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SOFT BOTTOM MACROFAUNA AND SEDIMENTS OFF RAKITU ISLAND, NORTH-EAST NEW ZEALAND

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SUMMARY

The benthic macrobiota and sediments were studied from 35 dredge samples taken from a 10 km² area of sea bed (1-70 m depth) west and north-west of Rakitu (Arid) Island on the east side of Great Barrier Island. Four macrofaunal associations and one subassociation were recognised.

An infaunal bivalve *Gari stangeri-Felaniella zelandica* association occurs in a wide variety of sediments in relatively sheltered, shallow (1-24 m) stations along the north-west coast of the island. A gravelly substrate biota, characterised by epibenthic algae, chitons, serpulids and bryozoa, occurs on pebbly substrates that cover the shelf (12-29 m) south-west of Rakitu in an area swept clean of fine sediment by strong bottom currents.

An association dominated by the sand dwelling, bristly lunulitiform bryozoan *Selenaria squamosa* covers a large area in a wide variety of sediment types in depths between 25 and 50 m. A *Selenaria-Zeacolpus* subassociation, characterised by the additional presence of common turritellid gastropods *Zeacolpus pagoda* or *Z. vittatus*, occurs in a narrow belt at 30-50 m depth around the foot of steep submarine slopes off the north-west coast of Rakitu.

An infaunal bivalve-ophiuroid association, *Cuspidaria-Amphiura-Notocallista*, lives in slightly muddy to muddy fine sand which covers an area of sea floor at 40-70 m depth, 1-2 km north-west of Rakitu Island.

INTRODUCTION

Field work was carried out during the Offshore Islands Research Group trip to Rakitu (Arid) Island, New Year 1980-1981. Rakitu Island is situated 2.5 km off eastern Great Barrier Island, north-east New Zealand (Fig. 1). The 35 dredge stations on which this paper is based were located off the west coast of Rakitu Island and spread over an area of 10 km² of sea floor (Fig. 1). Bathymetry of the study area is based on

