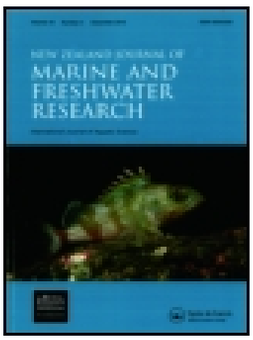

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DISTRIBUTIONS AND ASSOCIATIONS OF BENTHIC INVERTEBRATES IN A SHELTERED WATER SOFT-BOTTOM ENVIRONMENT (MARLBOROUGH SOUNDS, NEW ZEALAND)

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SUMMARY

Distribution patterns of benthic invertebrates in the Marlborough Sounds are related to depth and sediment grade. The assemblage of species found living in this sheltered water soft-bottom area is characterised by two species of polychaete of the genus *Asychis*, *Echinocardium cordatum*, and *Amphiura rosea*. The relationship of this association in the Marlborough Sounds to similar associations in other areas is briefly discussed.

INTRODUCTION

The Marlborough Sounds (Fig. 1) are a complex system of interfingering drowned valleys opening into Cook Strait which separates the North and South Islands of New Zealand. The shoreline of the sounds consists of beaches varying from cobbles to sand and broken shell, separated by rocky points. By contrast the bottom sediment in most places is soft mud. The geology of the area has been mapped and briefly described by Beck (1964).

Queen Charlotte Sound receives only small streams carrying the run-off from the surrounding hills, but two sizeable rivers, the Pelorus and the Kaituna, flow into the head of Pelorus Sound. It was expected that Pelorus Sound would be estuarine but, in the areas where the water was deep enough to allow sampling from the ship used, salinities were only slightly reduced with no apparent effect on the benthos.

Samples were taken throughout Pelorus and Queen Charlotte Sounds (Table 1, Fig. 1) with the exception of Tory Channel. The patterns of distribution and associations of benthic invertebrates found are described.

The only previous work in the area was done by Dell (1951) who described the faunas taken in three dredge hauls in the outer part of Queen Charlotte Sound.

