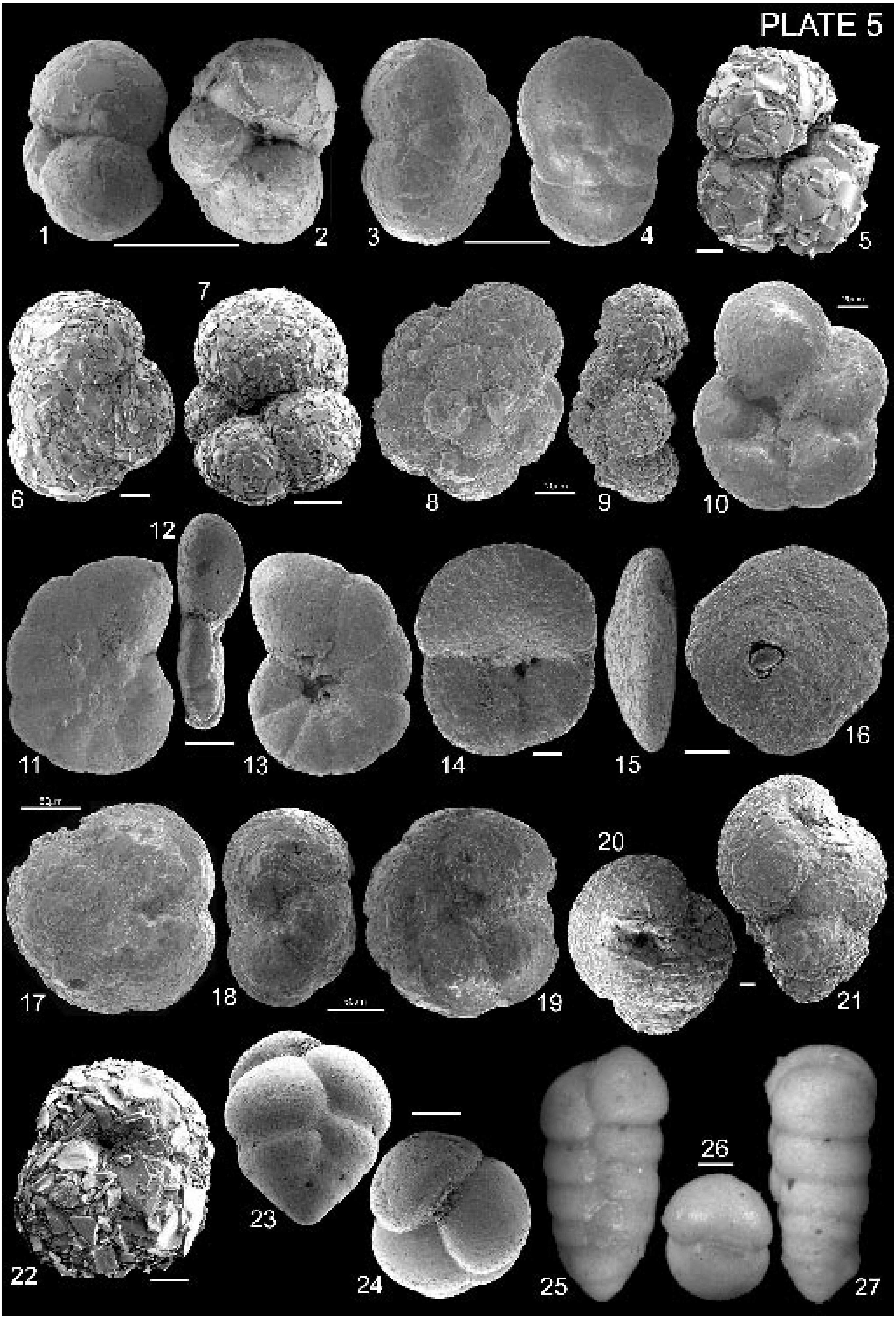

Plate 6

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1-3	***Martinottiella communis*** (d'Orbigny, 1846). BWH179/20-21, ODP 1122C-1H-CC, Bounty Trough, 4400 m. 1: apertural view of broken top. 2: top of broken piece.	**p.145**
4-5	***Martinottiella omnia*** Saidova, 1975. BWH179/16, F202457, Bay of Plenty, 2810 m.	**p.145**
6	***Karrerulina conversa*** (Grzybowski, 1901). BWH136/18, ODP 1123B-1H-1, 7-9 cm, Chatham Rise, 3290 m.	**p.145**
7	***Karrerulina conversa*** (Grzybowski, 1901). BWH136/19, ODP 1123B-1H-1, 7-9 cm, Chatham Rise, 3290 m.	**p.145**
8-9	***Pseudoclavulina serventyi*** (Chapman & Parr, 1935). BWH180/6, F201517, off North Cape, 133 m.	**p.146**
10	***Pseudoclavulina serventyi*** (Chapman & Parr, 1935). BWH180/7, F201517, off North Cape, 133 m.	**p.146**
11-13	***Siphotextularia blacki*** Vella, 1957. BWH195/9, NIWA Stn P525, off North Cape, 380 m.	**p.146**
14-15	***Siphotextularia flintii*** (Cushman, 1911). BWH137/22, ODP 1125A-1H-1, 18-20 cm, Chatham Rise, 1365 m.	**p.146**
16-17	***Siphotextularia foliosa*** Zheng, 1988. BWH181/18, F202439, offshore Taranaki, 498 m.	**p.146**
18	***Siphotextularia foliosa*** Zheng, 1988. BWH180/1, F202563, Pukaki Saddle, 1552 m.	**p.146**
19-21	***Siphotextularia mestayerae*** Vella, 1957. BWH194/27, F202351, Canterbury, off Banks Peninsula, 90 m.	**p.147**
22-23	***Siphotextularia fretensis*** Vella, 1957. BWH137/41, F202390, South Canterbury Bight, 100 m.	**p.147**
24	***Siphotextularia rolshauseni*** Phleger & Parker, 1951. BWH142/8, F202387, Bounty Trough, 2700 m.	**p.147**
25	***Siphotextularia rolshauseni*** Phleger & Parker, 1951. BWH137/44, F202366, Hikurangi Plateau, 2840 m.	**p.147**
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28-29	***Textularia lythostrota*** (Schwager, 1866). BWH179/18, ODP 1120C-1H-1, 0-2 cm, Pukaki Rise, 544 m.	**p.148**
30-32	***Textularia pseudogramen*** Chapman & Parr, 1937. BWH194/28, L17748, east of Northland, off Poor Knights Islands, 110 m.	**p.148**
33	***Textularia stricta*** Cushman, 1911. BWH136/22, L17749, east of Northland, off Poor Knights Islands, 155 m.	**p.148**
34	***Textularia stricta*** Cushman, 1911. BWH136/23, L17749, east of Northland, off Poor Knights Islands, 155 m. Scale Bar: 200 µm.	**p.148**
35-36	***Textularia stricta*** Cushman, 1911. Multifocus image, FP5207, L17748, east of Northland, off Poor Knights Islands, 110 m. Scale Bar: 200 µm.	**p.148**
37-38	***Cylindroclavulina bradyi*** (Cushman, 1911). BWH158/2, NIWA Stn P525, off North Cape, 380 m. Scale Bar: 200 µm.	**p.148**
39-40	***Cylindroclavulina bradyi*** (Cushman, 1911). BWH157/9, F202478, off Great Barrier Island, 549 m.	**p.148**

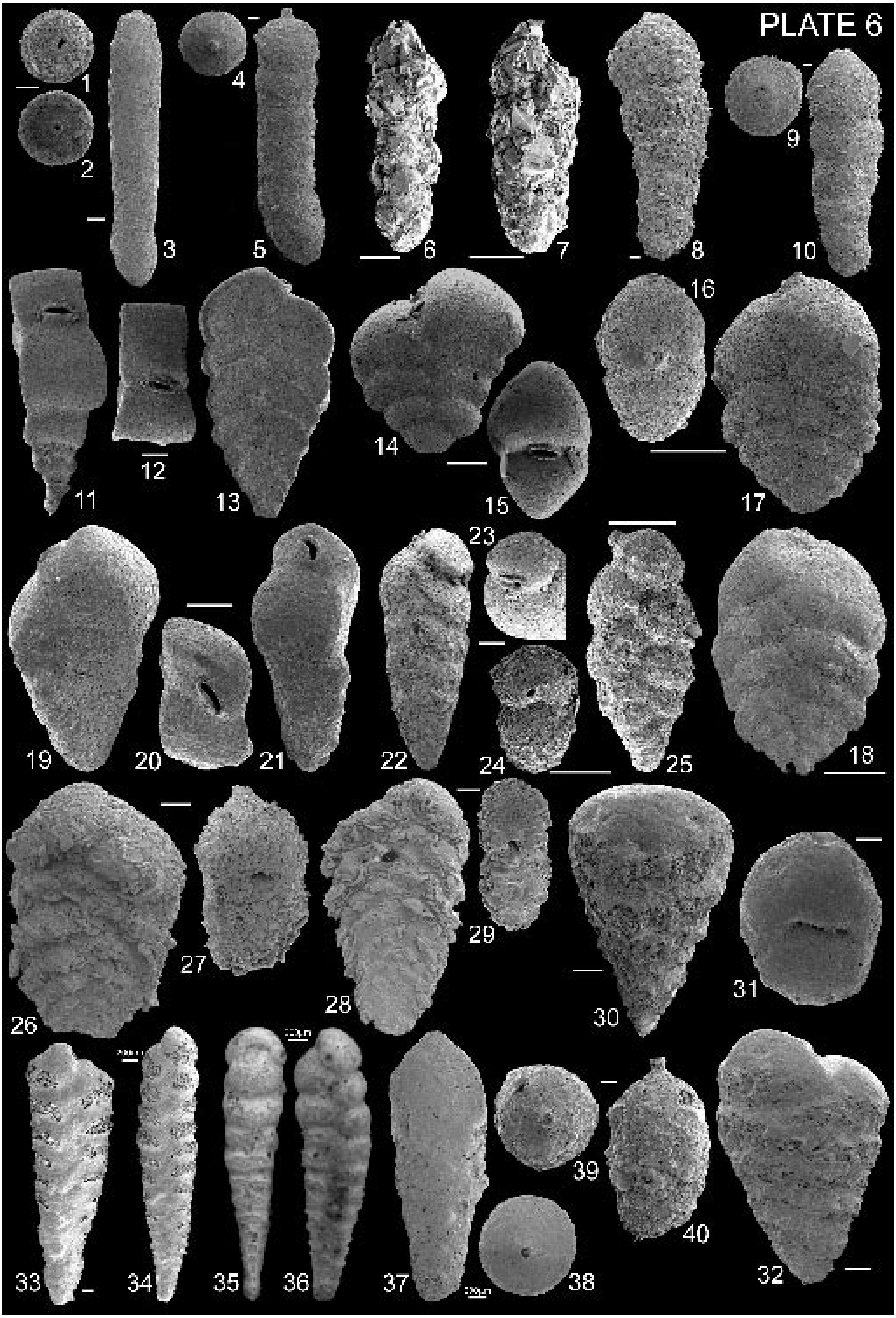
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Plate 7

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1-3	***Miliolinella subrotunda*** (Montagu, 1808). BWH195/24, L17748, east of Northland, off Poor Knights Islands, 110 m.	**p.149**
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5-6	***Nummoloculina contraria*** (d'Orbigny, 1846). BWH192/17, L17749, east of Northland, off Poor Knights Islands, 155 m. Scale Bar: 200 µm.	**p.149**
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9-10	***Pyrgo clypeata*** (d'Orbigny, 1846). BWH171/29, L17750, Hen & Chickens Islands, 47 m.	**p.150**
11-12	***Pyrgo comata*** (Brady, 1881). BWH185/18, F202451, New Caledonia Trough, 1233 m.	**p.150**
13-14	***Pyrgo depressa*** (d'Orbigny, 1826). BWH195/20, L17748, east of Northland, off Poor Knights Islands, 110 m.	**p.150**
15-16	***Pyrgo inornata*** (d'Orbigny, 1846). BWH127/40, F201050, east of Northland, off Hen & Chickens Islands, 77 m.	**p.151**
17-19	***Pyrgo inornata*** (d'Orbigny, 1846). Multifocus image, FP5208, L17748, east of Northland, off Poor Knights Islands, 110 m. Scale Bar: 200 µm.	**p.151**
20-21	***Pyrgo murrhina*** (Schwager, 1866). BWH171/33, F202399, Bounty Trough, 2250 m.	**p.151**
22-23	***Pyrgo murrhina*** (Schwager, 1866). BWH185/15. F202456, Havre Trough, 3091 m.	**p.151**

PLATE 7

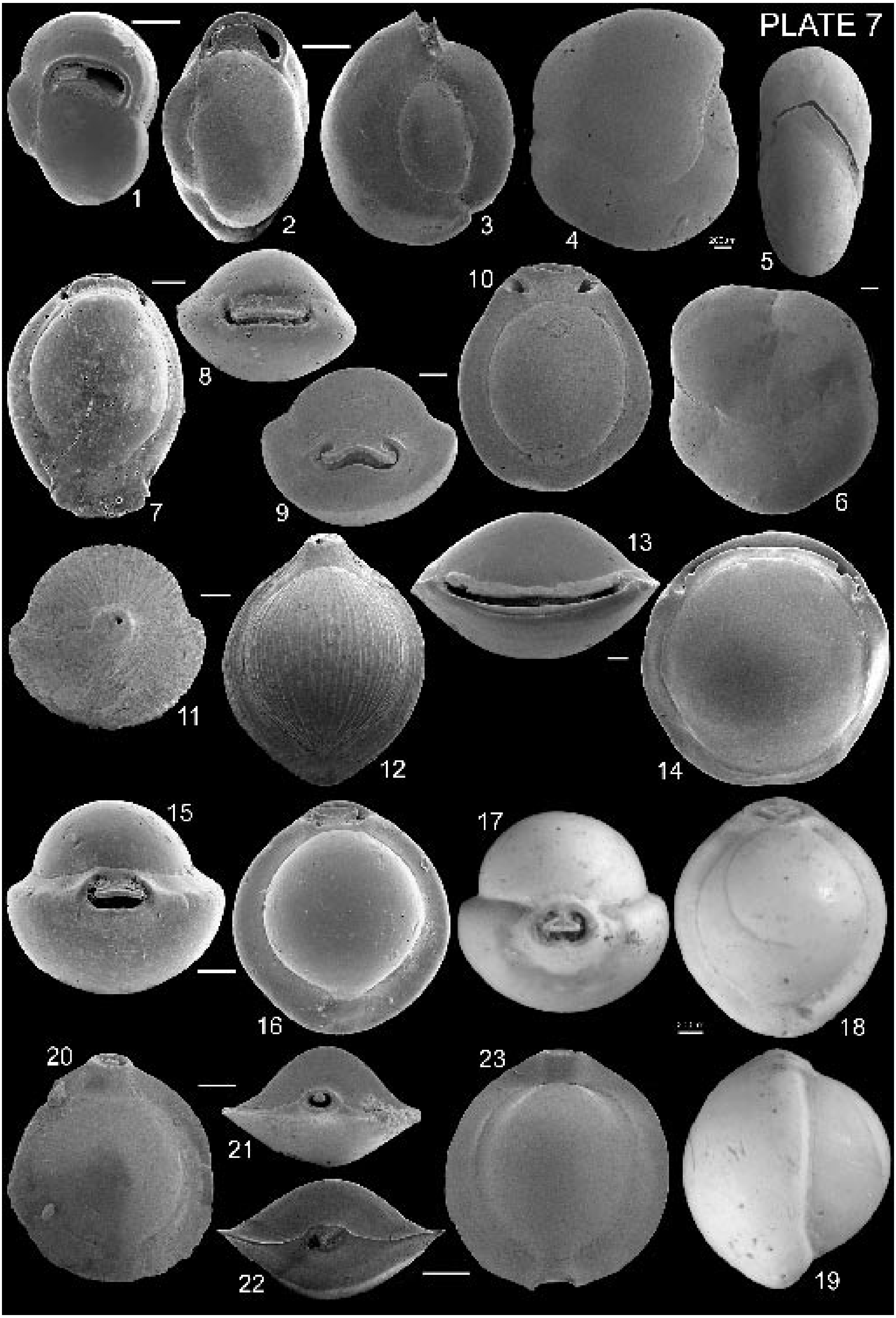

Plate 8

(Unless otherwise specified all scale bars = 100 μm)

Figs		
1-2	***Pyrgo ringens*** (Lamarck, 1804). BWH171/30, L17750, Hen & Chickens Islands, 47 m. Scale Bar: 200 μm.	**p.151**
3-4	***Pyrgo ringens*** (Lamarck, 1804). BWH191/7, L17750, Hen & Chickens Islands, 47 m. Scale Bar: 200 μm.	**p.151**
5-6	***Pyrgo serrata*** (Bailey, 1861). BWH171/31, F201288, West Coast, off Greymouth, 610 m.	**p.151**
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11	***Pyrgoella sphaera*** (d'Orbigny, 1839). BWH62-16, F201517, off North Cape, 133 m. Close-up of aperture.	**p.152**
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14	***Quinqueloculina auberiana*** d'Orbigny, 1839. BWH194/21, L17748, east of Northland, off Poor Knights Islands, 110 m.	**p.153**
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16-17	***Quinqueloculina boueana*** d'Orbigny, 1846. BWH185/19, L17750, Hen & Chickens Islands, 47 m.	**p.154**
18-19	***Quinqueloculina parvaggluta*** Vella, 1957. BWH195/30, F201042, off Mayor Island, 200 m.	**p.154**
20-22	***Quinqueloculina seminula*** (Linnaeus, 1758). BWH195/17, L17748, east of Northland, off Poor Knights Islands, 110 m.	**p.154**
23-24	***Quinqueloculina suborbicularis*** d'Orbigny, 1826 in Fornasini, 1905. BWH128/12, L13001, Wanganui Bight, 42 m.	**p.154**
25	***Quinqueloculina suborbicularis*** d'Orbigny, 1826 in Fornasini, 1905. BWH128/13, L13001, Wanganui Bight, 42 m.	**p.154**