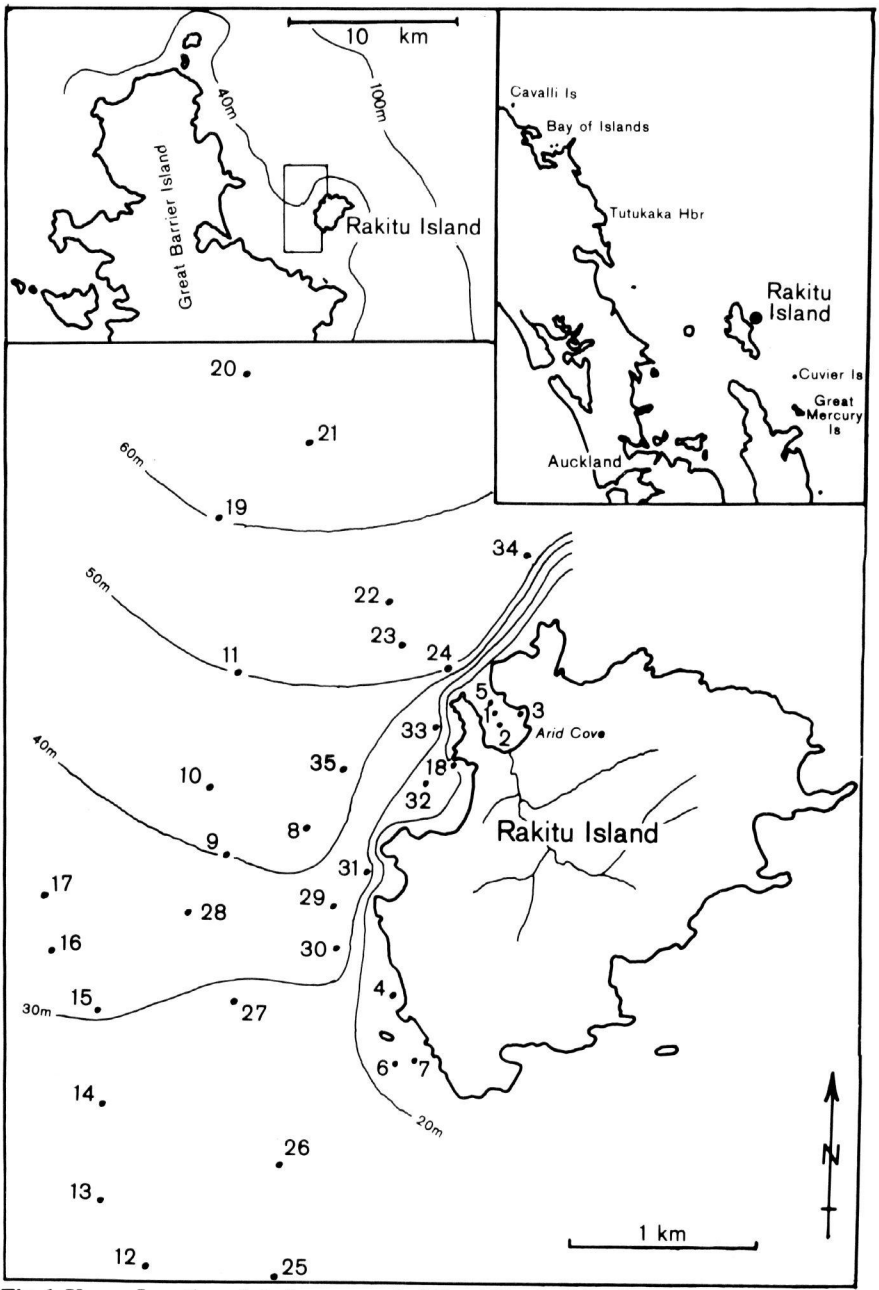

Fig. 1. Upper. Location of study area, east of Great Barrier Island, north-east New Zealand. Lower. Bathymetry (in metres) and station locations.

depths measured in the field and adjusted to mean low water spring tide level.

METHODS

Samples were collected using a small dredge (capacity 4.5 litres), described by Grace and Whitten (1974), hand-hauled from a 3.8 m aluminium dinghy with an 18 horsepower outboard motor. Under ideal conditions the dredge sampled an area of 0.075 m^2 of sea floor to a depth of 6 cm.

Upon retrieval, the volume of each sample was estimated and approximately 200 ml was removed for sediment analysis and foraminiferal studies. The rest of the sample was passed over a sieve with 2 mm openings and live organisms retained on it were sorted fresh, identified, counted and returned to the sea. A few specimens were retained for later laboratory identification.

Stations were located using a sextant to measure horizontal angles between fixed points on the shore. Depths were measured using a lead-weighted line.

Sediment grain size analyses were carried out in the laboratory using sieves.

RESULTS

Sediments (Fig. 2-4)

Grain size terminology follows Folk (1968, p. 26-30). Sediment type at each station is listed in Appendix 1 and their distribution shown in Figure 2.

The coarsest sediment is coarse sandy pebble gravel which covers the 25-29 m deep shelf, south-west of Rakitu Island (Fig. 3). This is the shallowest part of the channel between Rakitu and Great Barrier Islands and presumably strong bottom currents remove the finer sediment particles. The gravel clasts are predominantly greywacke - a rock type that does not occur on nearby Rakitu but forms a large section of the Great Barrier coastline 1.5-3 km to the south and south-west.

An 0.5-1 km wide belt of medium and coarse sand runs along the northern margin of the gravel and around the west and north-west coasts of Rakitu Island (Fig. 2). In the south this sand covers gently sloping sea floor of 10-38 m depth but in the north, where Rakitu drops off steeply to 50 m, this sand extends to depths of up to 57 m. Medium sand is more common in the south, whereas coarse sand (often pebbly) forms a fan off the north-west coast of Rakitu. Nearshore, around the island's coast, the sand is usually slightly shelly or pebbly whereas further offshore it is often slightly muddy.

An area of clean to slightly muddy fine sand (0.1-5.9% mud, Fig. 4) lies seaward of the belt of medium and coarse sand (Fig. 2). It covers gently sloping sea floor at depths of 27-59 m. Further seaward still, at depths of 58-69 m, the sea floor is covered by muddy fine sand, verging on very fine sand (Fig. 2). In the three stations sampled at these depths the mud content increases seaward from 11 to 18%.