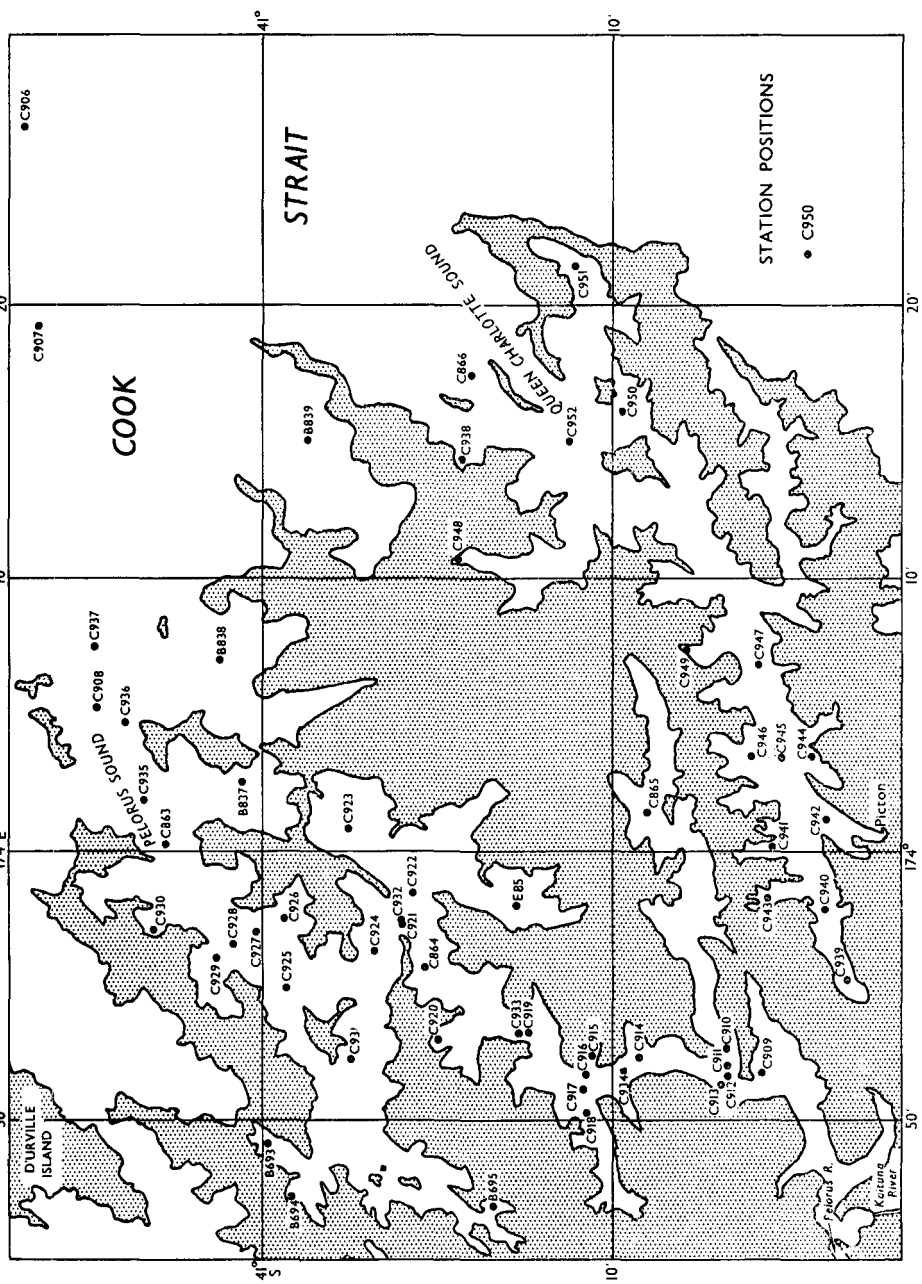

FIG. 1—The Marlborough Sounds, showing station positions.

METHODS

An orange-peel grab sampling an area of approximately 0.25 m^2 was used. The jaws of the grab were fitted with cover plates to minimise washing of the surface of the sample. A single sample was taken at each station and a 1 lb jar of sediment was retained for subsequent analysis.

The animals were removed from the sediment either by washing through a series of sieves with cheesecloth laid over the first one, or by hand-sorting through the mud. The cheesecloth was lifted off the sieve and preserved entire and the fine material picked from the cloth in the laboratory. This procedure is far quicker than picking off the sieve mesh at sea. At most stations the mud contained so few macro-organisms and was so resistant to washing through the sieves that hand-sorting was quicker. Such hand-sorting cannot be completely quantitative so population densities have not been calculated. Organisms less than 5 mm in length were not considered excepting only smaller specimens of *Linucula gallinacea* Finlay. Identifications other than echinoderms, molluscs, and some crustaceans were made by the author. Sponges, hydroids, and bryozoa were not identified. They did not occur frequently or abundantly enough to be important.

Sediment analyses were carried out in the New Zealand Oceanographic Institute using a combined sieve and pipette analysis. To simplify presentation the percentage of silt plus clay (<64 μ fraction) has been used as an index of the sediment grade, but the complete analyses have been considered.

TABLE 1—Station List

Station	Latitude S. ° ′	Longitude E. ° ′	Depth (metres)	Sediment (% <64 μ)
C 863	40 57.3	174 0.2	71	57
C 864	41 4.5	173 55.7	27	95
C 865	41 10.8	174 01.4	11	100
C 866	41 06	174 17.4	17	36
B 693	41 00	173 49.3	26	98
B 694	41 00.7	173 47.3	20	38
B 695	41 06.4	173 46.8	20	91
C 906	40 53.6	174 26.8	140	27
C 907	40 54	174 19.7	90	0
C 908	40 55.3	174 09.6	48	58
C 909	41 14	173 51.7	17	98
C 910	41 13	173 52.7	24	96
C 911	41 13	173 52	33	99
C 912	41 13	173 51.6	22	99
C 913	41 12.8	173 51.4	18	99
C 914	41 10.5	173 52.4	31	93
C 915	41 09.2	173 52.2	11	96