PLATE 8


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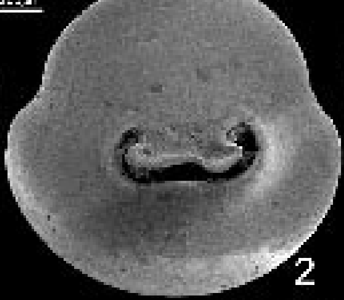
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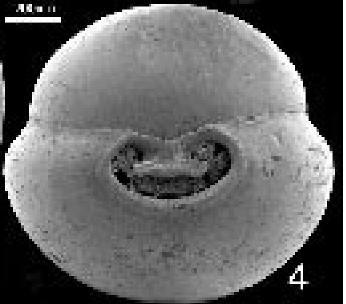
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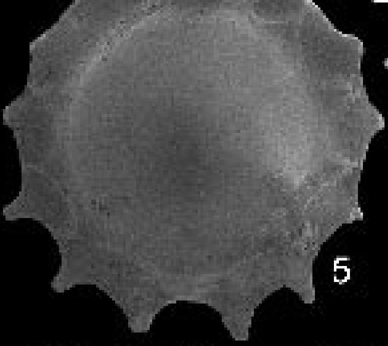
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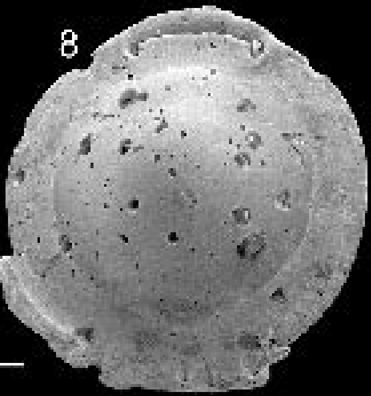
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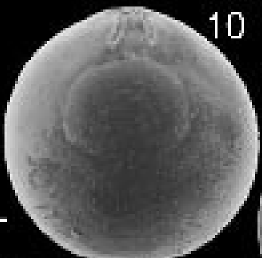
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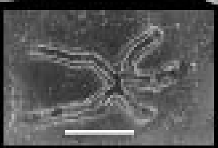
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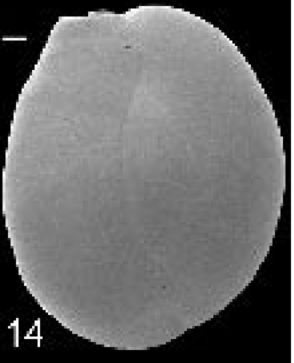
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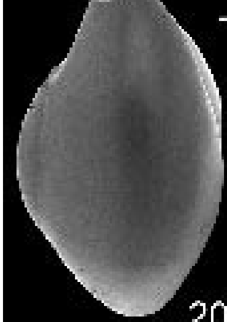
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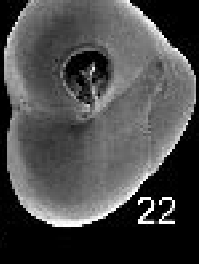
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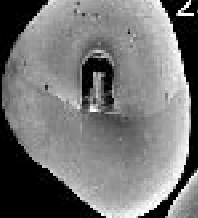
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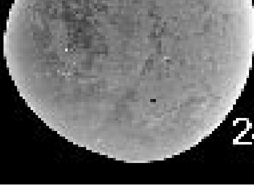
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Plate 9

(Unless otherwise specified all scale bars = 100 μm)

Figs		
1-4	***Quinqueloculina subpolygona*** Parr, 1945. Multifocus images, FP5209, F201227, Wanganui Bight, 88 m. Scale Bar: 0.1 mm.	**p.155**
5	***Quinqueloculina venusta*** Karrer, 1868. BWH172/29, ODP 1122A-7H-CC, Bounty Trough, 4400 m. Scale Bar: 0.1 mm.	**p.155**
6-7	***Quinqueloculina venusta*** Karrer, 1868. BWH172/30, ODP 1122A-7H-CC, Bounty Trough, 4400 m. Scale Bar: 0.1 mm.	**p.155**
8-9	***Sigmoilina sigmoidea*** (Brady, 1884). BWH172/34, F202550, Solander Trough, 896 m. Scale Bar: 0.1 mm.	**p.155**
10-11	***Sigmoilopsis elliptica*** (Galloway & Wissler, 1927). BWH168/39, F202511, Auckland Islands, 80 m. Scale Bar: 0.1 mm.	**p.156**
12-14	***Sigmoilopsis schlumbergeri*** (Silvestri, 1904). Multifocus image, FP5210, F202398, Bounty Trough, 1733 m.	**p.156**
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17-18	***Sigmoilopsis wanganuiensis*** Vella, 1957. BWH195/7, F201288, West Coast, off Greymouth, 610 m.	**p.156**
19-20	***Spirosigmoilina pusilla*** (Earland, 1934). BWH172/33, F202617, Kermadec Ridge, 2427 m.	**p.157**
21	***Spirosigmoilina tenuis*** (Czjzek, 1848). BWH124/13. F201354, Little Barrier Island, 77 m.	**p.157**
22	***Spirosigmoilina tenuis*** (Czjzek, 1848). BWH195/10, F201354, Little Barrier Island, 77 m. Scale Bar: 0.1 mm.	**p.157**
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27	***Inaequalina disparilis*** (Terquem, 1878). BWH38/12, F201012, Three Kings Islands, 200 m.	**p.158**
28-29	***Inaequalina disparilis*** (Terquem, 1878). Multifocus image, FP5211, L17748, east of Northland, off Poor Knights Islands, 110 m.	**p.158**
30-31	***Nummulopyrgo globulus*** (Hofker, 1976). BWH62/4, F201019, off North Cape, 150 m.	**p.158**
32	***Nummulopyrgo globulus*** (Hofker, 1976). BWH193/10, F201019, off North Cape, 150 m.	**p.158**

PLATE 9

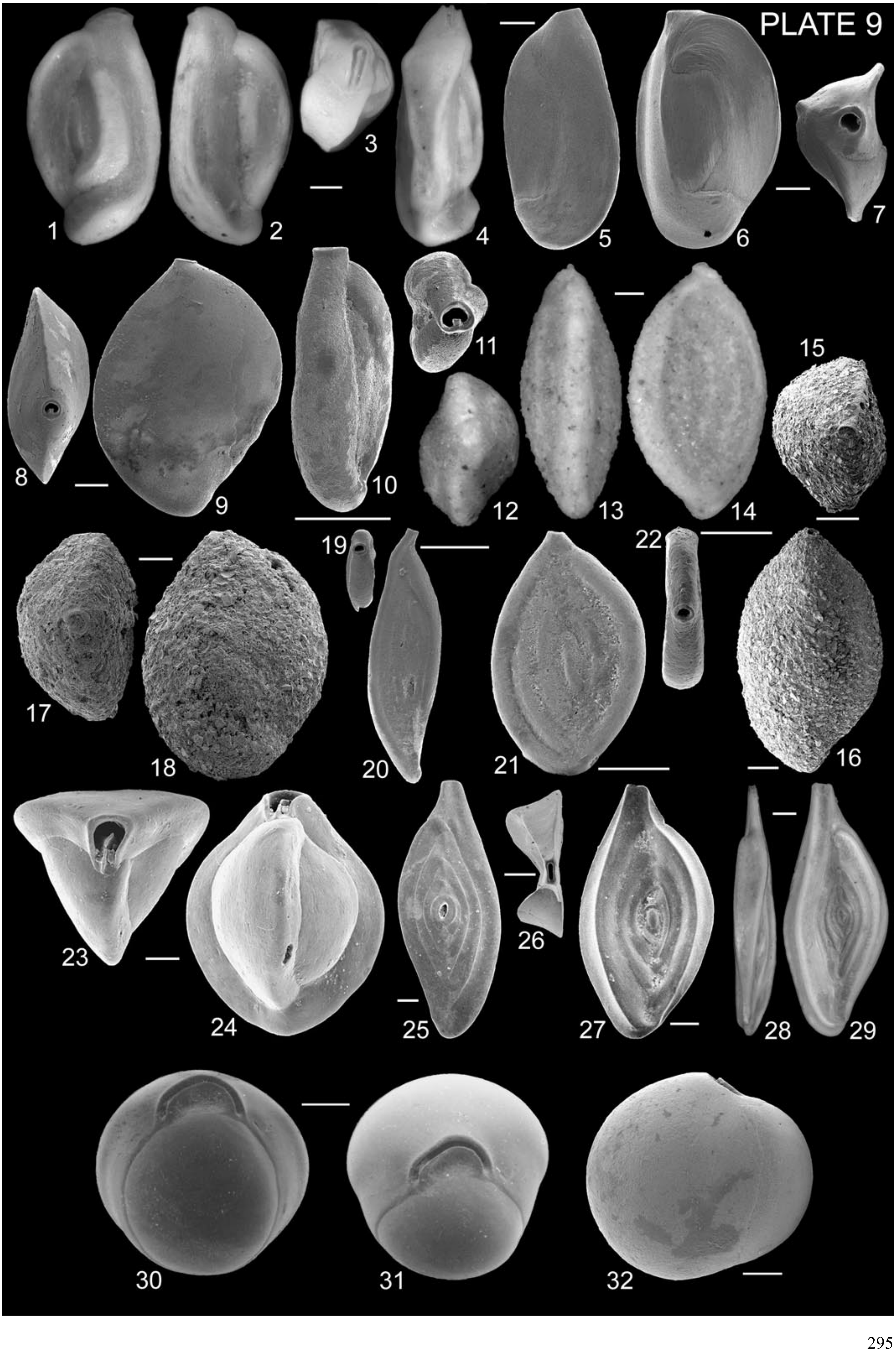
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Plate 10

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1	***Spiroloculina communis*** Cushman & Todd, 1944. BWH14/8, F201750, east of Northland, Cavalli Islands, 8 m.	**p.158**
2	***Spiroloculina communis*** Cushman & Todd, 1944. BWH125/1, L13027 Wanganui Bight, 78 m.	**p.158**
3-5	***Spiroloculina communis*** Cushman & Todd, 1944. Multifocus image, FP5212, L17748, east of Northland, off Poor Knights Islands, 110 m.	**p.158**
6-8	***Spiroloculina novozealandica*** Cushman & Todd, 1944. Multifocus image, FP5213, F201289, West Coast, off Greymouth, 610 m.	**p.158**
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11-12	***Cushmanina striatopunctata*** (Parker & Jones, 1865). BWH166/7, F202568, south of Campbell Plateau, 2074 m.	**p.159**
13	***Cushmanina striatopunctata*** (Parker & Jones, 1865). BWH166/8, F202568, south of Campbell Plateau, 2074 m.	**p.159**
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16-17	***Exsculptina exsculpta*** (Brady, 1881). BWH166/3, F202576, Campbell Plateau slopes, 4530 m.	**p.160**
18-19	***Favulina favosopunctata*** (Brady, 1881). BWH166/18, F202568, south Campbell Plateau, 2074 m.	**p.160**
20	***Favulina hexagona*** (Williamson, 1848). BWH7/5, F201762, east of Northland, Cavalli Islands, 36 m.	**p.160**
21	***Favulina hexagona*** (Williamson, 1848). BWH119/2. F201960, east Northland, Taiwawe Bay, 4 m.	**p.160**
22-23	***Favulina hexagoniformis*** (McCulloch, 1997). BWH166/4, F202522, south of Stewart Island, 187 m.	**p.161**
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26-27	***Favulina vadosa*** (McCulloch, 1977). BWH166/16, F202566, south Campbell Plateau, 1685 m.	**p.161**
28-29	***Fissurina bispinosa*** (Heron-Allen & Earland, 1932). BWH168/25, F201106, Enderby Island, Auckland Islands, 10 m.	**p.161**
30-31	***Fissurina* aff. *fimbriata*** (Brady, 1881). BWH172/1, F202370, Hikurangi Plateau, 4096 m.	**p.162**
32	***Fissurina laureata*** (Heron-Allen & Earland, 1932). BWH168/33, F201106, Enderby Island, Auckland Islands, 10 m.	**p.162**
33	***Fissurina laureata*** (Heron-Allen & Earland, 1932). BWH168/32, F201106, Enderby Island, Auckland Islands, 10 m.	**p.162**
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35	***Fissurina spinosa*** (Sidebottom, 1912). BWH171/36, F202448, offshore Taranaki, 850 m.	**p.162**

PLATE 10

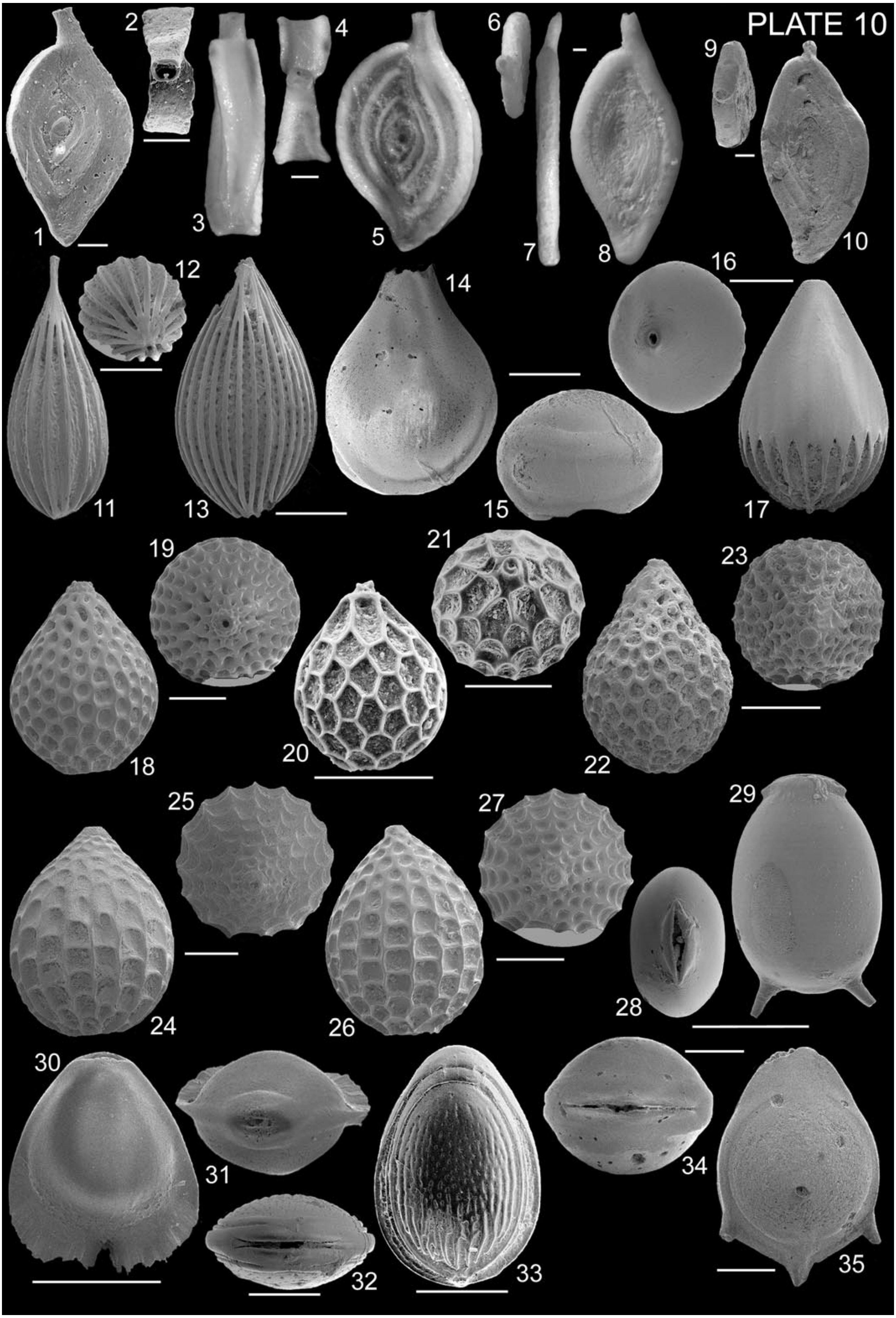
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Plate 11

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1-2	***Galwayella trigonomarginata*** (Parker & Jones, 1865). BWH166/20, F201107, Auckland Islands, Enderby Island, 10 m.	**p.162**
3-4	***Homalahedra liratiformis*** (McCulloch, 1977). BWH168/26, F201106, Enderby Island, Auckland Islands, 10 m.	**p.162**
5-6	***Laculatina quadrilatera*** (Earland, 1934). BWH166/5, F202576, Campbell Plateau slopes, 4530 m.	**p.163**
7-8	***Lagenosolenia confossa*** McCulloch, 1977. BWH125/38, L13023, Wanganui Bight, 77 m.	**p.163**
9-10	***Lagenosolenia falcata*** (Chaster, 1892). BWH172/7, F201108, Auckland Islands, 10 m.	**p.163**
11-12	***Lagnea honshuensis*** (McCulloch, 1977). BWH166/26, F201107, Auckland Islands, Enderby Island, 10 m.	**p.164**
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17-18	***Oolina stelligera*** (Brady, 1881). BWH166/1, F202576, Campbell Plateau slopes, 4530 m.	**p.164**
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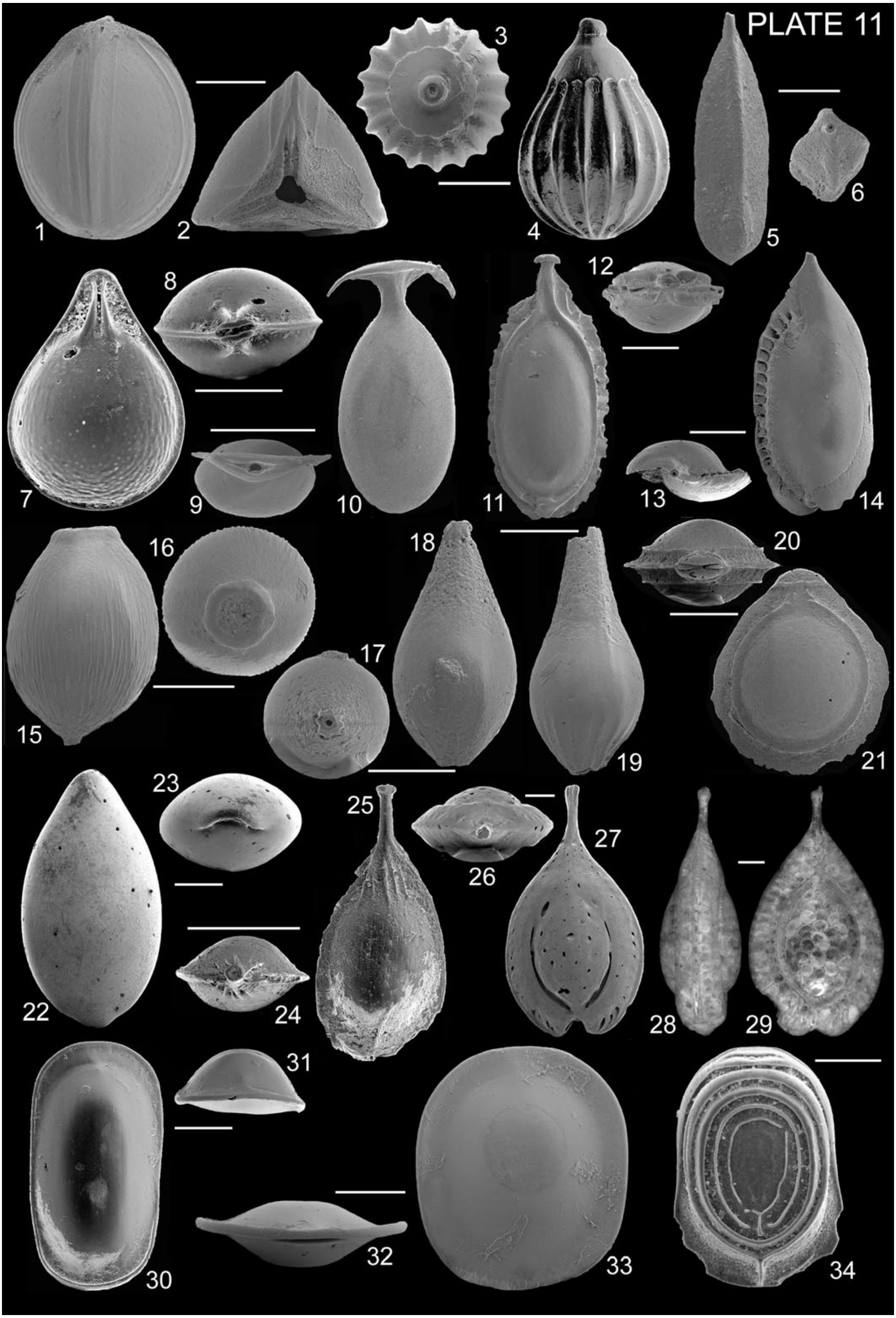
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Plate 12

(Unless otherwise specified all scale bars = 100 µm)