In Arid Cove on the north-west coast of Rakitu Island, the sediment is mostly slightly muddy coarse to very coarse sand. This coarse sand is presumably moved into the cove by north-westerly storms which blow straight in. A pocket of slightly muddy fine sand occurs in a sheltered

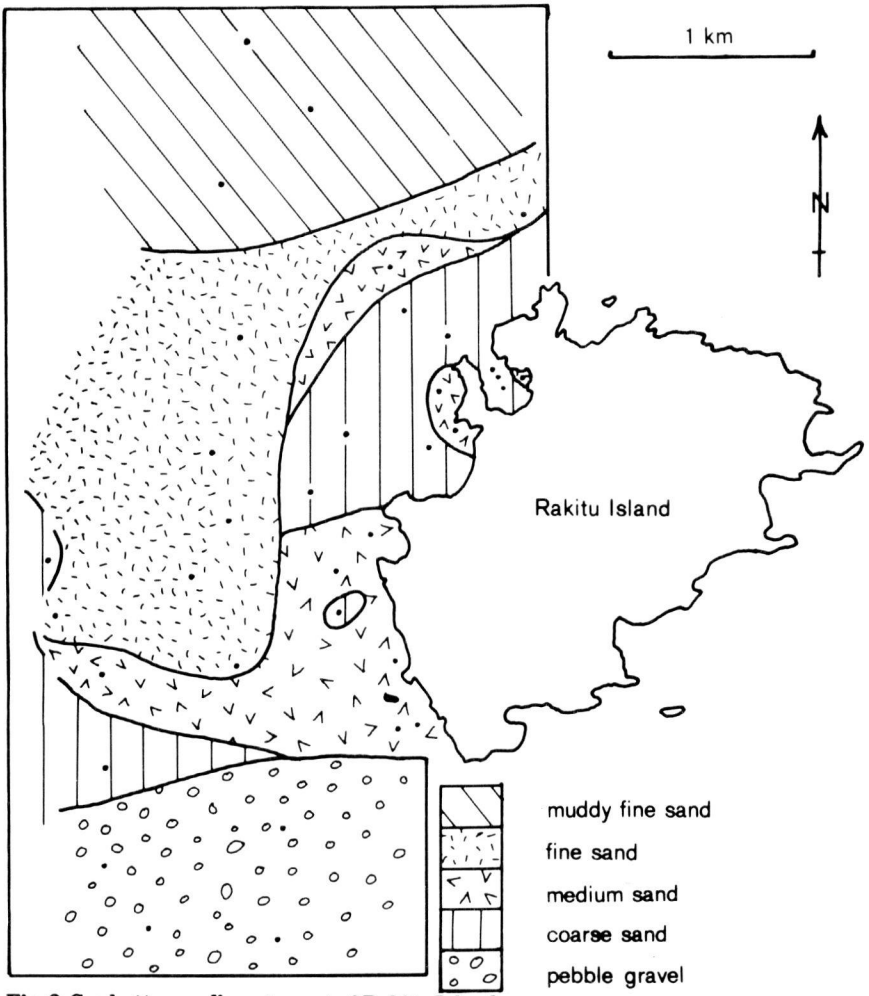

Fig. 2. Sea bottom sediments west of Rakitu Island.

embayment on the north side of the cove (Fig. 2). Inside Arid Cove the muddiest sediment (4-9% mud) occurs in the shallows near the head of the bay and cleaner sand (1-2% mud) occurs in the more storm-swept entrance.

At station 35 the dredge struck a solid rock reef at 42 m and no sediment was recovered.

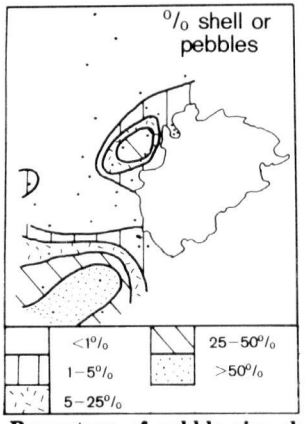

Fig. 3. Percentage of pebble size clasts, including shells (larger than 4 mm) in sediments.

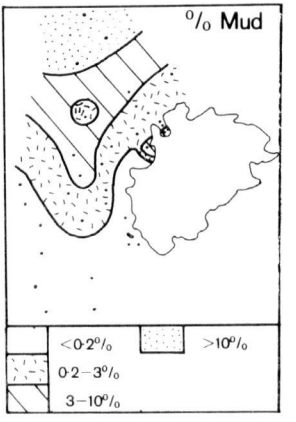

Fig. 4. Percentage of mud (grains finer than 0.0625 mm) in sediments.

Benthic biota (Fig. 5)

In analysing the benthic biota an attempt has been made to recognise "associations" by an intuitive, non-statistical approach. The term "association" is used here for a recurring combination of taxa that has a considerable degree of continuity in space. The associations are named after the dominant and most characteristic taxa.