C 916	41 09	173 51.7	25	98
C 917	41 09	173 51.2	29	99
C 918	41 09	173 50.4	15	99
C 919	41 07.4	173 53.4	52	94
C 920	41 04.8	173 58.1	16	99
C 921	41 04.9	173 57.3	75	78
C 922	41 04.2	173 58.3	33	97
C 923	41 02.4	174 01	39	99
C 924	41 03.1	173 56.4	63	n.a.
C 925	41 00.6	173 55.1	39	88
C 926	41 00.5	173 57.7	25	97
C 927	40 59.8	173 57.2	48	80
C 928	40 59.1	173 56.7	48	69
C 929	40 58.6	173 56.2	28	81
C 930	40 56.9	173 57.3	31	91
C 931	41 02.4	173 52.4	36	98
C 932	41 03.9	173 57.5	66	—
C 933	41 07.2	173 53.3	50	—
C 934	41 10.1	173 57.8	33	—
C 935	40 56.7	174 2.2	31	64
C 936	40 56.1	174 49	100	12
C 937	40 55.4	174 7.7	25	39
C 938	41 5.6	174 14.3	22	95
C 939	41 16.2	173 55.2	13	96
C 940	41 15.7	173 57.8	29	95
C 941	41 14.3	174 0.1	33	94
C 942	41 15.8	174 01.1	35	94
C 943	41 14.1	173 88.2	19	27
C 944	41 15.3	174 03.4	32	82
C 945	41 14.4	174 03.4	41	97
C 946	41 13.6	174 03.4	43	96
C 947	41 13.8	174 06.8	40	95
C 948	41 05.5	174 10.7	24	n.a.
C 949	41 11.9	174 07.4	24	92
C 950	41 10.2	174 16.2	44	96
C 951	41 05.9	174 21.5	45	n.a.
C 952	41 08.7	174 15	48	n.a.
B 837	40 59	174 03	40	96
B 838	40 59	174 07	17	46
B 839	41 01.3	174 15.2	20	46
E 85	41 07.6	173 58.3	31	n.a.

Stations	Date	Cruise	Ship	Leader
C 863 – C 866	4–5.3.62	Benthos North	*Taranui*	D. G. McKnight
B 693 – B 695	30.10.62	Benthos South	,,	D. G. McKnight
C 906 – C 952	7–14.2.63	Pelorus Benthos	,,	I. N. Estcourt
B 837 – B 839	21.3.63	Aotea	,,	J. C. McDougall
E 85	30.3.64	Chatham Camera	,,	I. N. Estcourt

Stations C 932, C 933, and C 934 were hydrology stations only. Water samples were taken at C 909 and C 930 in addition to the grab sample, and surface and bottom salinities and temperatures (Table 2) at these five stations were obtained using standard reversing bottles and thermometers. The salinities were determined by conductivity measurements.

TABLE 2—Salinity and temperature in Pelorus Sound

		Salinity ‰		Temperature °C	
Station	Date	Surface	Bottom	Surface	Bottom
C 909	8.2.63	33.672	34.387	24.4	19.2
C 934	11.2.63	33.956	34.342	19.51	15.61
C 933	11.2.63	34.302	34.617	18.78	18.00
C 932	11.2.63	34.582	34.691	18.22	17.81
C 930	11.2.63	34.677	34.806	17.67	17.4

The data show a slight salinity stratification and a very small decrease in bottom salinity from the entrance to the innermost station.

The distributions of the species were related to station position, depth, and sediment. Other factors may influence distribution, and in a computer analysis of samples from the Gulf of California Parker (1964) considered the following variables: date, time of day, depth, station position, sediment, collecting gear, and other organisms. In the present study most of the stations were taken within a few days, all in daylight, and only one type of grab was used.