Figs		
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5-6	***Hyalinonetrion gracillima*** (Seguenza, 1862). BWH166/14, F202567, Bounty Trough, 1756 m. Scale Bars: 100 & 50 µm.	**p.167**
7-8	***Lagena crenata*** Parker & Jones, 1865. BWH191/29, F201866, off Great Barrier Island, 68 m.	**p.168**
9-10	***Lagena crenata*** Parker & Jones, 1865. BWH172/4, F201866, off Great Barrier Island, 68 m.	**p.168**
11-12	***Lagena hispidula*** Cushman, 1913. BWH166/9, F202575, south-east Campbell Plateau, 4500 m.	**p.168**
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15-16	***Lagena peculiariformis*** Albani & Yassini, 1989. BWH166/15, F202552, Pukaki Saddle, 978 m.	**p.168**
17-18	***Lagena tokiokai*** Uchio, 1962. BWH172/2, F202384, Chatham Rise, 1300 m.	**p.168**
19-20	***Procerolagena distomamargaritifera*** (Parker & Jones, 1865). BWH171/6, F201048, east of Northland, off Hen & Chickens Islands, 60 m.	**p.169**
21-22	***Procerolagena meridionalis*** (Wiesner, 1931). BWH166/12, F202573, south of Campbell Plateau, 4138 m.	**p.169**
23-24	***Procerolagena meridionalis*** (Wiesner, 1931). BWH166/14, F202573, south of Campbell Plateau, 4138 m. Scale Bar: 50 µm.	**p.169**
25-26	***Procerolagena multilatera*** **(**McCulloch, 1977). BWH166/21, F202573, south of Campbell Plateau, 4138 m. Scale Bar: 50 µm.	**p.169**
27-28	***Botuloides pauciloculus*** Zheng, 1979. BWH193/5, ODP 1125A-1H-1, 4-6 cm, Chatham Rise, 1365 m.	**p.169**
29-30	***Dentalina cuvieri*** (d'Orbigny, 1826). Multifocus image, FP5215, L17753, off Great Barrier Island, 200 m. Scale Bar: 200 µm.	**p.170**
31	***Frondicularia compta*** Brady, 1879. Multifocus image, FP5216, F201042, Bay of Plenty, off Mayor Island, 200 m.	**p.170**
32-33	***Frondicularia compta*** Brady, 1879. Multifocus image, FP5217, F201042, Bay of Plenty, off Mayor Island, 200 m.	**p.170**
34-35	***Laevidentalina advena*** (Cushman, 1923). Multifocus image, FP5218, F201517, North Cape, 133 m.	**p.170**
36-37	***Laevidentalina badenensis*** (d'Orbigny, 1846). Multifocus image, FP5219, F202042, northern Great Barrier Island, 59 m. Scale Bar: 200 µm.	**p.170**
38-39	***Laevidentalina badenensis*** (d'Orbigny, 1846). BWH123/17, L17748, east of Northland, off Poor Knights Islands, 110 m.	**p.170**
40-41	***Laevidentalina elegans*** (d'Orbigny, 1846). BWH193/7, F201517, off North Cape, 133 m.	**p.171**
42	***Laevidentalina elegans*** (d'Orbigny, 1846). Multifocus image, FP5220, F201517, off North Cape, 133 m.	**p.171**
43	***Laevidentalina haueri*** (Neugeboren, 1856). BWH123/14, 110 m, L17748, off Poor Knights Islands, 110 m.	**p.171**
44-45	***Laevidentalina haueri*** (Neugeboren, 1856). BWH123/13, L17748, east of Northland, off Poor Knights Islands, 110 m.	**p.171**
46-47	***Laevidentalina haueri*** (Neugeboren, 1856). Multifocus image, FP5221, L17748, east of Northland, off Poor Knights Islands, 110 m.	**p.171**
48-49	***Laevidentalina inornata*** (d'Orbigny, 1846). Multifocus image, FP5222, F201288, West Coast, off Greymouth, 610 m.	**p.171**
50	***Laevidentalina inornata*** (d'Orbigny, 1846). BWH123/16, L17748, east of Northland, off Poor Knights Islands, 110 m.	**p.171**
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53-56	***Laevidentalina sidebottomi*** (Cushman, 1923). BWH195/37 & Multifocus images, NIWA Stn P525, off North Cape, 380 m.	**p.171**
57-58	***Lingulina grandis*** Cushman, 1917. BWH184/1, L9928, Bay of Islands, 54 m. Scale Bar: 500 µm.	**p.172**
59	***Mucronina*** aff. ***advena*** (Cushman, 1923). Multifocus image, FP5223, F201288, West Coast, off Greymouth, 610 m.	**p.172**
60-61	***Mucronina*** aff. ***advena*** (Cushman, 1923). Multifocus image, FP5224, F201288, West Coast, off Greymouth, 610 m.	**p.172**
62	***Pseudonodosaria brevis*** (d'Orbigny, 1846). BWH144/6, F201289, West Coast, off Greymouth, 610 m.	**p.172**
63	***Pseudonodosaria brevis*** (d'Orbigny, 1846). BWH144/7, F201289, West Coast, off Greymouth, 610 m.	**p.172**

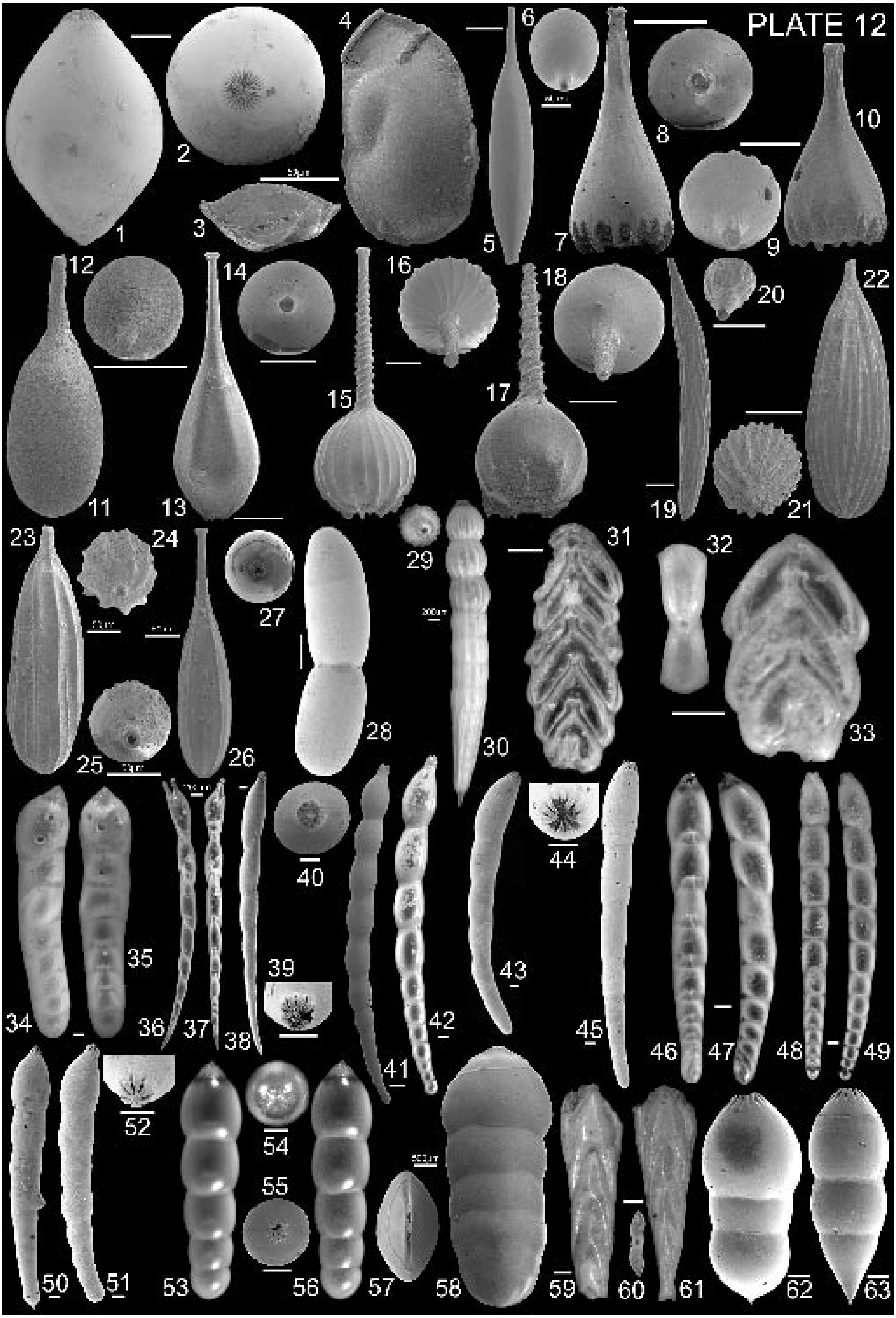
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Plate 13

(Unless otherwise specified all scale bars = 100 μm)

Figs		
1-2	***Francuscia extensa*** (Cushman, 1923). BWH184/12, F202456, Havre Trough, 3091 m.	**p.172**
3-4	***Pyrulina angusta*** (Egger, 1857). Multifocus image, FP5225, F202455, Havre Trough, 3148 m.	**p.173**
5-6	***Pyrulina fusiformis*** (Roemer, 1838). Multifocus image, FP5226, F202459, northeast of the Bay of Plenty, 2550 m.	**p.173**
7-8	***Pyrulina fusiformis*** (Roemer, 1838). BWH185/9, F202457, Havre Trough, 2810 m.	**p.173**
9	***Ramulina globulifera*** Brady, 1879. BWH157/11, F202480, Bay of Plenty, off Mercury Islands, 430 m.	**p.173**
10-11	***Sigmoidella elegantissima*** Parker & Jones, 1870. BWH125/35, F202276, Stewart Island, Port Pegasus, 16 m.	**p.173**
12-13	***Sigmoidella elegantissima*** Parker & Jones, 1870. Multifocus image, FP5227, F202060, off Great Barrier Island, 51 m.	**p.173**
14-16	***Sigmoidella pacifica*** Cushman & Ozawa, 1928. Multifocus image, FP5228, F202515, off Stewart Island, 143 m.	**p.173**
17-18	***Amphicoryna georgechapronierei*** Yassini & Jones, 1995. BWH195/26, F201048, east of Northland, off Hen & Chickens Islands, 60 m.	**p.174**
19	***Amphicoryna hirsuta*** f. ***hirsuta*** (d'Orbigny, 1826). BWH144/20, F201289, West Coast, off Greymouth, 610 m.	**p.174**
20	***Amphicoryna hirsuta*** f. ***sublineata*** (Brady, 1884). BWH143/11, F201289, West Coast, off Greymouth, 610 m.	**p.174**
21-22	***Amphicoryna separans*** (Brady, 1884). BWH157/10, F202480, Bay of Plenty, off Mercury Islands, 480 m.	**p.175**
23-24	***Astacolus crepidulus*** (Fichtel & Moll, 1798). BWH124/4, F202312, Stewart Island, Port Pegasus, 3 m.	**p.175**
25	***Hemirobulina angistoma*** Stache, 1864. BWH185/2, F201050, east of Northland, off Hen & Chickens Islands, 77 m.	**p.175**
26-27	***Hemirobulina angistoma*** Stache, 1864. BWH185/3, F201050, east of Northland, off Hen & Chickens Islands, 77 m.	**p.175**
28-30	***Hemirobulina hydropica*** (Hornibrook, 1961). Multifocus image, FP5229, F201517, off North Cape, 133 m.	**p.175**
31-32	***Lenticulina anaglypta*** (Loeblich & Tappan, 1987). BWH172/16, AU17811, NE of Great Barrier Island, 70 m. Scale Bar: 500 μm.	**p.176**
33-34	***Lenticulina australis*** Parr, 1950. BWH129/46, L13010, Wanganui Bight, 35 m.	**p.177**

PLATE 13

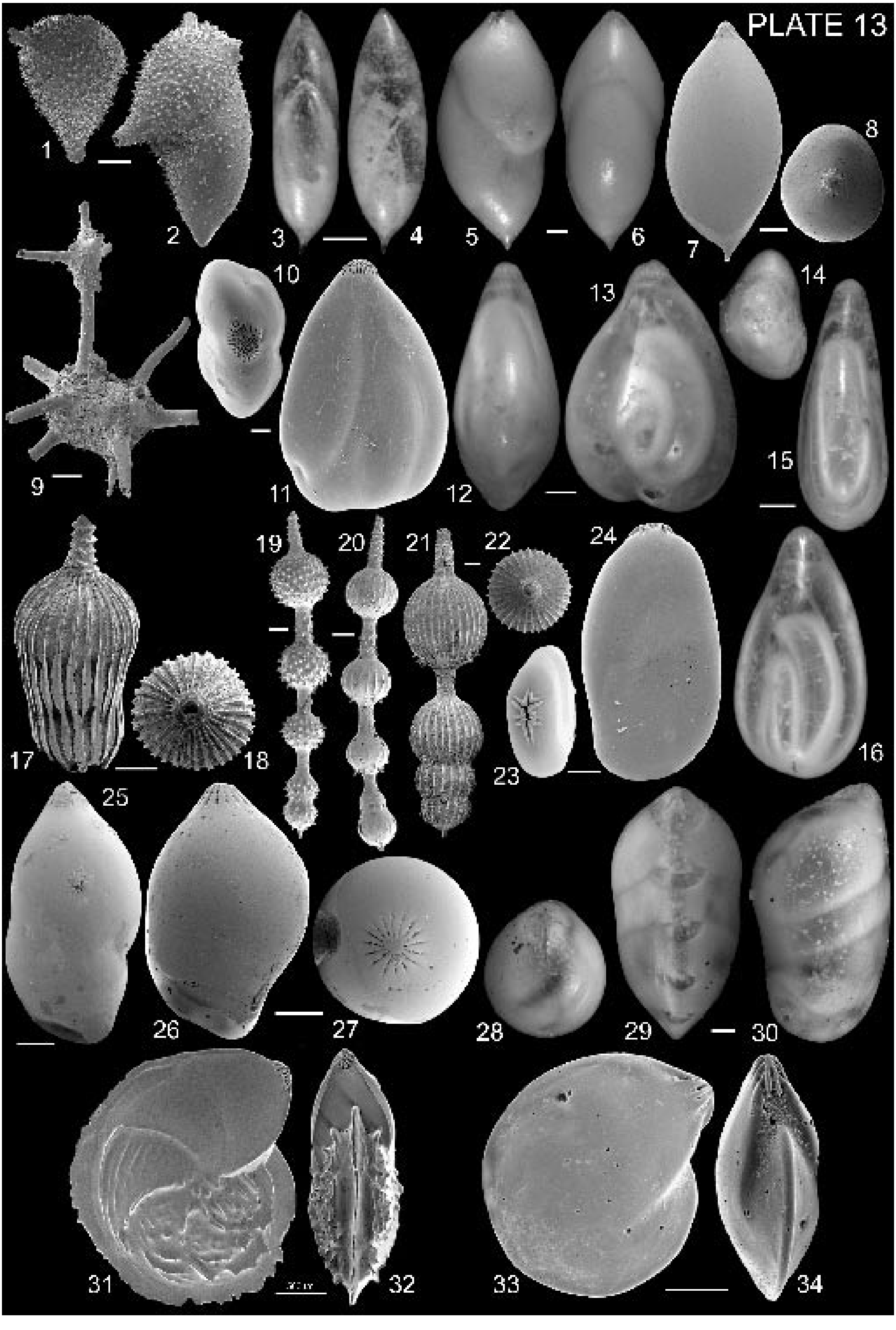
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Plate 14

Drawings by Margaret S. Morley
(Unless otherwise specified all scale bars = 100 μm)

Figs		
1-2	***Astacolus crepidulus*** (Fichtel & Moll, 1798). FP5230, L14055, off Chatham Island, 35 m.	**p.175**
3-4	***Lenticulina anaglypta*** (Loeblich & Tappan, 1987). FP5231, AU17811, off Great Barrier Island, 70 m.	**p.176**
5-6	***Lenticulina antarctica*** Parr, 1950. FP5232, F201577, Hawke Bay, 57 m.	**p.177**
7-8	***Lenticulina australis*** Parr, 1950. FP5233, L17749, east of Northland, Poor Knights Islands, 155 m.	**p.177**
9-10	***Lenticulina calcar*** (Linnaeus, 1758). FP5234, F201289, West Coast, off Greymouth, 610 m.	**p.177**
11-12	***Lenticulina cultrata*** Montfort, 1808**.** FP5235, F201289, West Coast, off Greymouth, 610 m.	**p.177**
13-14	***Lenticulina denticulifera*** (Cushman, 1913). FP5236, F201289, West Coast, off Greymouth, 610 m.	**p.177**
15-16	***Lenticulina foliata*** (Stache, 1865)**.** FP5237 , F201289, West Coast, off Greymouth, 610 m.	**p.178**
17-18	***Lenticulina formosa*** (Cushman, 1923). FP5238, F201289, West Coast, off Greymouth, 610 m.	**p.178**
19-20	***Lenticulina gibba*** (d'Orbigny, 1839). FP5239, F201354, off Little Barrier Island, 77 m.	**p.178**
21-22	***Lenticulina limbosa*** (Reuss, 1863). FP5240, F201289, West Coast, off Greymouth, 610 m.	**p.178**
23-24	***Lenticulina orbicularis*** (d'Orbigny, 1826). FP5241, F201289, West Coast, off Greymouth, 610 m.	**p.178**
25-26	***Lenticulina subgibba*** Parr, 1950. FP5242, L13014, Wanganui Bight, 72 m.	**p.179**
27-28	***Lenticulina submamilligera*** (Cushman, 1917). FP5243, F201354, east of Northland, off Little Barrier Island, 77 m.	**p.179**
29-30	***Lenticulina suborbicularis*** Parr, 1950. FP5244, L17748, east of Northland, off Poor Knights Island, 110 m.	**p.179**
31-32	***Lenticulina tasmanica*** Parr, 1950. FP5245, L17748, east of Northland, off Poor Knights Island, 110 m.	**p.179**
33-34	***Neolenticulina variabilis*** (Reuss, 1850). FP5246, F201050, east of Northland, off Hen & Chickens Islands, 77 m.	**p.180**