Four associations and one subassociation are recognised in the study area. Full census data is given in Appendix 2. For each association the dominant taxa are listed, together with the percentage of stations in which they occur.

1. *Gari stangeri-Felaniella zelandica* association

Stations: 1, 2, 5, 18.
Marginal stations: 3, 4, 32 (total = 7)
Sediment: slightly muddy fine sand to pebbly coarse sand
Depth: 1.5 to 23.5 m
Wave energy: moderate to low
Characterising species: *Gari stangeri* (85%), *Felaniella zelandica* (56%)
Common associated species: *Cominella quoyana* (56%), *Cominella glandiformis* (42%), *Owenia fusiformis* (56%), *Epitonium minora* (28%)

This association occurs in fine to coarse sand, in most of the stations

shallower than 24 m. These seven stations (located in Arid Cove Aquarium Bay and bay north of Ora Pt) are the most sheltered in the study area, being protected by Rakitu Island from all storms except those from the west or north-west. They are thus not subjected to oceanic swells because of the protection afforded by Great Barrier Island.

The live biota is not abundant in any station but is usually characterised by the presence of the bivalve *Gari stangeri* often together

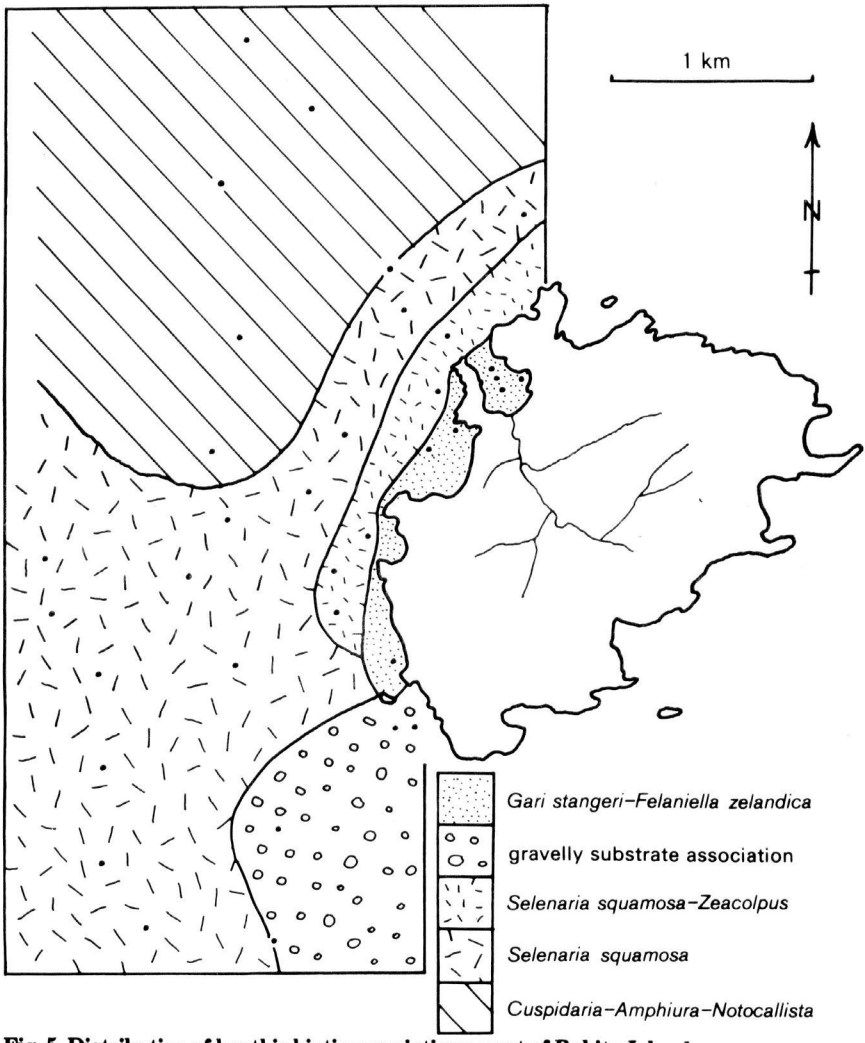

Fig. 5. Distribution of benthic biotic associations, west of Rakitu Island.

with *Felaniella zelandica*, carnivorous gastropods of the genus *Cominella*, and the polychaete *Owenia fusiformis*. *Cominella glandiformis* is restricted to stations shallower than 10 m.