The relation between species, station, depth, and sediment grade was analysed by plotting depth and sediment grade for each station where a species occurred (*cf.* Sanders 1958). Such plots (Fig. 2) were drawn for 38 of the species. A small number of patterns were found, each repeated by several species. Most of the species taken fitted easily into one or other of these patterns of relation with depth and sediment grade.

Species which occurred alive at less than three stations have been excluded from this analysis except that molluscs and echinoids with one live plus two dead occurrences have been included.

(a) Species found only in depths of less than 65 m and sediments with over 60% $<64\ \mu$ particles:

Polychaeta
Heterospio sp.
Onuphis aucklandensis Augener
Priapuloidea
Priapulus australis (de Guerne)
Crustacea Thalassinidea
Callianassa filholi Milne Edwards
Ophiuroidea
Monamphiura alba (Mortensen)
Ophiocentrus novaezelandiae Gilsen
Holothuroidea
Paracaudina chilensis (Muller)
Protankyra uncinata (Hutton)

The depth–sediment relation shown by these species is exemplified by Fig, 2 d.

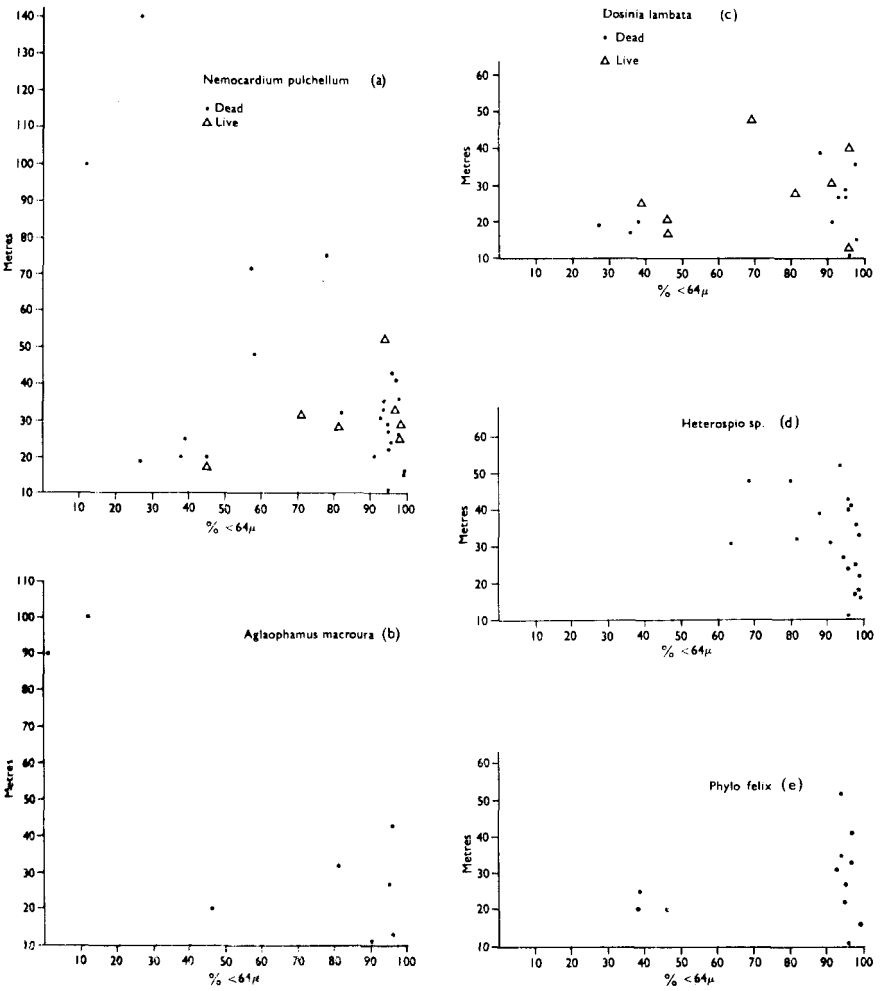

FIG. 2—Occurrence of selected species plotted against depth and sediment grade.