PLATE 14

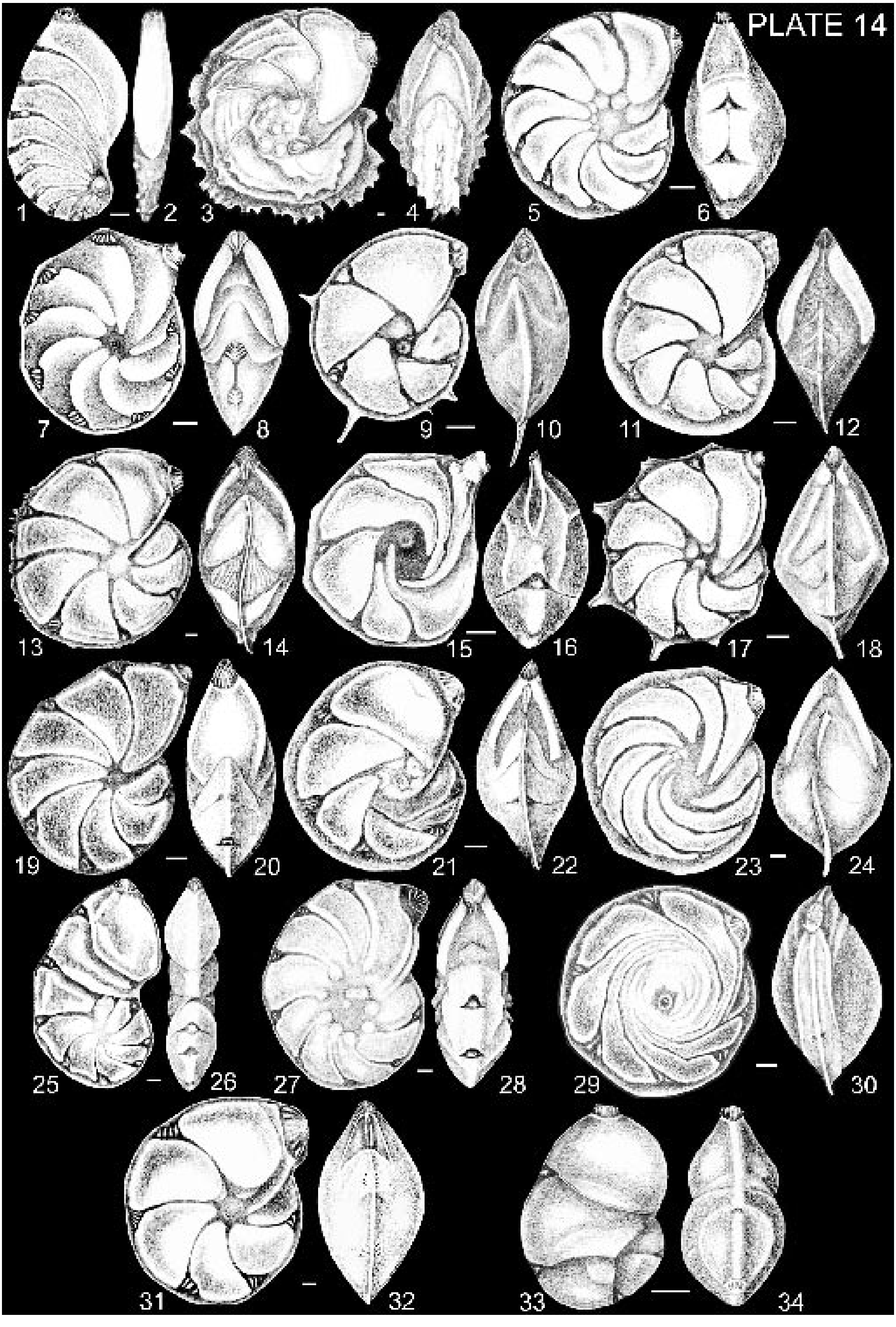
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Plate 15

(Unless otherwise specified all scale bars = 100 μm)

Figs		
1-2	***Lenticulina calcar*** (Linnaeus, 1758). BWH172/20, F201289, West Coast, off Greymouth, 610 m.	**p.177**
3-4	***Lenticulina formosa*** (Cushman, 1923). BWH159/1, NIWA Stn P525, off North Cape, 380 m.	**p.178**
5-6	***Lenticulina subgibba*** Parr, 1950. BWH123/3&4, F201050, east of Northland, off Hen & Chicken Islands, 77 m.	**p.179**
7-8	***Lenticulina submamilligera*** (Cushman, 1917). BWH172/17, NIWA Stn F861, off Hawke Bay, 329 m. Scale Bar: 500 μm.	**p.179**
9	***Marginulina striata*** d'Orbigny, 1852. BWH185/4, F201050, east of Northland, off Hen & Chicken Islands, 77 m.	**p.179**
10-11	***Marginulina striata*** d'Orbigny, 1852. BWH185/5, F201050, east of Northland, off Hen & Chicken Islands, 77 m.	**p.179**
12	***Marginulinopsis bradyi*** (Goës, 1894). BWH144/10, F201389, off Great Barrier Island, 550 m.	**p.180**
13-14	***Marginulinopsis tenuis*** (Bornemann, 1855). BWH185/8, F202480, Bay of Plenty, off Mercury Islands, 480 m.	**p.180**
15-16	***Neolenticulina variabilis*** (Reuss, 1850). BWH123/5, F201050, east of Northland, off Hen & Chicken Islands, 77 m.	**p.180**
17	***Planularia spinipes*** (Cushman, 1913). BWH124/2, F201517, off North Cape, 133 m.	**p.180**
18-19	***Planularia spinipes*** (Cushman, 1913). BWH124/3, F201517, off North Cape, 133 m.	**p.180**
20-21	***Saracenaria altifrons*** (Parr, 1950). BWH172/13, F201050, east of Northland, off Hen & Chicken Islands, 77 m.	**p.181**
22-24	***Saracenaria altifrons*** (Parr, 1950). Multifocus image, FP5248, F201050, east of Northland, off Hen & Chickens Islands, 77 m.	**p.181**
25	***Saracenaria italica*** Defrance, 1824. BWH123/1, F201517, off North Cape, 133 m.	**p.181**
26-27	***Saracenaria italica*** Defrance, 1824. BWH193/6, F201517, off North Cape, 133 m.	**p.181**
28	***Saracenaria latifrons*** (Brady, 1884). BWH122/32, F201050, east of Northland, off Hen & Chicken Islands, 77 m.	**p.181**
29-30	***Saracenaria latifrons*** (Brady, 1884). BWH172/18, F201354, east of Northland, off Little Barrier Island, 77 m.	**p.181**
31-34	***Saracenaria latifrons*** (Brady, 1884). Multifocus image, FP5249, F201354, east of Northland, off Little Barrier Island, 77 m.	**p.181**

PLATE 15

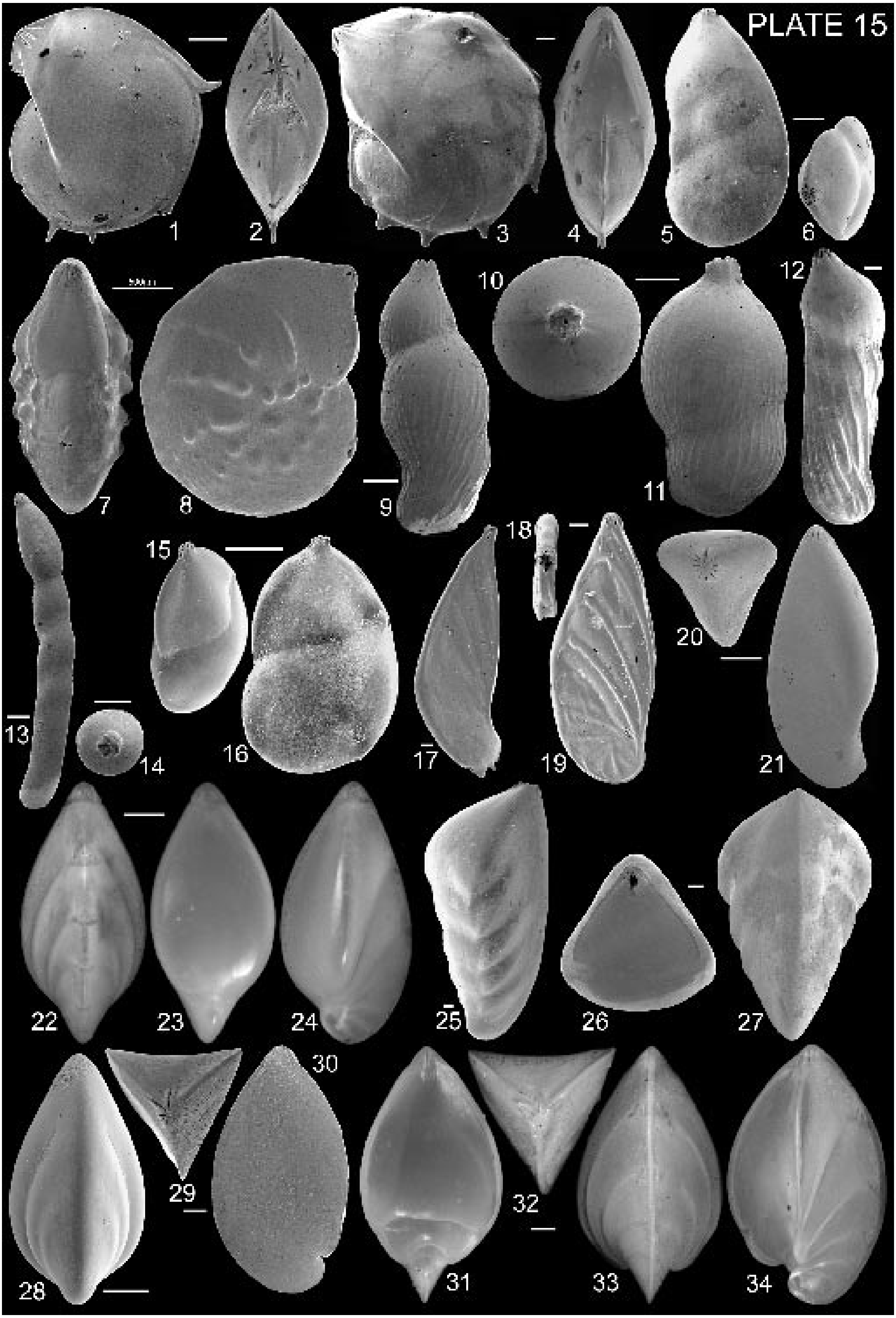
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Plate 16

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1-2	***Saracenaria spinosa*** Eichenberg, 1935. BWH123/2, F201517, off North Cape, 133 m.	**p.181**
3	***Vaginulina inflata*** Parr, 1950**.** BWH144/24, F201169, Fiordland, George Sound, <220 m.	**p.182**
4-5	***Vaginulina spinigera*** Brady, 1881. BWH192/20, F201288, West Coast, off Greymouth, 610 m.	**p.182**
6-7	***Vaginulina spinigera*** Brady, 1881. Multifocus image, FP5250, ODP 1125A-2H-5, 93-95 cm, Chatham Rise, 1365 m.	**p.182**
8-9	***Vaginulinopsis gnamptina*** Loeblich & Tappan, 1994. BWH, 185/7, F201517, off North Cape, 133 m.	**p.182**
10-11	***Vaginulinopsis gnamptina*** Loeblich & Tappan, 1994. Multifocus images, FP5251, F201517, off North Cape, 133 m.	**p.182**
12-13	***Vaginulinopsis tasmanica*** Parr, 1950. BWH192/19, F201517, off North Cape, 133 m.	**p.182**
14-15	***Vaginulinopsis tasmanica*** Parr, 1950. Multifocus image, FP5252, L17742, Bay of Plenty, off Cuvier Island, 70 m.	**p.182**
16	***Hoeglundina elegans*** (d'Orbigny, 1826). BWH124/21, F201354, east of Northland, off Little Barrier Island, 77 m.	**p.183**
17-18	***Hoeglundina elegans*** (d'Orbigny, 1826). BWH124/20, F201354, east of Northland, off Little Barrier Island, 77 m.	**p.183**
19-21	***Hoeglundina elegans*** (d'Orbigny, 1826). Multifocus images, FP5253, F201866, Great Barrier Island, 68 m.	**p.183**
22-24	***Robertinoides oceanicus*** (Cushman & Parker, 1947). Multifocus images, FP5254, F201019, North Cape, 150 m.	**p.183**
25-26	***Bolivina alata*** (Seguenza, 1862). BWH172/23, F202395, Chatham Rise, 1130 m.	**p.184**
27	***Bolivina cacozela*** Vella, 1957. BWH141/68, F202359, Chatham Rise, 101 m.	**p.184**
28	***Bolivina cacozela*** Vella, 1957. BWH141/67, F202359, Chatham Rise, 101 m.	**p.184**
29-30	***Bolivina compacta*** Sidebottom, 1905. BWH130/34, L14083, Chatham Islands, 6 m.	**p.185**
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37-38	***Bolivina pusilla*** Schwager, 1866**.** BWH172/27, F202422, New Caledonia Basin, 2000 m.	**p.186**
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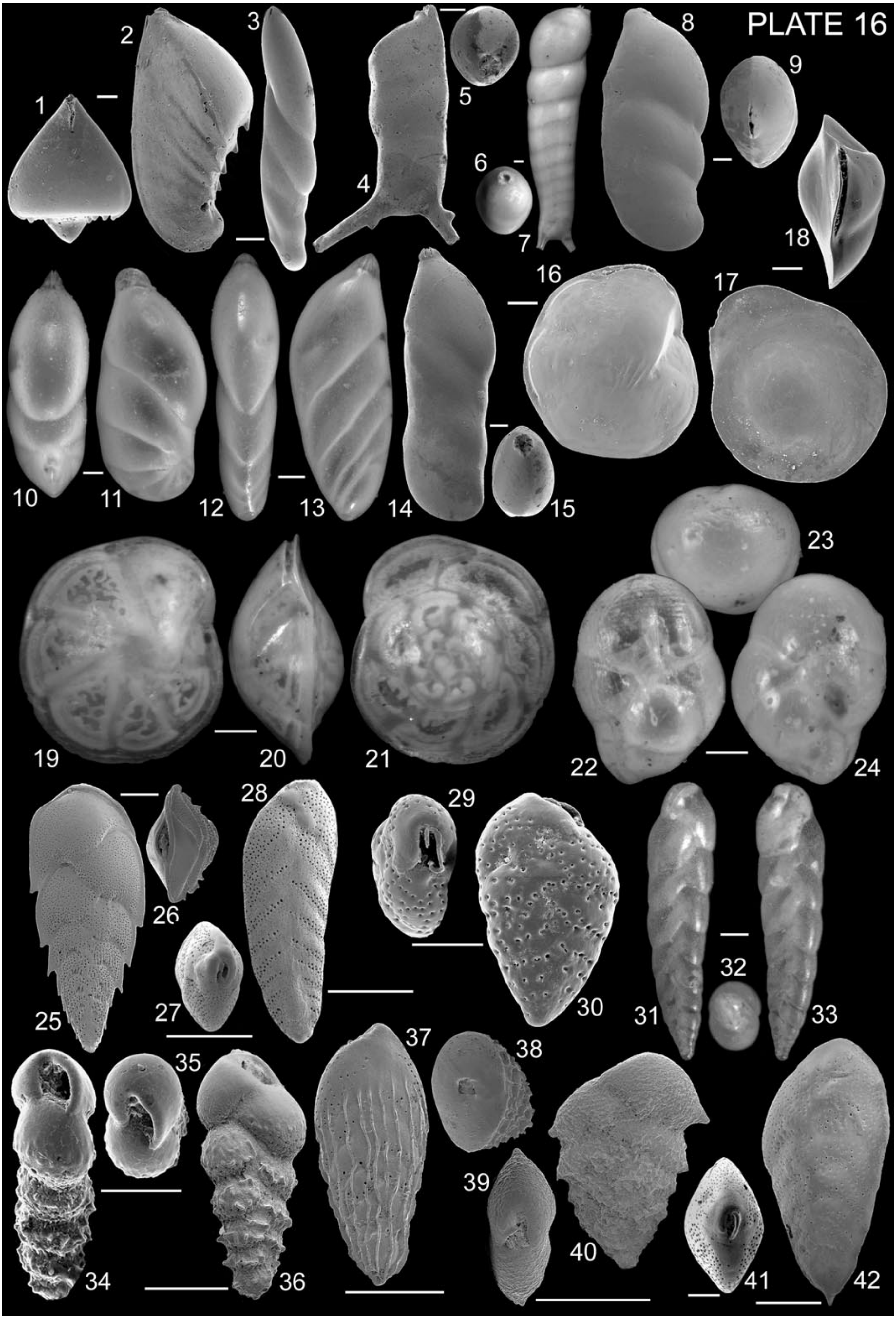

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Plate 17

(Unless otherwise specified all scale bars = 100 µm)

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PLATE 17

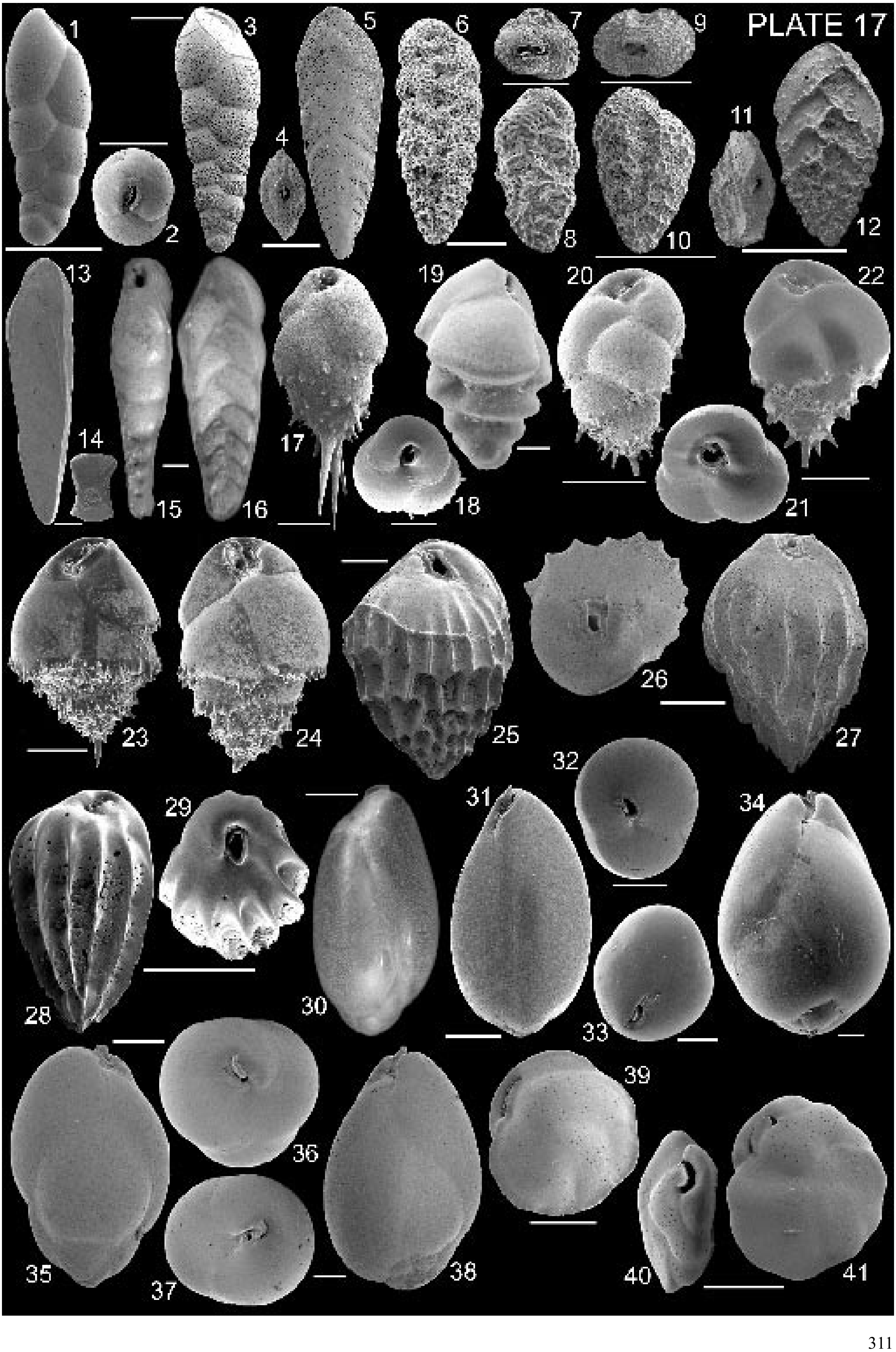
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Plate 18

(Unless otherwise specified all scale bars = 100 µm)