2. Gravelly substrate association

Stations: 6, 7, 26
Marginal stations: 25 (total = 4)
Sediment: slightly pebbly medium sand to coarse sandy pebble gravel
Depth: 12.5-28.5 m
Wave energy: moderate to low
Common species: *Caulerpa hypnoides* (50%), rhodoliths (50%), membraniporiform bryozoa (50%), "*Spirorbis*" (50%), *Acanthochitona zelandica* (50%), *Rhyssoplax stangeri* (50%), hermit crabs (50%).

This association occurs on pebble gravel, or in areas of medium sand with scattered surface pebbles and cobbles that lie off the south-west of Rakitu Island (Fig. 5).

The live biota is not abundant but is characterised by forms that live encrusted or attached to pebbles or large shells. These include the algae *Caulerpa*, *Codium*, *Lithothamnion* and *Zonaria*, chitons, serpulid polychaetes and encrusting bryozoa. The infauna is probably grossly undersampled because of the inefficient performance of the dredge in this coarse substrate.

3. *Selenaria squamosa* association

Stations: 8, 12, 13, 15, 16, 17, 23, 27, 28, 34
Marginal stations: 9, 10, 14, 22, 25 (total = 15)
Sediment: slightly muddy fine sand to coarse sandy pebble gravel
Depth: 25.5-58 m
Wave energy: moderate
Characterising species: *Selenaria squamosa* (93%)
Common associated species: maldanid polychaetes (53%), *Scalpomactra scalpellum* (47%), *Nemocardium pulchellum* (33%), *Nucula nitidula* (33%), amphipods (33%)

This association occurs in fine to coarse sand and sandy pebble gravel at depths of 25-60 m and occupies a large proportion of the study area west of Rakitu Island. The association always lies between the shallower *Gari-Felaniella* and gravelly substrate associations and the deeper *Cuspidaria-Amphiura* association (Fig. 5).

In common with all the study area, the live biota is not abundant and is characterised by the presence of the sand-dwelling lunulitiform bryozoan *Selenaria squamosa*, which has a maximum abundance of 280 per m^2(stn 34), and the absence of common turritellid gastropods of the genus *Zeacolpus* which characterises subassociation 3a. A number of infaunal bivalves occur primarily in this association e.g. *Scalpomactra scalpellum*, *Nemocardium pulchellum*, *Nucula nitidula*, *Gari hodgei* and *Tellina huttoni*, and help to characterise its biota.

3a. *Selenaria squamosa-Zeacolpus* subassociation

Stations: 24, 29, 30, 31, 33 (total = 5)
Sediment: slightly muddy medium sand to slightly shelly coarse sand
Depth: 30.5-51 m
Wave energy: moderate
Characterising species: *Selenaria squamosa* (100%), *Zeacolpus pagoda* (80%) or *Zeacolpu vittatus* (20%).
Common associated species: *Spectamen verum* (60%), *Pupa kirki* (60%), *Scalpomactr scalpellum* (60%), *Pleuromeris zelandica* (40%).

This association occurs in medium to coarse sand at 30-50 m deptl around the foot of steep submarine slopes, on the north-west coast o Rakitu Island (Fig. 1,5).

Selenaria squamosa occurs in all stations up to a maximun abundance of 500 per m². Common *Zeacolpus pagoda* (100-300 per m² occur in four stations and *Zeacolpus vittatus* (120 per m²) in one (stn 31) Other characteristically associated species are the gastropod: *Spectamen verum* and *Pupa kirki* and the bivalves *Scalpomactr scalpellum* and *Pleuromeris zelandica*, although none are common.

4. *Cuspidaria-Amphiura-Notocallista* association

Stations: 11, 19, 20, 21
Marginal stations: 9, 10, 22 (total = 7)
Sediment: muddy fine sand to slightly muddy medium sand
Depth: 40-68.5 m
Wave energy: low
Characterising species: *Cuspidaria* spp. (71%), *Amphiura* sp. (100%), *Notocallist multistriata* (71%)
Common associated species: Terebellid polychaetes (71%), *Pectinaria australis* (57%) maldanid polychaetes (57%), *Sigalion* sp. (43%), *Nemocardium pulchellum* (43%) *Austrofusus glans* (29%).

This association occurs in fine-grained sediments (mostly muddy fine sand) at depths greater than 40 m north-west of Rakitu Island (Fig. 5) and presumably extends some distance further across the middle part of the continental shelf in this region.