Protankyra uncinata occurred at Sta. C 921, depth 75 m, but otherwise falls into this group. It was found only in sediments with over 78% <64 μ. The distribution (Fig. 3) of the most frequently found species in this group, *Heterospio* sp., illustrates its restriction to the most sheltered parts of the Sounds.

(b) Species found in depths of less than 65 m and sediments with over 60% <64 μ particles except for occurrences at Sta. C 937, C 943, B 694, or B 839 (Fig. 2 e):

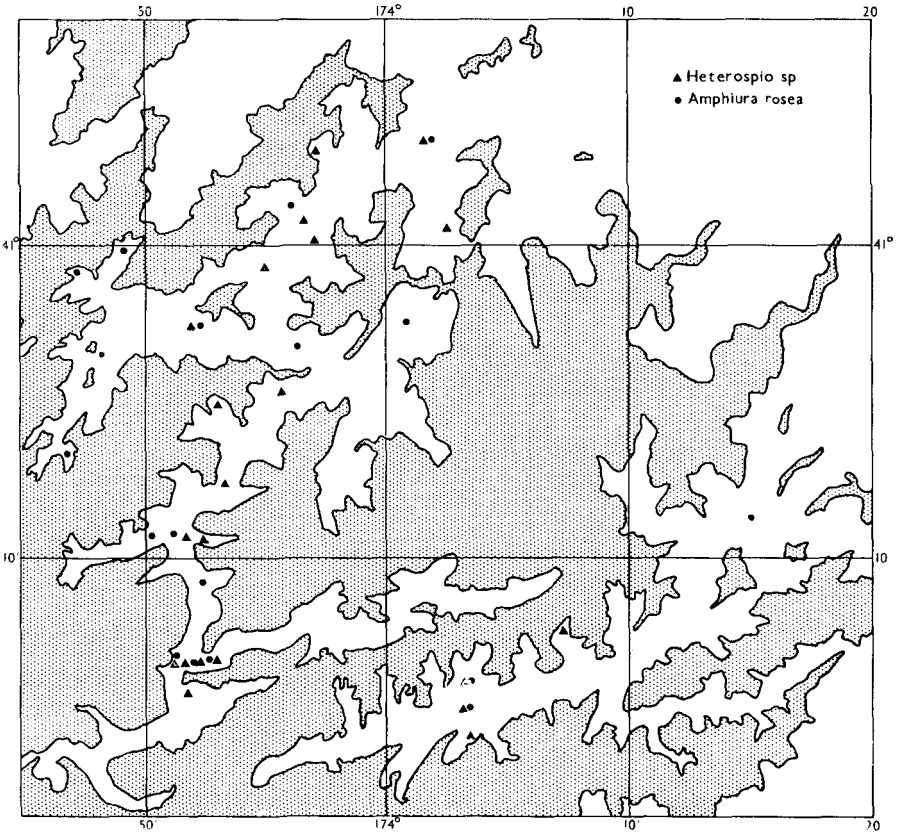

FIG. 3—The distribution of the polychaete *Heterospio* sp. and of the ophiuroid *Amphiura rosea*.

Polychaeta
- *Asychis theodori* (Augener)
- *Glycera lamellipodia* Knox
- *Lumbrinereis* sp. B
- *Lumbrinereis sphaerocephala* (Schmarda)
- *Lysilla* sp.
- *Nicomache* sp.
- *Phylo felix* Kinberg
- *Polynoid* sp.
- *Prionospio pinnata* Ehlers

Echiuroidea
- *Urechis novaezelandiae* (Dendy)

Sipunculoidea
- *Golfingia cantabriensis* (Edmonds)

Crustacea Brachyura
- *Hemiplax hirtipes* (Jacquinot)

Gastropoda
- *Baryspira mucronata* (Sowerby)
- *Struthiolaria* (*Pelicaria*) *vermis* (Martyn)