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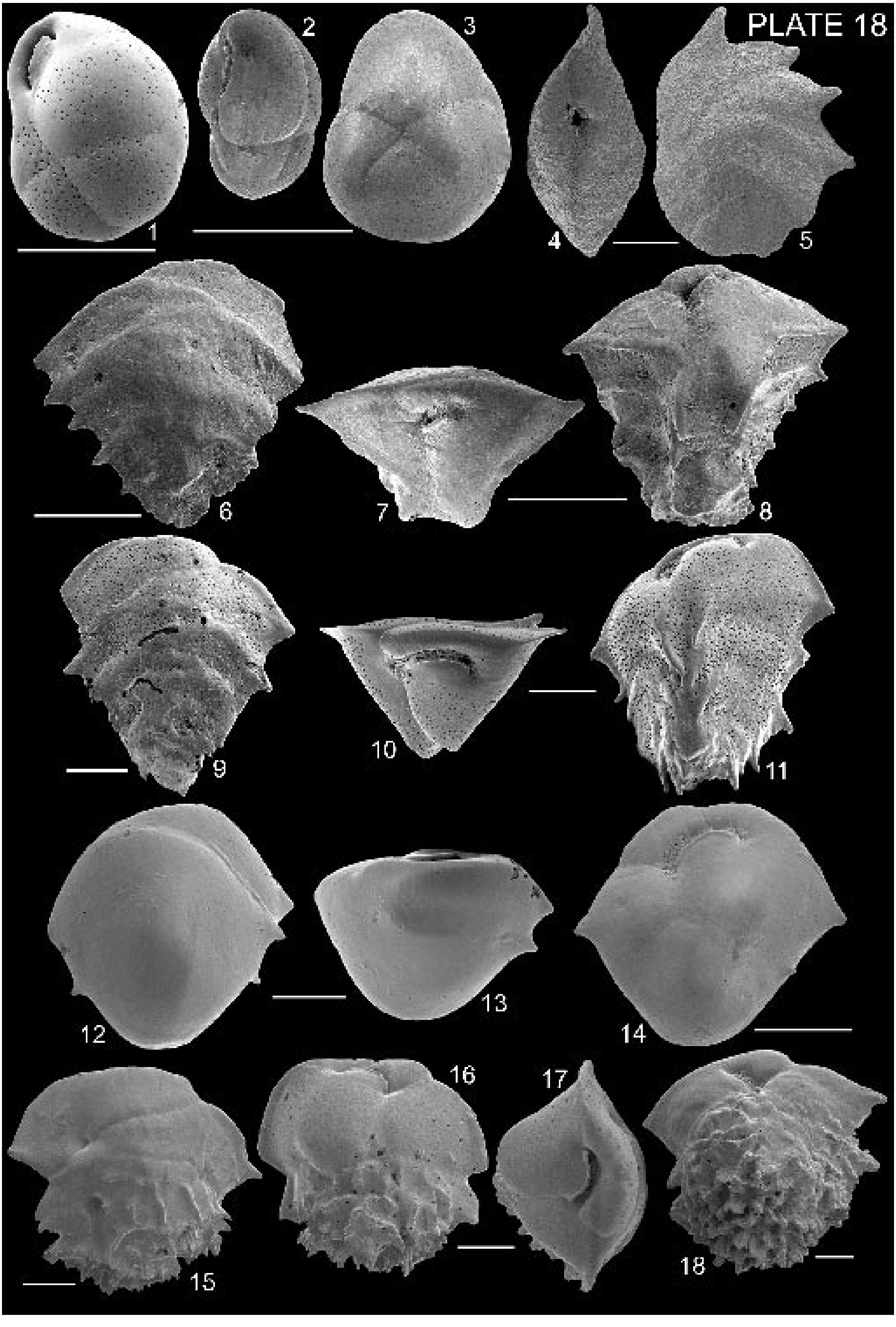

Plate 19

(Unless otherwise specified all scale bars = 100 µm)

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17	***Globocassidulina canalisuturata*** Eade, 1967. BWH156/1, ODP 1119C-1H-5, 18-22 cm, Canterbury Bight, 396 m.	**p.197**
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PLATE 19

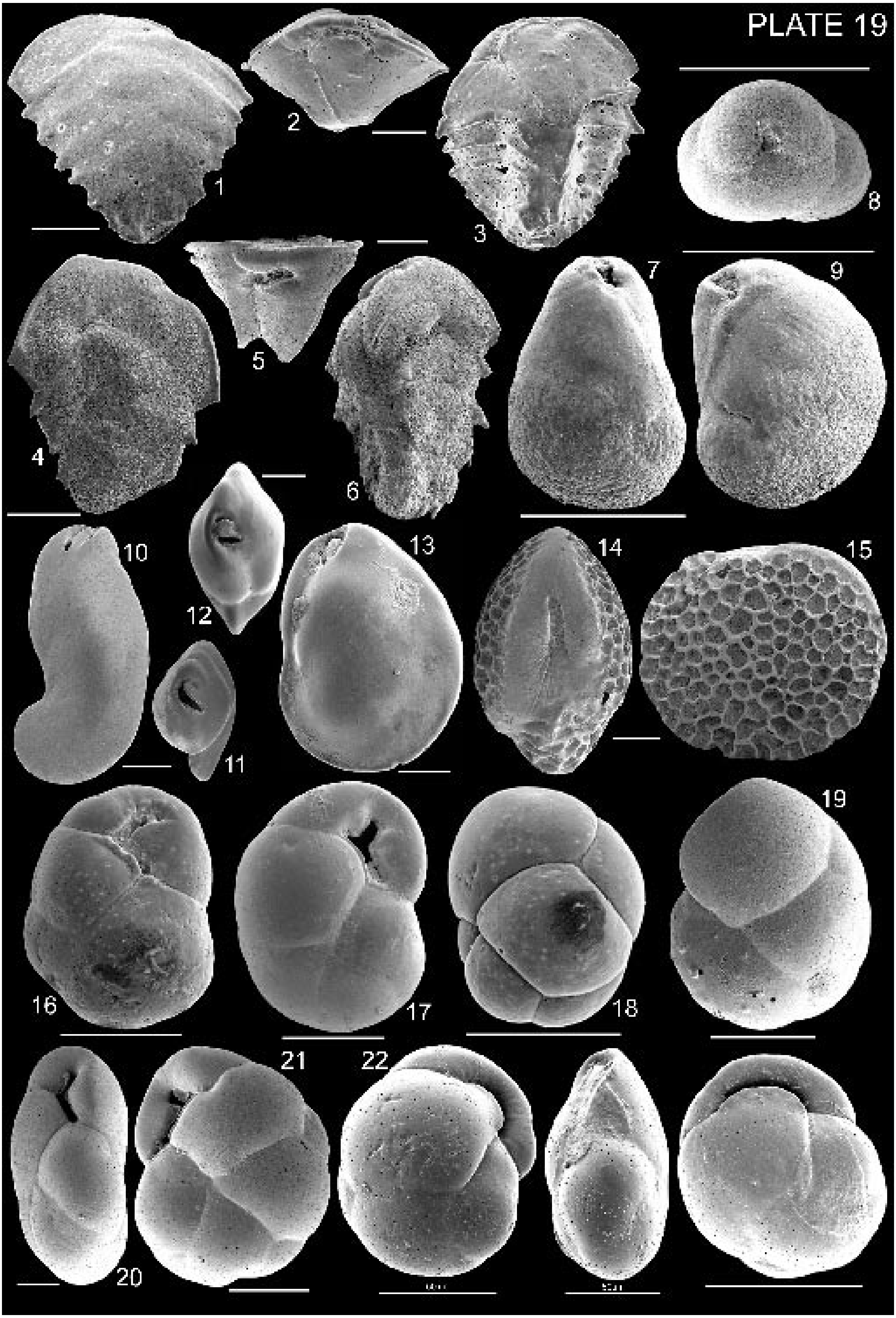

Plate 20

(Unless otherwise specified all scale bars = 100 μm)

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1-3	***Globocassidulina spherica*** Eade, 1967. BWH193/24, F201042, off Gt Barrier Island, 750 m.	**p.198**
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27-28	***Saidovina karreriana*** (Brady, 1881). BWH195/21, F17748, east of Northland, off Poor Knights Islands, 110 m.	**p.201**
29-30	***Siphogenerina columellaris*** (Brady, 1881). BWH124/1, F201908, east of Northland, Little Barrier Island, 7 m.	**p.202**
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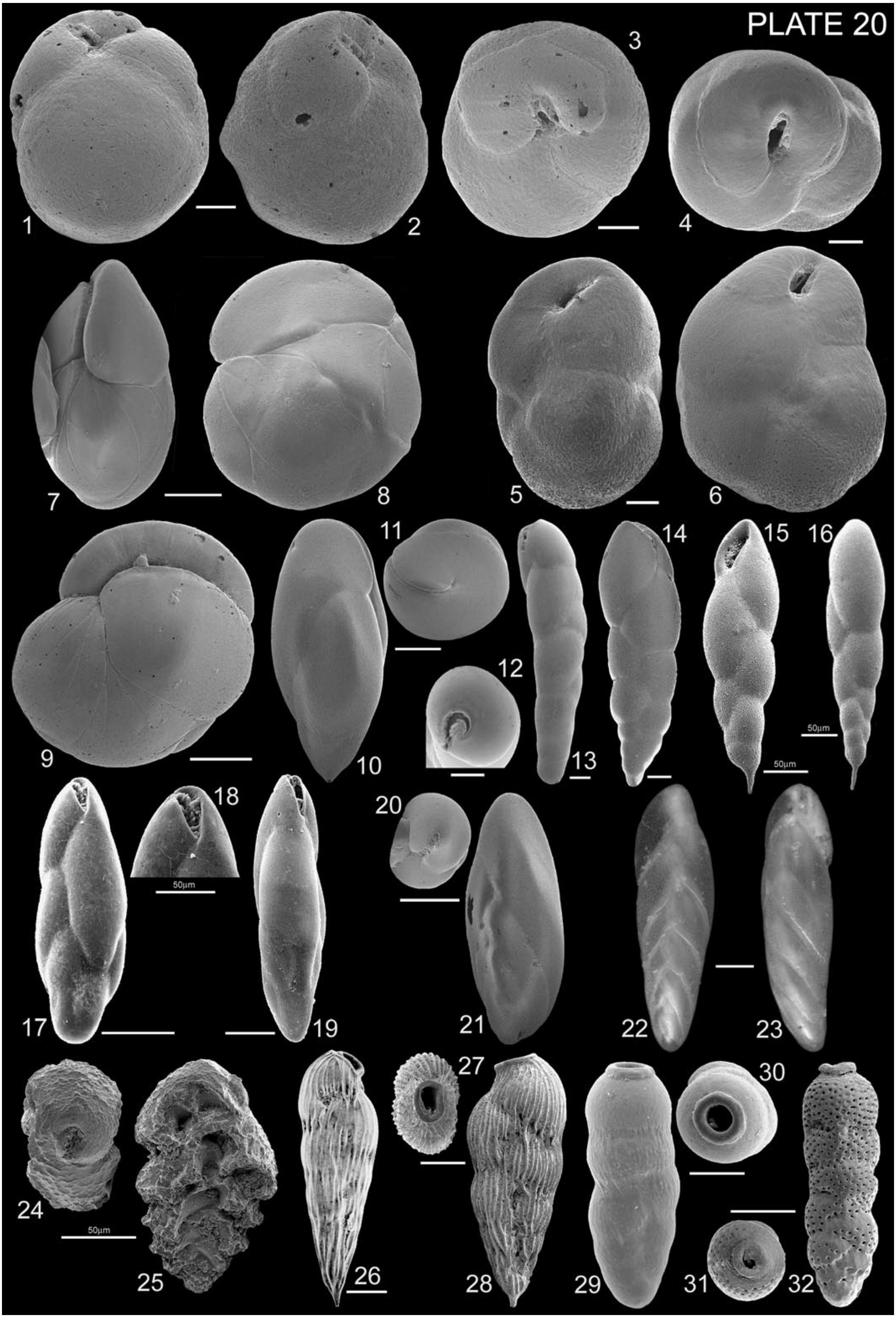
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Plate 21

(Unless otherwise specified all scale bars = 100 μm)

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17	***Trifarina bradyi*** Cushman, 1923. BWH 171/25, F201390, off Great Barrier Island, 750 m.	**p.204**
18	***Trifarina occidentalis*** (Cushman, 1923). BWH139/21, F202355, Chatham Rise, 854 m. Scale Bar: 50 μm.	**p.205**
19	***Trifarina occidentalis*** (Cushman, 1923). BWH 139/19, F202355, Chatham Rise, 854 m.	**p.205**
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27	***Uvigerina peregrina*** s.l. Cushman, 1923. BWH140/1, F202401, Bounty Trough, 3166 m.	**p.206**
28	***Uvigerina peregrina*** s.l. Cushman, 1923. BWH59/1, F201289, West Coast, off Greymouth, 610 m.	**p.206**
29	***Uvigerina peregrina*** s.l. Cushman, 1923. BWH140/2, F202401, Bounty Trough, 3166 m.	**p.206**
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33-34	***Chilostomella oolina*** Schwager, 1878. BWH184/16, F202404, Bounty Fan, 4440 m.	**p.206**
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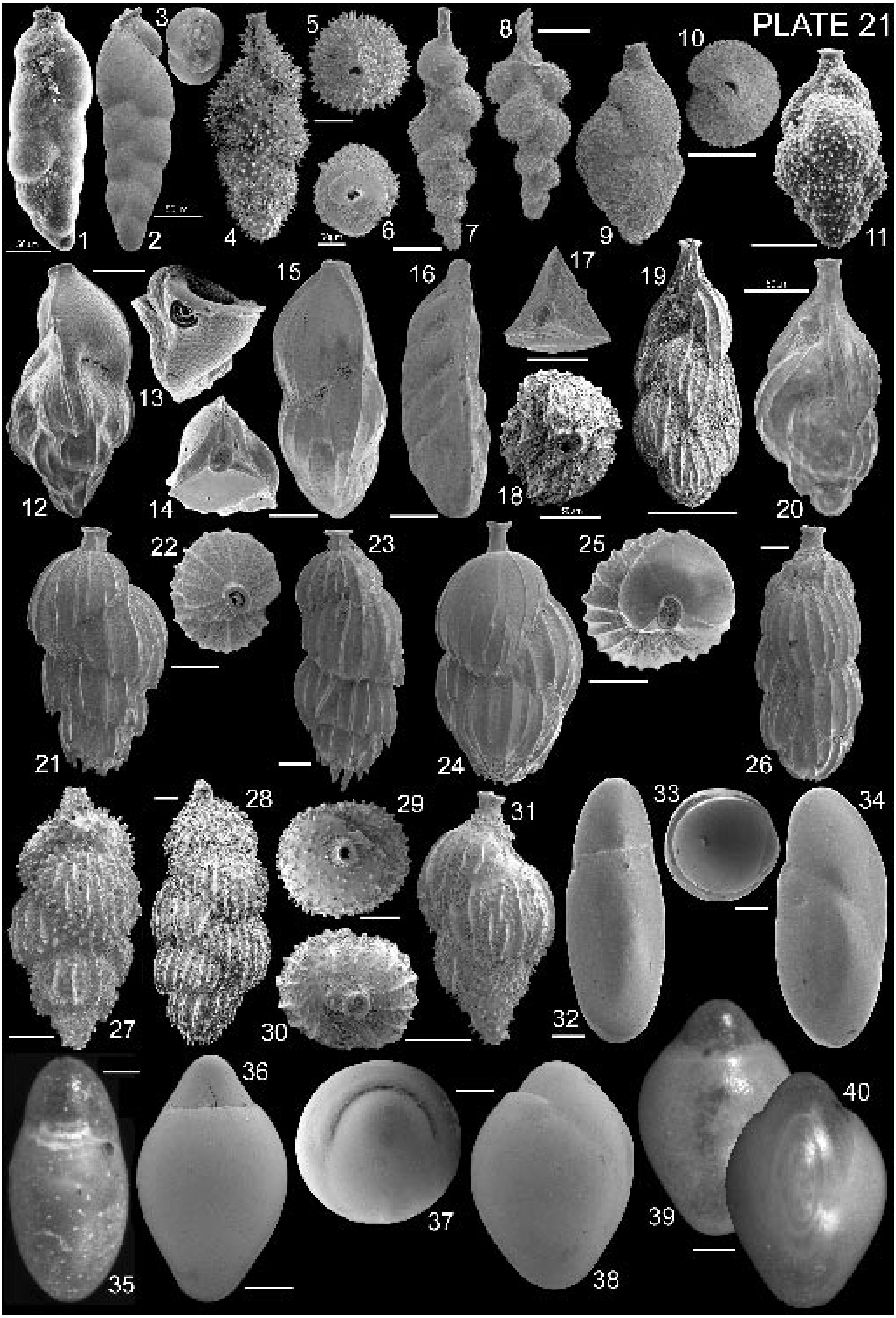
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Plate 22

(Unless otherwise specified all scale bars = 100 µm)

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7-9	***Cibicides dispars*** s.l. (d'Orbigny, 1839). Multifocus image, FP5261, F201266, Cook Strait, off Stephens Island, 106 m. Comment: topotype of junior synonym *C. marlboroughensis.*	**p.208**
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11-12	***Cibicides lobulatus*** (Walker & Jacob, 1798). BWH194/10, F202379, Chatham Rise, 289 m.	**p.209**
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PLATE 22

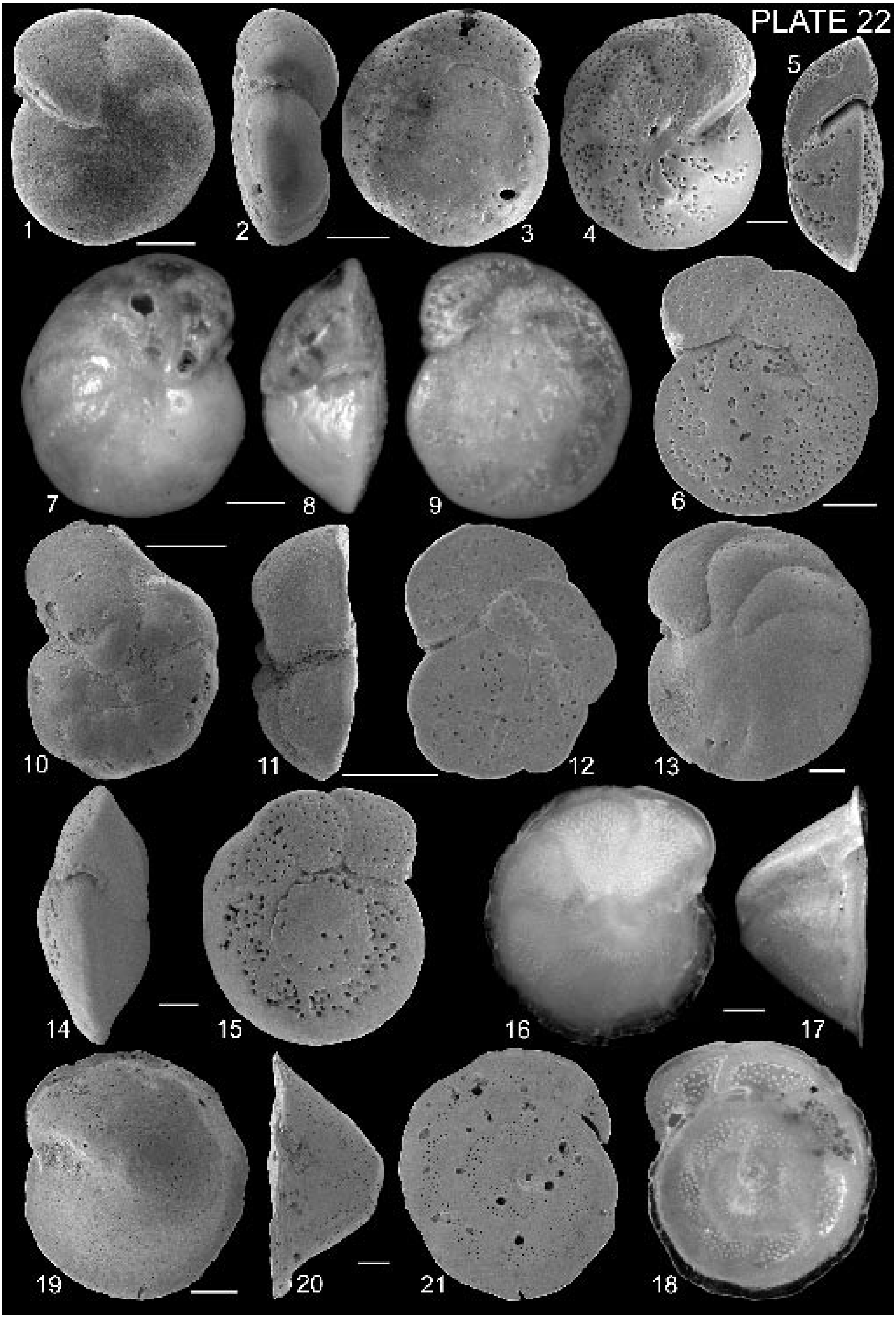

Plate 23

(Unless otherwise specified all scale bars = 100 µm)