All stations contain live ophiuroids of the genus *Amphiura*. Shells of the bivalves *Cuspidaria willetti*, *Cuspidaria trailli* and *Notocallista multistriata* are present in all stations although they were not always found living. Other molluscs that were found primarily in this association, though in low numbers, include *Austrofusus glans*, *Nuculana (Saccella) bellula* and *Divaricella huttoniana*. Polychaetes are common here, especially terebellids, maldanids, *Pectinaria australis* and *Sigalion* sp.

COMPARISONS WITH OTHER AREAS

None of the benthic associations recognised off Rakitu Island have

previously been recognised around the New Zealand shelf, although each has taxa in common with described associations.

The *Gari stangeri-Felaniella zelandica* association has some taxonomic similarities to the ascidian-*Gari stangeri* subassociation that occurs in clean sand at 7-12 m depth in the outer part of Tutukaka Harbour (Brook *et al.* 1981). It also has many taxa in common with the *Zeacolpus-Zegalerus* community found in shelly sand around the Cavalli Islands (Grace and Hayward 1980) but differs in the absence of the characterising species *Zeacolpus pagoda, Zegalerus tenuis* and juvenile *Tawera spissa.*

The *Selenaria squamosa* association of Rakitu has features in common with McKnight's (1969) *Scalpomactra scalpellum-Maorimactra ordinaria* community, found most often in sand on the open shelf at 20-60 m depth. They share the prominent occurrence of the bivalves *Scalpomactra scalpellum, Nemocardium pulchellum* and *Nucula nitidula,* but McKnight makes no comment on the presence or absence of lunulitiform bryozoa. *Selenaria squamosa* is common in fine sand at 30-40 m depth off the Cavalli Islands in the *Nemocardium pulchellum* community of Grace and Hayward (1980). The molluscs in this Cavalli community however, are intermediate in composition between the Rakitu *Selenaria squamosa* and *Cuspidaria-Amphiura-Notocallista* associations.

Selenaria squamosa is also abundant in medium to fine sand at 30-40 m off Cuvier Islands (stns 5, 6 of Hayward and Grace 1981) in an unnamed association. Among the few mollusca present are *Zeacolpus vittatus, Spectamen verum* and *Scalpomactra scalpellum,* which suggests that these Cuvier stations could be placed in our *Selenaria squamosa-Zeacolpus* subassociation. The abundance of turritellid gastropods in this subassociation is similar to that found in the shallower *Zeacolpus pagoda-Zegalerus tenuis* community of the eastern Bay of Islands (Hayward *et al.* 1981) and Cavalli Islands (Grace and Hayward 1980). Apart from *Zeacolpus* and *Scalpomactra* however, there are few other taxa in common.

The *Cuspidaria-Amphiura-Notocallista* association has many mollusca in common with McKnight's (1969) *Amphiura-Dosinia lambata* community which occurs at 1-50 m around the North Island, but the Rakitu fauna lacks two of the characterising species (*Dosinia lambata* and *Echinocardium cordatum*). There are also features in common with McKnight's *Nemocardium pulchellum-Venericardia purpurata* community and Grace and Grace's (1976) *Caryocorbula-Pleuromeris* community from 20-30 m off Great Mercury Island, but insufficient to equate either with the Rakitu association.

DISCUSSION

The distribution of benthic macrofaunal associations off Rakitu Island is difficult to correlate with any one physical variable. Unlike the eastern Bay of Islands (Hayward *et al.* 1981), there is no strong correlation with sediment grain size. It seems that an interplay of factors, some of them not easily identifiable, determines the distribution of associations in this area. The most striking feature about their distribution is the orderly sequence moving from shallow, inshore areas out to the deeper offshore part of the study area (Fig. 5).

Of the two shallowest associations, the gravelly substrate biota is primarily epifaunal on coarse sediment, swept clean of mud or very fine sand by strong bottom currents, whereas the infaunal bivalve association of *Gari-Felaniella* occurs in a wide variety of sediment types in areas sheltered from most storm wave activity.

At intermediate depths the *Selenaria squamosa* and *Selenaria-Zeacolpus* subassociation also occur in a wide variety of sediment types and appear to be subject to a highly variable range of bottom current and storm wave strengths. The *Selenaria-Zeacolpus* subassociation, lying as it does in a narrow belt in the lee of Rakitu, is probably more sheltered than the bulk of the *Selenaria* association.