Bivalvia
- *Atrina zelandica* (Gray)
- *Neilo australis* (Quoy and Gaimard)
- *Nemocardium pulchellum* (Gray)
- *Notocallista multistriata* (Sowerby)
- *Pleuromeris zelandica* (Deshayes)
- *Thyasira* (*Parathyasira*) *resupina neozelanica* Iredale

Ophiuroidea
- *Amphiura rosea* Farquhar
- *Amphiura norae* Benham

Holothuroidea
- *Pentadactyla longidentis* (Hutton)

The sediments at Sta. C 937 and B 839 were similar with 55% and 54% respectively of fine and very fine sand (125–64 μ) while Sta. C 943 and B 694 had shell and gravel in a mud matrix. This admixture of coarser material apparently makes little difference to the biological properties of the sediment judging from the number of species which extend to these stations from more muddy ones.

Lumbrinereis sphaerocephala, like *Protankyra uncinata,* occurred at Sta. C 921 in deeper water than the rest of the species in the group.

Both live specimens and dead shell occurrences of *Neilo australis* conformed to the limits for the group, but dead shells of *Atrina zelandica, Nemocardium pulchellum* (Fig. 2 a), *Notocallista multistriata, Pleuromeris zelandica,* and *Thyasira* (*Parathyasira*) *resupina neozelanica* occurred over a wider range of depths and sediments. Live occurrences have been given most weight in grouping species, but the significance of dead shell distribution is considered later.

(c) Species found in depths of less than 65 m but occurring in a wider variety of sediments than species in the last group (Fig. 2 c):

Polychaeta
Asychis trifilosa Augener
Clymene (*Euclymene*) *insecta* (Ehlers)
Goniada maorica Benham

Bivalvia
Dosinia lambata (Gould)
Tellina charlottae (Smith)
Zenatia acinaces (Quoy and Gaimard)

All occurrences of *Dosinia lambata* and *Zenatia acinaces* were within the limits for the group, but dead shells of *Tellina charlottae* were found over most of the range of depths and sediments sampled.

(d) Species occurring over most of the range of depths and sediments sampled (Fig. 2 b):

Polychaeta
Aglaophamus macroura (Schmarda)
Lumbrinereis sp. A
Pherusa kerguelarum (Grube)

Gastropoda
Zegalerus tenuis (Gray)

Bivalvia
Dosinula zelandica (Gray)
Linucula gallinacea Finlay
Notocorbula zelandica (Quoy and Gaimard)

Echinoidea
Echinocardium cordatum (Pennant)
Pseudechinus albocinctus (Hutton)

Pseudechinus albocinctus occurred live only at station C 946, but spines or fragments of test were found at 24 widely scattered stations. Only *Linucula gallinacea* and *Echinocardium cordatum* occurred at Sta. C 906, the deepest station worked.

(e) Species concentrated in the outer parts of the Sounds:

Polychaeta
Capitellethus dispar (Ehlers)
Phyllochaetopterus socialis Claparede

Bivalvia
Gari stangeri (Gray)
Nucula nitidula Adams
Venericardia purpurata (Deshayes)

Gastropoda

Poirieria zelandica (Quoy and Gaimard)
Struthiolaria papulosa (Martyn)

Nucula nitidula was found live only at Sta. C 906 and as dead shell at Sta. C 907, C 929, and C 866. This suggests that it is an inhabitant of open water. The other species have distributions based on Sta. C 935, C 937, B 837, B 838, B 839, and C 866 (Fig. 1) and extending more or less into the Sounds. Their distributions seem to be related to the geography rather than to changes in depth and sediment.

(f) Species whose occurrence may be governed by current velocities:

Polychaeta

Amphicteis gunneri Sars
Owenia fusiformis Delle Chiaje
Pista cristata (Muller)

Ophiuroidea

Axiognathus squamata (Delle Chiaje)

The occurrences of these species plotted against depth and sediment did not show any grouping either collectively or for any one species.