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4-5	***Cibicides subhaidingeri*** Parr, 1950. BWH156/16, AU17808, off Great Barrier Is, 144 m.	**p.210**
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14-16	***Cibicides variabilis*** (d'Orbigny, 1826). Multifocus images, FP5266, F202361, Chatham Rise, 285 m.	**p.210**
17	***Cibicides wuellerstorfi*** (Schwager, 1866). BWH194/17, F201289, West Coast, off Greymouth, 610 m.	**p.210**
18-22	***Cibicides wuellerstorfi*** (Schwager, 1866). BWH194/18 & multifocus image, F201390, off Great Barrier Island, 750 m.	**p.210**

PLATE 23

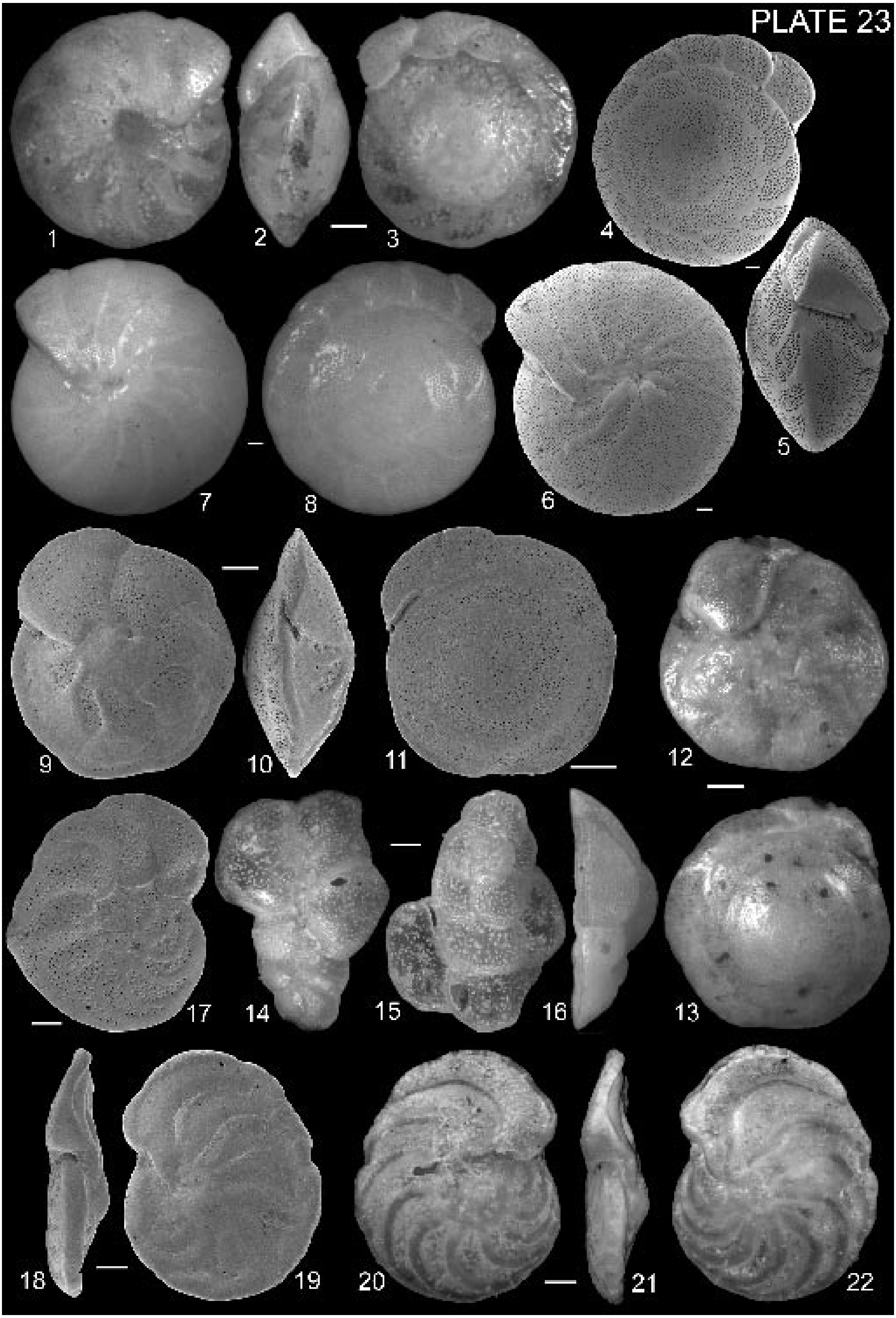

Plate 24

(Unless otherwise specified all scale bars = 100 µm)

Figs		
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3	***Neoeponides shreibersii*** (d'Orbigny, 1846). BWH157/3, F202482, off North Cape, 380 m.	**p.211**
4	***Discorbinella bertheloti*** (d'Orbigny, 1839). BWH154/12, F202438, North Taranaki Bight, 155 m.	**p.211**
5-6	***Discorbinella bertheloti*** (d'Orbigny, 1839). BWH154/11, F202438, North Taranaki Bight, 155 m.	**p.211**
7	***Discorbinella complanata*** (Sidebottom, 1918). BWH19/3, F201724, east of Northland, Cavalli Islands, 17 m.	**p.212**
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10-11	***Discorbinella subcomplanata*** (Parr, 1950). BWH129/39, F201009, west of Northland, 87 m.	**p.212**
12	***Discorbinella subcomplanata*** (Parr, 1950). BWH129/40, F201009, west of Northland, 87 m.	**p.212**
13	***Discorbinella timida*** Hornibrook, 1961. BWH18/28, F201719, east of Northland, Cavalli Islands, 40 m.	**p.212**
14-15	***Discorbinella timida*** Hornibrook, 1961. BWH124/11, F201842, Northland, Tutukaka Harbour, 15 m.	**p.212**
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18	***Laticarinina altocamerata*** (Heron-Allen & Earland, 1922). BWH191/20, F202473, east of Great Barrier Island, 754 m.	**p.212**
19	***Laticarinina pauperata*** (Parker & Jones, 1865). BWH191/23, F202473, east of Great Barrier Island, 754 m.	**p.213**
20-21	***Laticarinina pauperata*** (Parker & Jones, 1865). BWH191/22, F202473, east of Great Barrier Island, 754 m.	**p.213**

PLATE 24

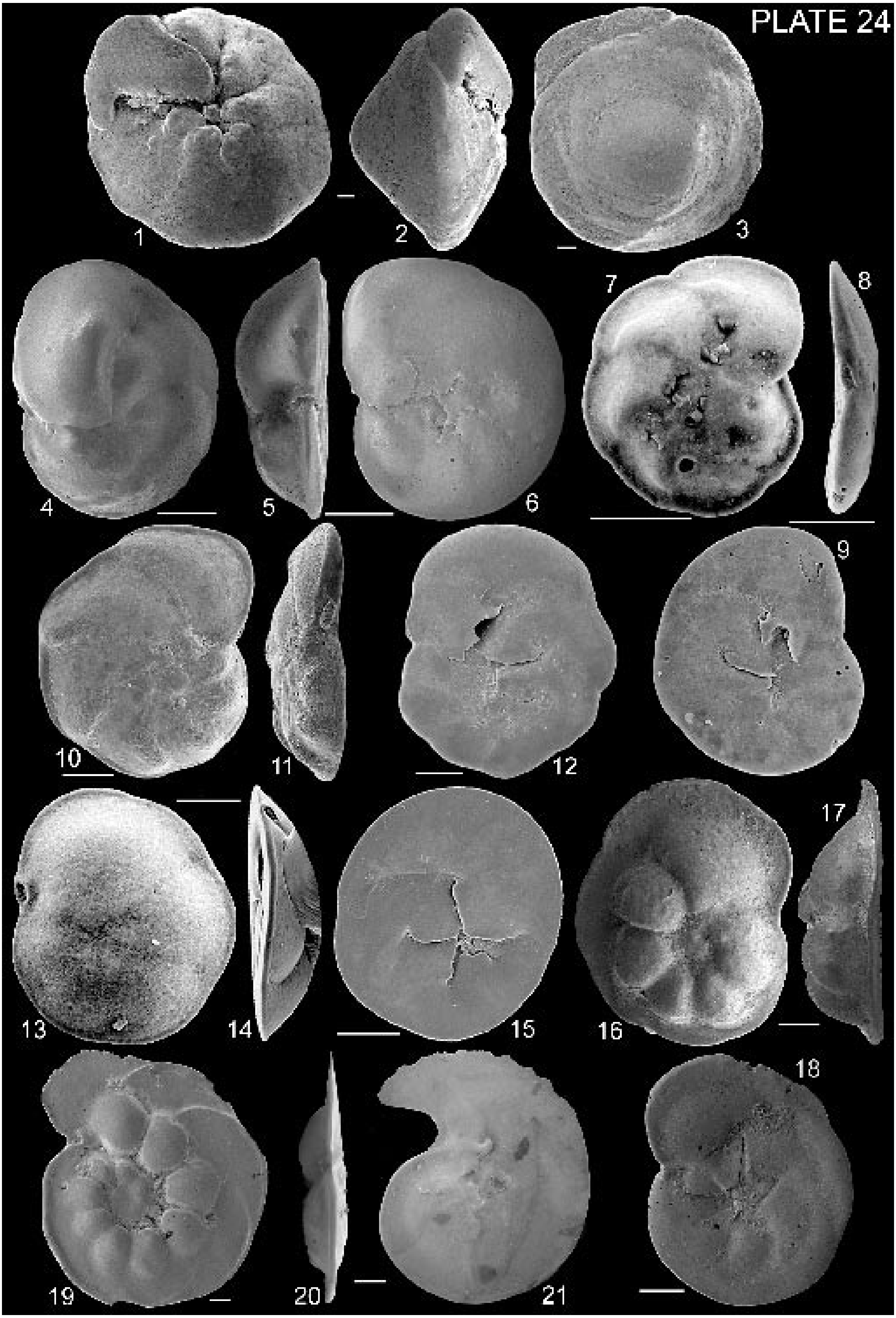

Plate 25

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1	***Notorotalia aucklandica*** Vella, 1957. BWH131/8, F201002, Auckland Islands, 12 m.	**p.214**
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4-5	***Notorotalia depressa*** Vella, 1957. BWH121/2, L13026, Wanganui Bight, 49 m.	**p.214**
6	***Notorotalia depressa*** Vella, 1957. BWH121/1, L13026, Wanganui Bight, 49 m.	**p.214**
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11-12	***Notorotalia zelandica*** Finlay, 1939. BWH121/11, L637, Marlborough Sounds, Queen Charlotte Sound, 37 m.	**p.215**
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14-15	***Nuttallides bradyi*** (Earland, 1934). BWH179/39, F202458, northeast of Coromandel Peninsula, 2654 m.	**p.215**
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20	***Alabaminella weddellensis*** (Earland, 1936). BWH138/4, F202400, Bounty Trough, 2424 m. Scale Bar: 50 µm.	**p.216**
21-22	***Alabaminella weddellensis*** (Earland, 1936). BWH138/5, F202400, Bounty Trough, 2424 m. Scale Bar: 50 µm.	**p.216**

PLATE 25

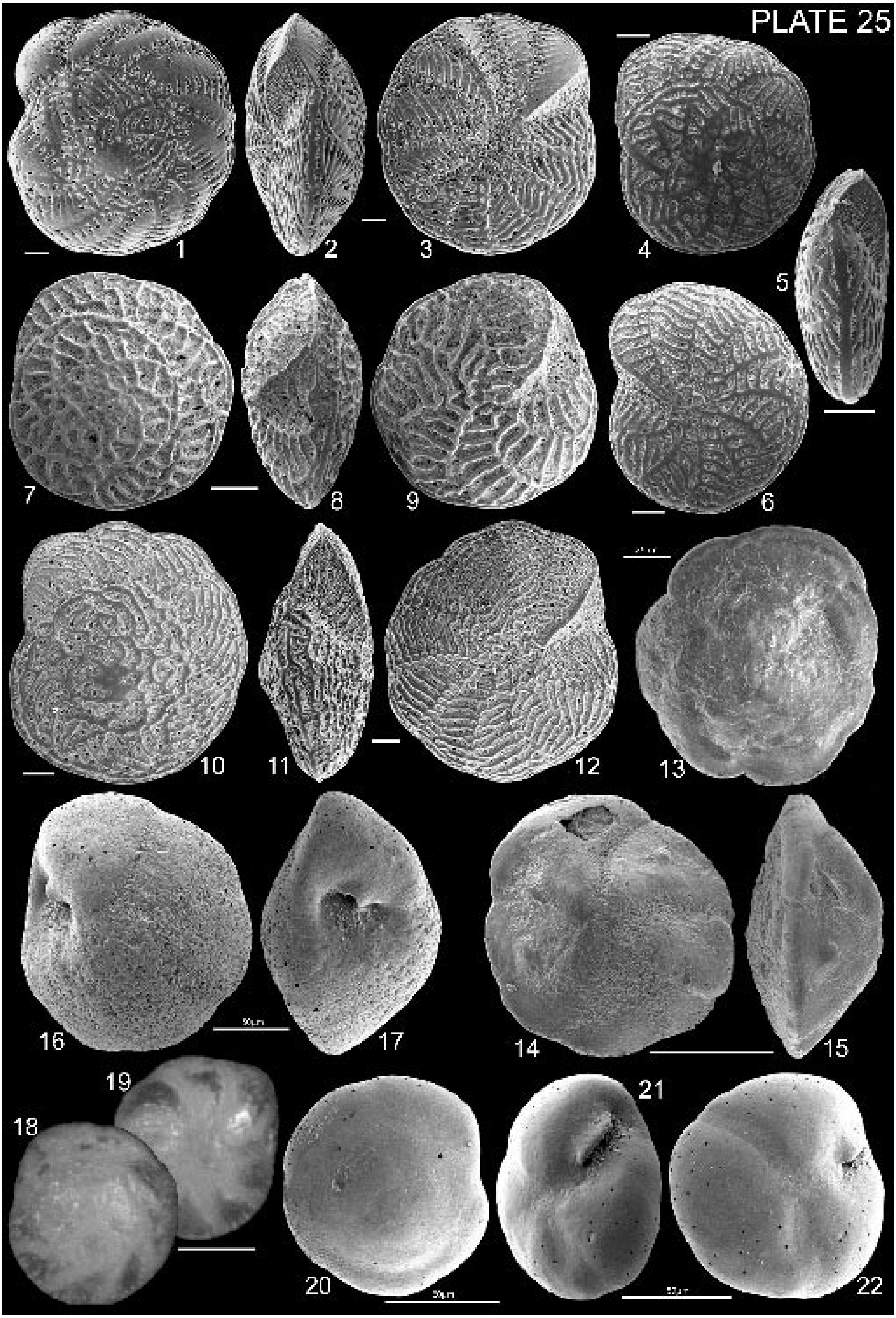

Plate 26

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1	***Ioanella tumidula*** (Brady, 1884). BWH139/23, F202403, Bounty Trough, 4163 m. Scale Bar: 50 µm.	**p.216**
2	***Ioanella tumidula*** (Brady, 1884). BWH139/24, F202403, Bounty Trough, 4163 m. Scale Bar: 50 µm.	**p.216**
3	***Ioanella tumidula*** (Brady, 1884). BWH139/25, F202403, Bounty Trough, 4163 m. Scale Bar: 50 µm.	**p.216**
4	***Porogavelinella ujiiei*** Kawagata, 1999. BWH139/5, F202375, east of Chatham Island, 752 m. Scale Bar: 50 µm.	**p.217**
5	***Porogavelinella ujiiei*** Kawagata, 1999. BWH139/4, F202375, east of Chatham Island, 752 m. Scale Bar: 50 µm.	**p.217**
6	***Porogavelinella ujiiei*** Kawagata, 1999. BWH139/1, F202375, east of Chatham Island, 752 m. Scale Bar: 50 µm.	**p.217**
7-8	***Discanomalina coronata*** (Parker & Jones, 1857). BWH184/18, F201015, off Auckland Islands, 300 m.	**p.217**
9-10	***Discanomalina semipunctata*** (Bailey, 1851). BWH157/5, F202478, northeast of Coromandel Peninsula, 549 m.	**p.217**
11-12	***Discanomalina semipunctata*** (Bailey, 1851). BWH157/6, F202478, northeast of Coromandel Peninsula, 549 m.	**p.217**
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15	***Gyroidina danvillensis*** Howe & Wallace, 1932**.** BWH184/24, F202428, North Island west coast, off Kawhia Harbour, 794 m. Scale Bar: 50 µm.	**p.218**
16	***Gyroidina kawagatai*** (Ujiie, 1995). BWH141/53, F202410, Bounty Trough, 2670 m. Scale Bar: 50 µm.	**p.218**
17	***Gyroidina kawagatai*** (Ujiie, 1995). BWH141/55, F202410, Bounty Trough, 2670 m. Scale Bar: 50 µm.	**p.218**
18	***Gyroidina kawagatai*** (Ujiie, 1995). BWH141/54, F202410, Bounty Trough, 2670 m. Scale Bar: 50 µm.	**p.218**