The deepest association, *Cuspidaria-Amphiura-Notocallista*, appears to inhabit the most uniform physical environment, occurring in fine sand, probably below the influence of wave energy. The most variable feature is the percentage of mud, which ranges from 0.2% in station 11 to 18% in station 20.

ACKNOWLEDGEMENTS

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APPENDIX I. Station Data

Station	Depth (m)	Sediment[1]	Sample vol.(cc)	No.of taxa	Association[2]
1	8.5	slM,c.sand	3 600	5	G
2	5.5	slM,slSh,v.c.sand	4 000	11	G
3	3	slM,f.sand	3 100	5	(G)
4	1.5	m.sand	3 600	1	(G)
5	9.5	slM,slSh,c.sand	2 700	17	G
6	14	slG,m.sand	900	3	gr
7	12.5	slG,m.sand	2 700	13	gr
8	45	slM,G,v.c.sand	3 600	13	S
9	40	slM,f.sand	3 100	18	(S,C)
10	44.5	slM,f.sand	3 600	8	(S,C)
11	50	f.sand	3 100	11	C
12	25.5	c.S,p.gravel	3 100	11	S
13	28	c.S,p.gravel	3 100	6	S
14	28.5	slG,slSh,c.sand	3 100	7	(S)
15	30.5	m.sand	3 100	8	S
16	34	f.sand	3 100	12	S
17	37.5	slSh,c.sand	3 600	9	S
18	23.5	slM,slSh,m.sand	3 600	9	G
19	60	M,f.sand	4 000	7	C
20	68.5	M,f.sand	4 000	9	C
21	65	M,f.sand	4 000	9	C
22	56.5	slM,m.sand	3 600	14	(S,C)
23	52.5	slM,slSh,c.sand	3 100	7	S
24	51	slSh,c.sand	2 700	9	S z
25	28.5	c.S,Sh,p.gravel	2 250	11	(gr,S)
26	24.5	slS,p.gravel	900	15	gr
27	27.5	f.sand	3 100	5	S
28	36	slM,f.sand	3 100	14	S
29	34	slM,m.sand	3 100	15	S z
30	31	c.sand	3 100	14	S z
31	30.5	slSh,m.sand	3 100	5	S z
32	23	G,c.sand	3 100	5	(G)
33	34	G,m.sand	3 100	10	S z
34	58	slM,f.sand	3 100	9	S
35	42	solid rock	0	0	-

[1]. sl = slightly, G = gravelly, M = muddy, S = sandy, Sh = shelly, f. = fine, m. = medium, c. = coarse, v.c. = very coarse, p = pebble.
[2]. C = *Cuspidaria-Amphiura-Notocallista;* G = *Gari stangeri-Felaniella zelandica;* gr = gravelly substrate biota; S = *Selenaria squamosa;* S z = *Selenaria squamosa-Zeacolpus;* = marginal station.

APPENDIX II. Species counts. For each species, the station at which that species occurs is given, followed in brackets by the number of individuals occurring live in the sample. Where no figures in brackets are given, information is qualitative only.

ALGAE	
Caulerpa hypnoides	5,6,7
Codium fragile	25
Lithothamnion paint	12,26
Zonaria sp.	26
Coralline "rhodoliths"	8,13,14,25,26
unidentified small red algae	25,26
BRYOZOA	
celleporiform	12(1)
membraniporiform	25,26
Selenaria squamosa	8(2),9(3),10(1),12(3),13(12),15(5),16(4),17(9),22(9),23(4),24(2), 25(1),27(5),28(9),29(22),39(4),31(8),33(25),34(14)
PORIFERA	
orange sponge	26
yellow sponge	26
COELENTERATA	
Sphenotrochus ralphae	13(1),30(1),34(1)
POLYCHAETA	
Aglaophamus macroura	20(1),33(1)
Ampharete sp.	28(1)
Boccardia sp.	3,25
Filograna sp.	26
Glycera sp.	17(1)
Hyalinoecia sp.	8(1)
Lumbriconereis sp.	8(1),17(1),20(1),23(1)
Magelona papillicornis	9(1)
Owenia fusiformis	1(3),2(13),3(2),5(35),9(2)
Pectinaria australis	11(1),17(1),19(3),21(1),22(1)
Sigalion sp.	9(1),11(1),22(1),34(1)
"*Spirorbis*" sp.	7,26
Eunicidae	2(3)
Maldanidae	1(1),7(2),8(1),10(1),11(2),12(2),14(1),15(6),16(3),18(1),20(2), 21(7),28(1),33(1),34(9),
Nereidae	7(1)
Phyllodocidae	34(1)
Sabellidae	8(1),16(1),17(1),28(3)
Serpulidae	25(1)
Spionidae	2(1),3(1),9(1),10(2),20(1)
Syllidae	7(1),18(3)
Terebellidae	9(1),10(2),11(3),17(1),19(1),22(2)
unidentified	1(2),5(3),7(2),8(1),9(1),11(4),12(4),14(3),15(3),16(1),17(9),18(3), 19(3),21(6),22(5),23(3),24(41),26(1),27(5),27(5),28(11),29(13), 30(4),31(3),32(2),33(2),34(16)
PLATYHELMINTHES	14(1)
NEMERTEA	
brown	19(1),11(3)
orange	8(1),29(1)
AMPHINEURA	
Acanthochitona zelandica	7(1),25(1),32(1)
Ischnochiton maorianus	7(1)
Rhyssoplax stangeri	12(2),25(3),26(3)
GASTROPODA	
Austrofusus glans	9(1),21(1)