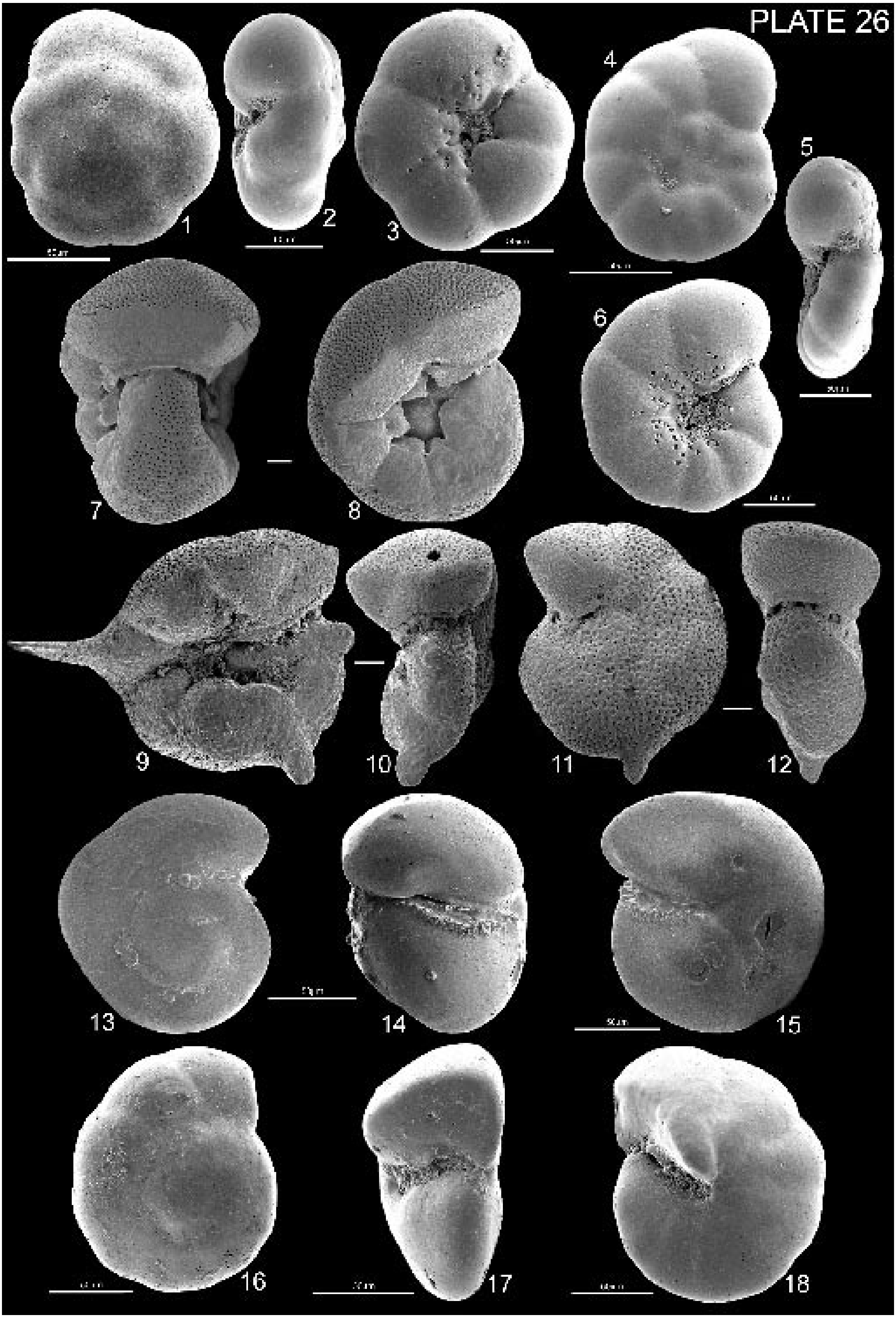
PLATE 26

Plate 27

(Unless otherwise specified all scale bars = 100 μm)

Figs		
1	***Gyroidina orbicularis*** (d'Orbigny, 1826). BWH184/21, ODP 1122A-7H-CC, Bounty Fan, 4435 m.	**p.219**
2	***Gyroidina orbicularis*** (d'Orbigny, 1826). BWH139/13, F202400, Bounty Trough, 2424 m.	**p.219**
3	***Gyroidina orbicularis*** (d'Orbigny, 1826). BWH184/20, F202423, New Caledonia Basin, 2150 m.	**p.219**
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7	***Gyroidina soldanii*** (d'Orbigny, 1826). BWH184/19, F202402, Bounty Trough, 3538 m.	**p.219**
8	***Gyroidina soldanii*** (d'Orbigny, 1826). BWH139/11, F202375, Chatham Rise, 752 m.	**p.219**
9	***Gyroidina soldanii*** (d'Orbigny, 1826). BWH139/9, F202375, Chatham Rise, 752 m.	**p.219**
10-12	***Gyroidina soldanii*** (d'Orbigny, 1826). Multifocus images, FP5269, F202402, Bounty Trough, 3538 m.	**p.219**
13-14	***Hanzawaia*** cf. ***wilcoxensis*** (Cushman & Pontin, 1932). BWH180/9, F202358, Hikurangi Channel, 2332 m. Scale Bar: 50 μm.	**p.220**
15-17	***Hanzawaia*** cf. ***wilcoxensis*** (Cushman & Pontin, 1932). BWH193/13, F202377, eastern end Chatham Rise, 2030 m. Scale Bar: 50 μm.	**p.220**
18	***Heronallenia translucens*** Parr, 1945. BWH179/2, F202573, south of Campbell Plateau, 4138 m.	**p.220**
19-20	***Heronallenia translucens*** Parr, 1945. BWH179/1, F202573, south of Campbell Plateau, 4138 m.	**p.220**

PLATE 27

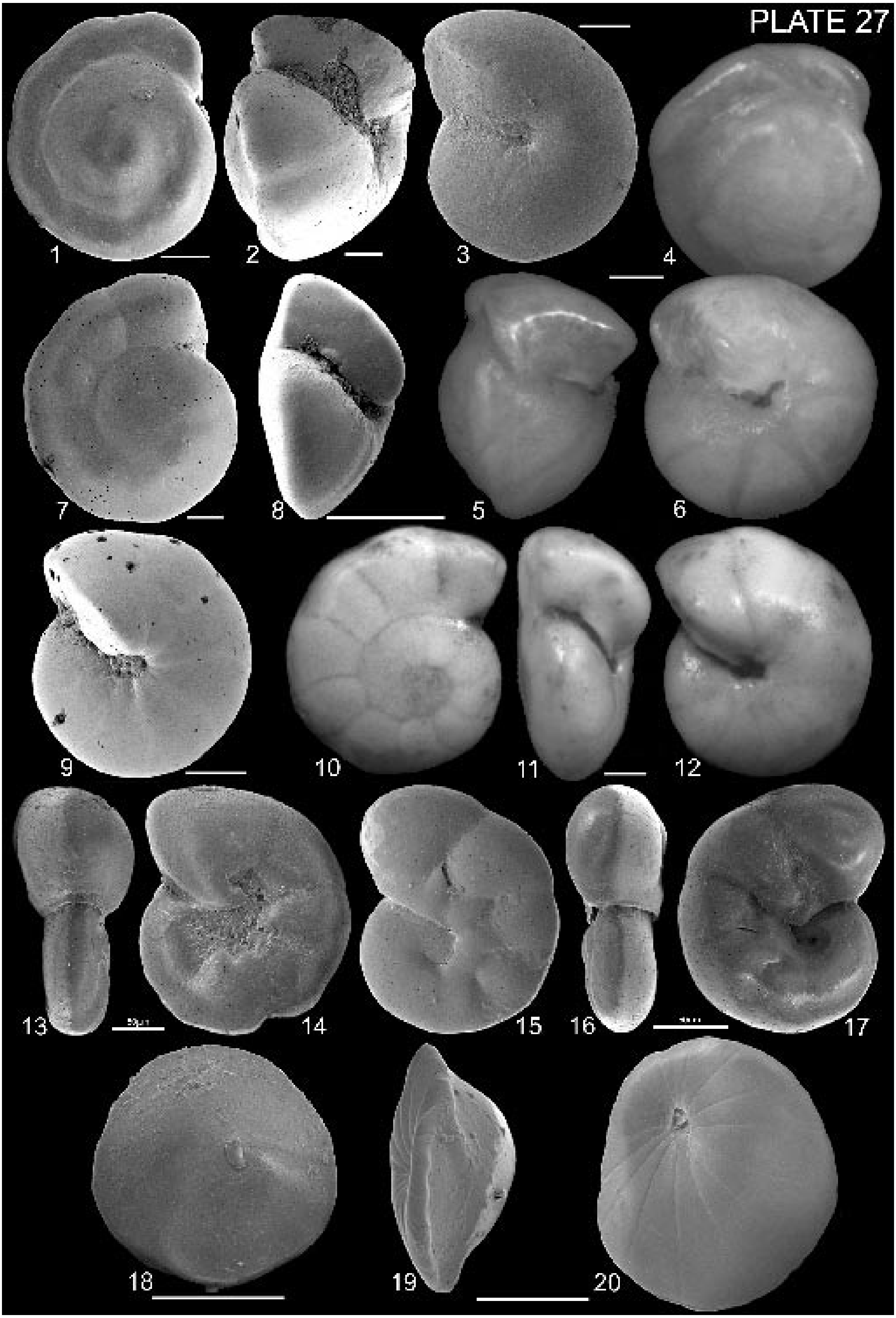

Plate 28

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1	***Heronallenia unguiculata*** (Sidebottom, 1918). BWH184/11, AU18099, Auckland Islands, 10 m. Scale Bar: 50 µm.	**p.220**
2-3	***Heronallenia unguiculata*** (Sidebottom, 1918). BWH169/14, AU18099, Auckland Islands, 10 m. Scale Bar: 50 µm.	**p.220**
4	***Anomalinoides glabratus*** (Cushman, 1924). BWH141/50, F202377, east of Chatham Island, 2030 m. Scale Bar: 50 µm.	**p.221**
5	***Anomalinoides glabratus*** (Cushman, 1924). BWH141/52, F202377, east of Chatham Island, 2030 m. Scale Bar: 50 µm.	**p.221**
6	***Anomalinoides glabratus*** (Cushman, 1924). BWH141/51, F202377, east of Chatham Island, 2030 m. Scale Bar: 50 µm.	**p.221**
7	***Anomalinoides semicribratus*** (Beckmann, 1954). BWH179/12, F202402, Bounty Trough, 3538 m.	**p.221**
8-9	***Anomalinoides semicribratus*** (Beckmann, 1954). BWH179/13, F202402, Bounty Trough, 3538 m.	**p.221**
10	***Anomalinoides sphericus*** (Finlay, 1940). BWH20/7, F201720, east of Northland, Cavalli Islands, 41 m.	**p.221**
11	***Anomalinoides sphericus*** (Finlay, 1940). BWH125/42, F202328, Stewart Island, Port Pegasus, 38 m.	**p.221**
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13	***Astrononion novozealandicum*** Cushman & Edwards, 1937. BWH141/4, F202380, Chatham Rise, 547 m. Scale Bar: 50 µm.	**p.222**
14	***Astrononion novozealandicum*** Cushman & Edwards, 1937. BWH141/3, F202380, Chatham Rise, 547 m. Scale Bar: 50 µm.	**p.222**
15-16	***Astrononion novozealandicum*** Cushman & Edwards, 1937. BWH116/22, L13021, Wanganui Bight, 109 m.	**p.222**
17-18	***Melonis affinis*** (Reuss, 1851). BWH138/27, F202375, east of Chatham Island, 752 m.	**p.222**
19	***Melonis pompilioides*** (Fichtel & Moll, 1798). BWH179/32, F202402, Bounty Trough, 3538 m.	**p.223**
20	***Melonis pompilioides*** (Fichtel & Moll, 1798). BWH179/31, F202402, Bounty Trough, 3538 m.	**p.223**
21-22	***Nonion pacificum*** (Cushman, 1924). BWH179/34, F202377, east end Chatham Rise, 2030 m. Scale Bar: 50 µm.	**p.223**

PLATE 28

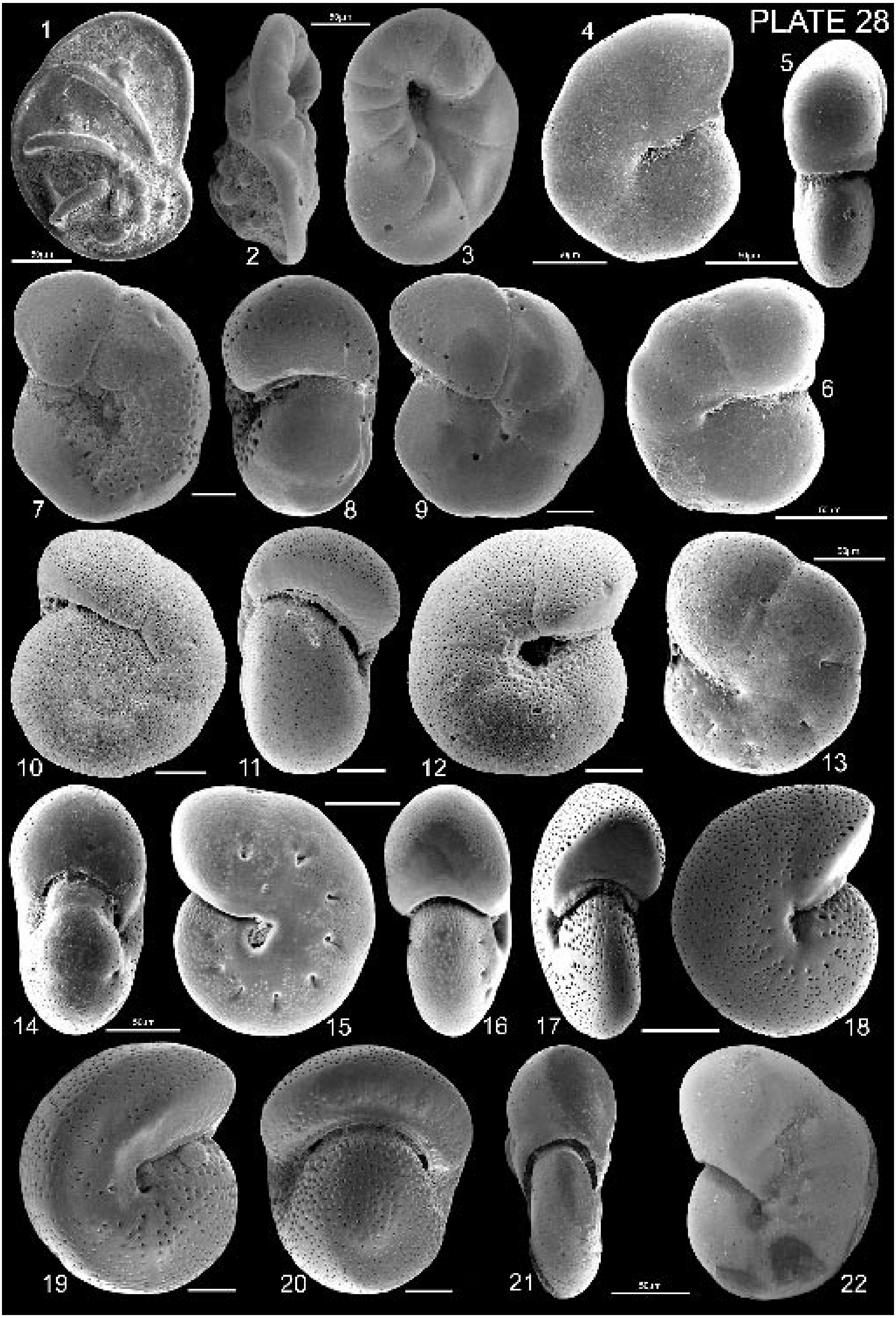

Plate 29

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1	***Nonion pacificum*** (Cushman, 1924). BWH142/26, F202377, east end Chatham Rise, 2030 m.	**p.223**
2	***Nonion pacificum*** (Cushman, 1924). BWH142/1, F202400, Bounty Trough, 2424 m. Scale Bar: 50 µm.	**p.223**
3	***Nonionella auris*** (d'Orbigny, 1839). BWH142/16, F202409, Bounty Trough, 2284 m. Scale Bar: 50 µm.	**p.224**
4	***Nonionella auris*** (d'Orbigny, 1839). BWH142/21, F202377, east end Chatham Rise, 2030 m.	**p.224**
5	***Nonionella auris*** (d'Orbigny, 1839). BWH142/25, F202377, east end Chatham Rise, 2030 m. Scale Bar: 50 µm.	**p.224**
6	***Nonionella magnalingua*** Finlay, 1940. BWH63/20, F201982, Cook Strait, Kapiti Island, 38 m.	**p.224**
7	***Nonionella magnalingua*** Finlay, 1940. BWH63/17, F201982, Cook Strait, Kapiti Island, 38 m.	**p.224**
8	***Nonionella magnalingua*** Finlay, 1940. BWH63/18, F201982, Cook Strait, Kapiti Island, 38 m.	**p.224**
9	***Nonionellina flemingi*** (Vella, 1957). BWH142/55, F202353, western Chatham Rise, 366 m.	**p.224**
10	***Nonionellina flemingi*** (Vella, 1957). BWH118/42, L646, Marlborough Sounds, Queen Charlotte Sound, 31 m.	**p.224**
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12-13	***Nonionoides grateloupii*** (d'Orbigny, 1826). BWH192/36, F202419, North Island west coast, west of Raglan, 1545 m. Scale Bar: 50 µm.	**p.225**
14	***Nonionoides grateloupii*** (d'Orbigny, 1826). Multifocus image, FP5270, F202383, Chatham Rise, 1080 m.	**p.225**
15	***Pullenia bulloides*** (d'Orbigny, 1846). BWH141/57, F202369, Hikurangi Plateau, 3654 m. Scale Bar: 50 µm.	**p.225**
16	***Pullenia bulloides*** (d'Orbigny, 1846). BWH138/19, F202366, Hikurangi Plateau, 2840 m.	**p.225**
17	***Pullenia bulloides*** (d'Orbigny, 1846). BWH141/56, F202369, Hikurangi Plateau, 3654 m.	**p.225**
18	***Pullenia quinqueloba*** (Reuss, 1851). BWH138/21, F202375, east of Chatham Island, 752 m.	**p.226**
19	***Pullenia quinqueloba*** (Reuss, 1851). BWH141/58, F202378, northeast of Chatham Island, 3550 m.	**p.226**
20	***Pullenia quinqueloba*** (Reuss, 1851). BWH141/59, F202378, northeast of Chatham Island, 3550 m. Scale Bar: 50 µm.	**p.226**
21-22	***Pullenia salisburyi*** Stewart & Stewart, 1930. BWH138/23, F202375, east of Chatham Island, 752 m.	**p.226**
23-24	***Pullenia salisburyi*** Stewart & Stewart, 1930. BWH184/27, ODP 1122C-1H-CC, Bounty Trough, 4400 m.	**p.226**

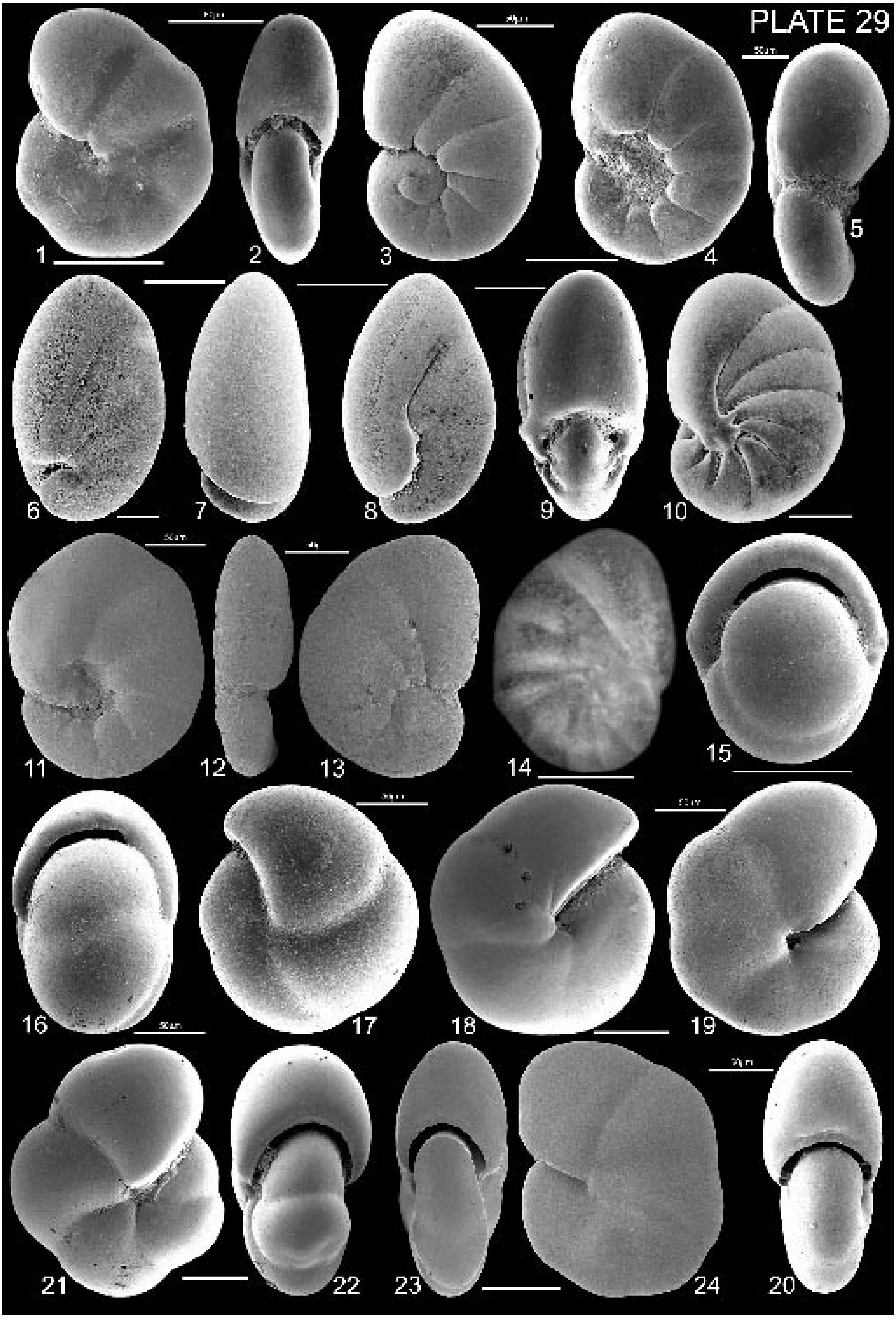
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Plate 30

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1-2	***Pulleniella asymmetrica*** Ujiie, 1990, BWH192/39, F202618, off East Cape, 2175 m. Scale Bar: 50 µm.	**p.226**
3	***Oridorsalis umbonatus*** (Reuss, 1851). BWH138/30, F202358, Hikurangi Channel, 2332 m.	**p.227**
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10-12	***Cancris oblongus*** (Williamson, 1858). Multifocus images, FP5271, L17749, east of Northland, off Poor Knights Islands, 155 m Scale Bar: 0.2 mm	**p.228**
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15	***Cancris oblongus*** (Williamson, 1858). BWH192/42, L17749, east of Northland, off Poor Knights Islands, 155 m Scale Bar: 0.2 mm	**p.228**
16	***Valvulineria minuta*** (Schubert, 1904). BWH184/6, F202376, east end Chatham Rise, 1128 m. Scale Bar: 50 µm.	**p.228**
17-18	***Valvulineria minuta*** (Schubert, 1904). BWH184/5, F202376, east end Chatham Rise, 1128 m. Scale Bar: 50 µm.	**p.228**
19-20	***Planulina ariminensis*** d'Orbigny, 1826. Multifocus images, FP5272, F202566, south of Campbell Plateau, 1685 m.	**p.228**
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PLATE 30

Plate 31

(Unless otherwise specified all scale bars = 100 µm)

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1	***Eilohedra vitrea*** (Parker, 1953). BWH118/30, L629, Marlborough Sounds, Queen Charlotte Sound, 11 m. Scale Bar: 50 µm.	**p.228**
2-3	***Eilohedra vitrea*** (Parker, 1953). BWH118/32, L629, Marlborough Sounds, Queen Charlotte Sound, 11 m. Scale Bar: 50 µm.	**p.228**
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5	***Eilohedra vitrea*** (Parker, 1953). BWH154/16, F202427, North Island west coast, off Kawhia Harbour, 506 m. Scale Bar: 50 µm.	**p.228**
6	***Epistominella exigua*** (Brady, 1884). BWH138/37, F202400, Bounty Trough, 2424 m.	**p.229**
7	***Epistominella exigua*** (Brady, 1884). BWH138/35, F202400, Bounty Trough, 2424 m.	**p.229**
8	***Epistominella exigua*** (Brady, 1884). BWH138/39, F202400, Bounty Trough, 2424 m.	**p.229**
9-10	***Epistominella exigua*** (Brady, 1884). Multifocus images, FP5273, F202402, Bounty Trough, 3538 m.	**p.229**
11-12	***Quadrimorphina laevigata*** (Phleger & Parker, 1951). BWH179/7, F201517, off North Cape, 133 m. Scale Bar: 50 µm.	**p.229**
13	***Quadrimorphina laevigata*** (Phleger & Parker, 1951). BWH179/6, F201517, off North Cape, 133 m. Scale Bar: 50 µm.	**p.229**
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16	***Gavelinopsis praegeri*** (Heron-Allen & Earland, 1913). BWH132/8, L14059, Chatham Island, 25 m.	**p.230**
17	***Gavelinopsis praegeri*** (Heron-Allen & Earland, 1913). BWH141/38, F202361, Chatham Rise, 285 m.	**p.230**
18	***Gavelinopsis praegeri*** (Heron-Allen & Earland, 1913). BWH141/37, F202361, Chatham Rise, 285 m.	**p.230**
19-21	***Gavelinopsis praegeri*** (Heron-Allen & Earland, 1913). Multifocus images, FP5274, L2818, off Great Barrier Island, 35 m.	**p.230**

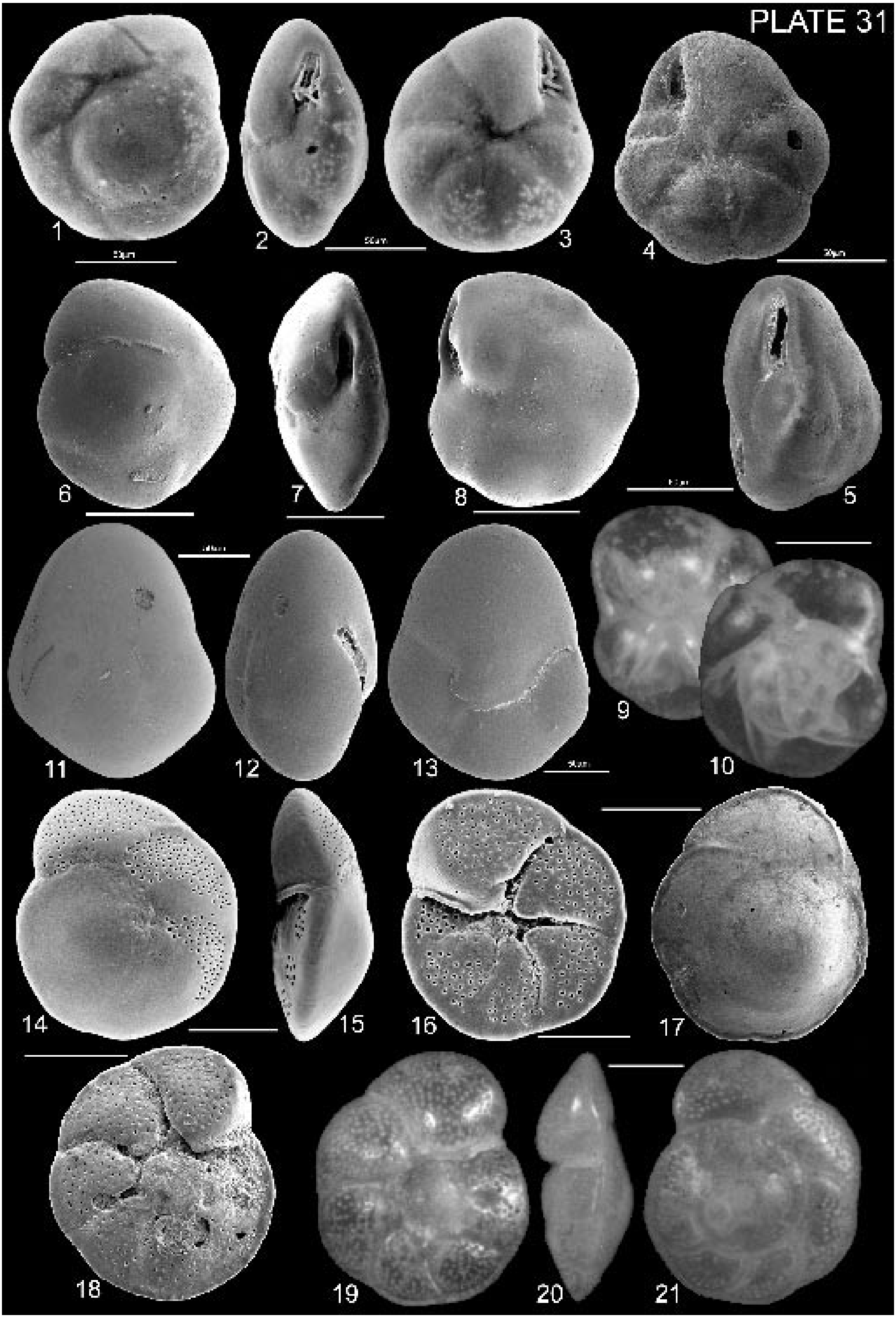
PLATE 31
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Plate 32

(Unless otherwise specified all scale bars = 100 µm)

Figs		
1-3	***Planodiscorbis rarescens*** (Brady, 1884). BWH192/41, ODP 1119-1H-1, 0-2 cm, Canterbury Bight, 395 m.	**p.230**
4-6	***Planodiscorbis rarescens*** (Brady, 1884). Multifocus image, FP5275, ODP 1119-1H-1, 0-2 cm, Canterbury Bight, 395 m.	**p.230**
7	***Rosalina irregularis*** (Rhumbler, 1906). BWH154/46, L24025, North Taranaki, 6 m.	**p.231**
8-9	***Rosalina irregularis*** (Rhumbler, 1906). BWH140a/5, F202055, Great Barrier Island, 28 m. Scale Bar: 50 µm.	**p.231**
10-11	***Rosalina irregularis*** (Rhumbler, 1906). Multifocus image, FP5276, F201049, east of Northland, off Poor Knights Islands, 120 m.	**p.231**
12-13	***Sphaeroidina bulloides*** d'Orbigny, 1826. BWH120/49, L13028, Wanganui Bight, 90 m.	**p.231**
14-15	***Spirotectina crassa*** Saidova, 1975. BWH179/9, F201390, east of Great Barrier Island, 500 m.	**p.232**
16-17	***Spirotectina crassa*** Saidova, 1975. Multifocus image, FP5277, F202446, west of Taranaki Bight, 541 m.	**p.232**
18	***Biarritzina proteiformis*** (Goës, 1882). BWH156/13, F202501, east of Northland, off the Cavalli Islands, 108 m. Scale Bar: 1 mm.	**p.232**
19	***Biarritzina proteiformis*** (Goës, 1882). BWH156/14, F202501, east of Northland, off the Cavalli Islands, 108 m. Scale Bar: 1 mm.	**p.232**

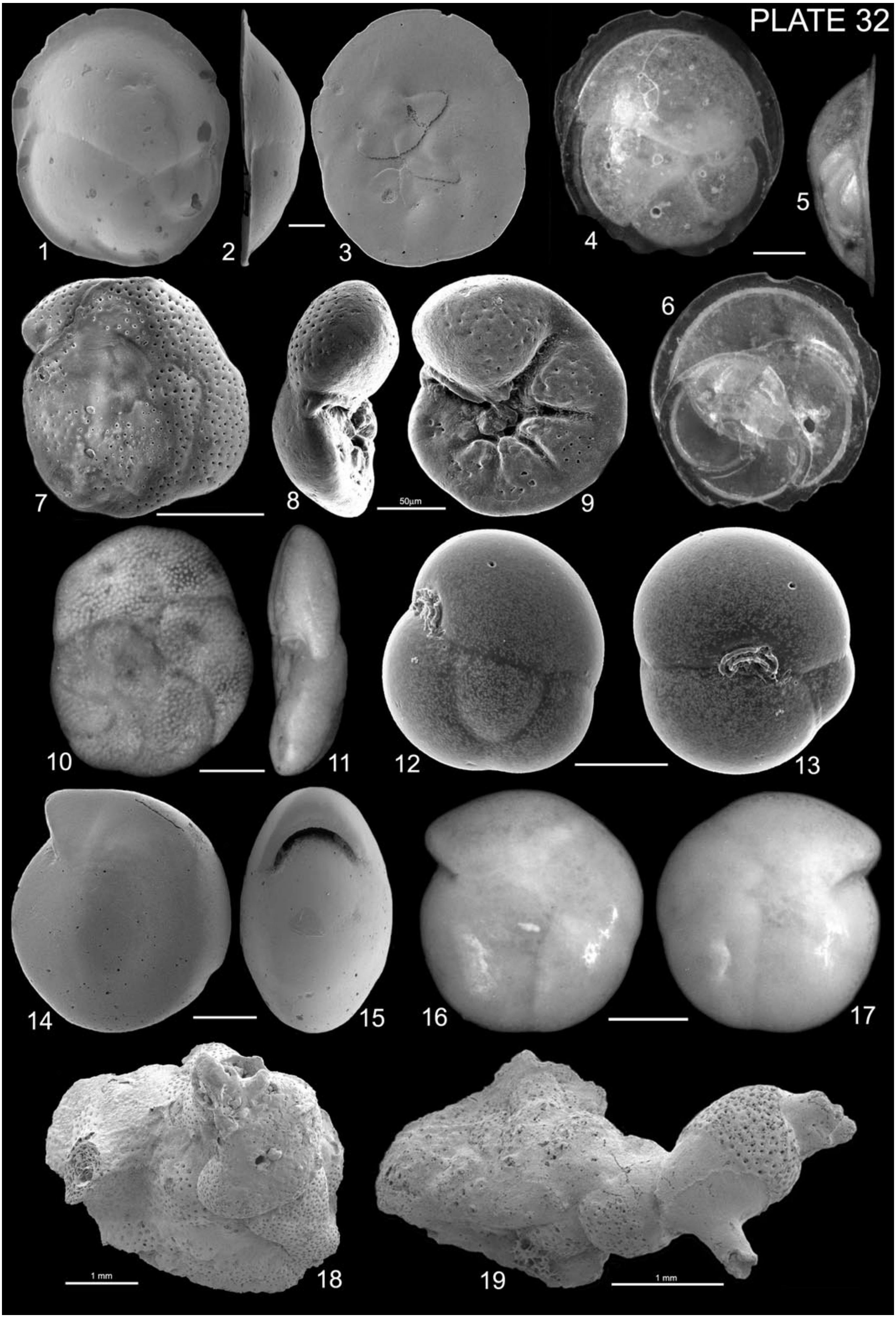


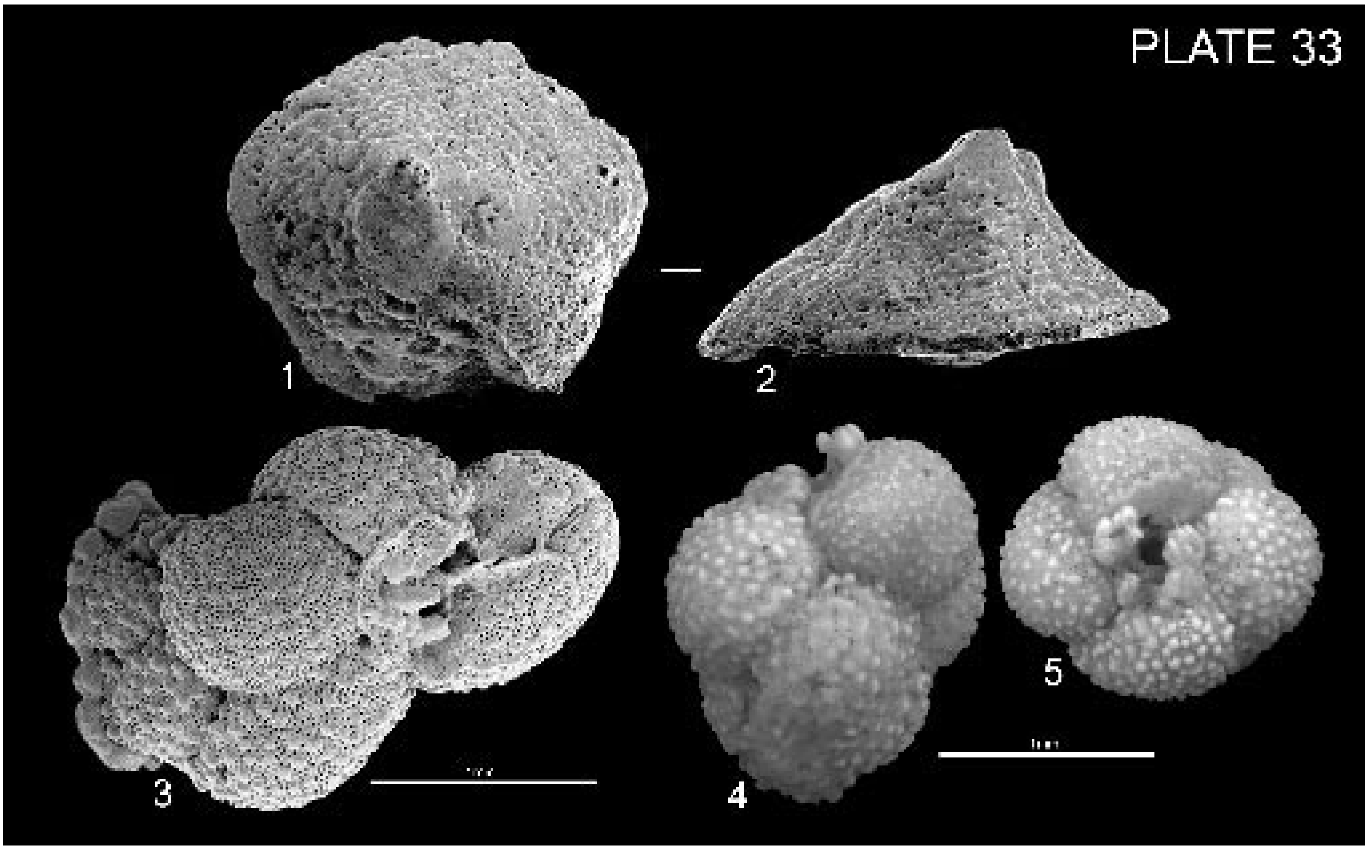
PLATE 32

Plate 33

(Unless otherwise specified all scale bars = 100 μm)

Figs		
1-2	***Carpenteria monticularis*** Carter, 1877. BWH157/1, F201390, off Great Barrier Island, 750 m.	**p.232**
3	***Rupertina pustulosa*** Hatta, 1992. BWH129/6, L17742, Bay of Plenty, off Cuvier Island, 70 m. Scale Bar: 1 mm.	**p.232**
4-5	***Rupertina pustulosa*** Hatta, 1992. Multifocus image, FP5247, L17748, east of Northland, Poor Knights Islands, 110 m. Scale Bar: 1 mm.	**p.232**

PLATE 33



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Includes references to species figured in the companion shallow-water monograph (GNS Monograph no. 21)