Cominella glandiformis	2(1),3(1),5(1)
C. quoyana	2(1),3(1),5(8),7(1),30(3),32(1)
Epitonium minora	2(2),5(1),28(1),30(1)
Maoricolpus roseus	30(1)
Microvoluta marginata	29(2)
Muricopsis octogonus	26(1)
Paxula sp.	2(1)
Pupa kirki	16(1),18(1),24(1),29(1),33(3)
Rissoina chathamensis	7(1)
Spectamen verum	22(1),24(8),30(3),33(2)
Xenophora neozelandica	28(1)
Zeacolpus pagoda	15(1),24(4),29(15),30(6),33(9)
Zeacolpus vittatus	31(6)
BIVALVIA	
Atrina zelandica	2(1)
Cardita brookesi	26(1)
Corbula zelandica	18(1),30(1)
Chlamys zelandica	8(2),22(1),23(1),24(4)
Cuspidaria trailli	9(1),11(1),22(1)
C. willetti	20(1),21(1)
Divaricella huttoniana	9(1)
Dosinia subrosea	30(1)
Felaniella zelandica	1(13),2(1),5(1),9(1),18(1)
Gari hodgei	15(3),16(1)
G. lineolata	5(1)
G. stangeri	1(3),2(5),4(1),5(1),8(1),12(1),13(1),18(1),29(1),30(1),32(1)
Hiatella arctica	16(1)
Limaria orientalis	8(3)
Limatula maoria	23(1)
Myadora boltoni	27(3)
M. novaezelandiae	29(3)
Nemocardium pulchellum	8(1),9(1),21(1),22(16),23(1),34(1)
Notocallista multistriata	9(1),10(1),11(1),20(1),21(2),24(1)
Nucula hartvigiana	5(1)
N. nitidula	5(1),8(1),9(2),12(1),22(1),28(1)
Nuculana (Saccella) bellula	11(1)
Pleuromeris zelandica	18(1),29(1),33(2)
Scalpomactra scalpellum	9(1),12(1),15(2),25(1),27(1),28(1),29(3),31(1),33(1),34(1)
Tawera spissa	7(7),30(2)
Tellina huttoni	16(1),28(1)
Tellina charlottae	5(1)
CRUSTACEA	
Amphipoda	7(2),9(1),14(1),16(2),17(2),19(1),28(2),29(1)
Paranthura sp.	5(1)
Isopoda	11(1),16(2),24(1)
Tanaidacea	29(1)
Cumacea	19(1)
unidentified hermits	5(2),7(3),12(1),13(1),16(2),18(1),22(1),25(1),27(2),30(3),31(10)
ECHINODERMATA	
Amphiura sp.	9(2),10(1),11(3),15(1),16(1),19(22),20(1),21(16),22(1),28(1)
Apatopygus recens	14(1)
Astropecten polyacanthus	5(1),6(1),28(1)
Cucumaria sp	26(1)
Echinocardium cordatum	15(2),29(1)

Pectinura cylindrica	5(1),6(1)
Trochodota sp.	2(3),5(1),9(1),29(1)
unidentified holothurian	10(1),20(1)
CHORDATA	
Agnesia sp.	21(1)
simple ascidian	26(5)

Note added in press: The lunulitiform bryozoan recorded as *Selenaria squamosa* should read *Otionella* sp. (D.P. Gordon, D.S.I.R. pers. comm.).