The three polychaetes feed on detritus gathered from the surface of the sediment. The rate of renewal of their food supply would be related to water movements. The stations at which they occurred are in narrows within the Sounds or are open to Cook Strait, positions likely to be subjected to current velocities higher than at other stations.

The stations at which one or other of these species occurred were C 911, C 915, C 919 (2 spp.), C 864, C 921 (2 spp.), C 924 (2 spp.), C 925, C 928, C 929, C 863 (4 spp.), C 936, B 837, B 838, and C 906.

(g) Species occurring live only at one or more of Sta. C 921, C 863, and C 936:

Bivalvia

Chlamys gemmulata Reeve
Glycymeris laticostata (Quoy and Gaimard)
Musculus impactus (Hermann)
Ostrea lutaria Hutton

Brachiopoda

Terebratella haurakiensis Allan

All these species were more widely distributed as dead shell. *Musculus impactus* and *Terebratella haurakiensis* may live in shallow rocky areas from which dead shell falls to the muddy bottom. Local residents say that oysters (*Ostrea*) can be taken by wading at low tide in some bays. However, in deep water it appears that these species occur in the Marlborough Sounds only at places where tidal currents are rapid enough to give a relatively clean coarse bottom, although the mud fraction of the sediments is still significant.

These three stations had distinctive faunas which are discussed in a later section.

(h) Miscellaneous species:

The polychaete *Lepidonotus polychromus* Schmarda and the bivalve *Austrovenus stutchburyi* (Gray) were the only species considered which did not fit into the above grouping.

Lepidonotus polychromus occurred at Sta. C 921 and C 863, which have high current velocities and relatively coarse sediment, and at station B 693 in a sheltered bay with very fine sediment.

Austrovenus stutchburyi (Gray) was found live only at station C 939 in 13 m. Dead shell occurred at Sta. C 945, E 85, and C 936. The usual habitat of *A. stuchburyi* is intertidal sandbanks and possibly dead shell was transported to these last three stations.

DEAD SHELL OCCURRENCES

Most mollusc species occurred in greater numbers and at more stations as dead shells than as live specimens. *Linucula gallinacea* had the largest number (14) of live occurrences, but dead shell was found at another 14 stations. *Nemocardium pulchellum* was found live only eight times in 38 occurrences, while several species were found live only once or twice in 10 or 12 occurrences.

Live occurrences were given greatest weight when fitting patterns of occurrence into the groups used above, but with so few live specimens the question of how much information on habitat preferences could be gained from dead shell was important.

Plots of occurrence against depth and sediment grade for *Dosinia lambata* (Fig. 2 c), *Linucula gallinacea,* and *Zenatia acinaces* were similar with the points representing live occurrences as widely spread as the points representing dead shell. Plots for *Nemocardium pulchellum* (Fig. 2 a), *Atrina zelandica, Notocallista multistriata, Pleuromeris zelandica,* and *Tellina charlottae* show that dead shell was found over a wider range, especially in depth, than live specimens.

Nemocardium pulchellum (Fig. 4) will serve as an example of these. Dead shell was found at Sta. C 921, C 863, C 936, and C 906 which have greater depths than those at which live specimens occurred. Sta. C 921, C 863, and C 936 are subjected to strong tidal currents and are close to stations at which *Nemocardium pulchellum* was found live. Transport of empty valves to these stations might be possible, but fresh valves at Sta. C 906 with the details of the sculpture still sharp are unlikely to have been transported any great distance. The sediment at this station was predominantly fine, and very fine sand, showing conspicuous ripple marking in bottom photographs. The surface layers are probably moved by tidal currents, an environment in which fine details would be rapidly erased from dead shells.

Only small numbers of live bivalves were taken. The numbers per sample for *Nemocardium pulchellum* were 1, 2, 2, 1, 1, 3, 1, 2; for *Tellina charlottae* 1, 1, 1, 4, 1, 5, 1, 1; and for *Dosinia lambata* 2, 3,

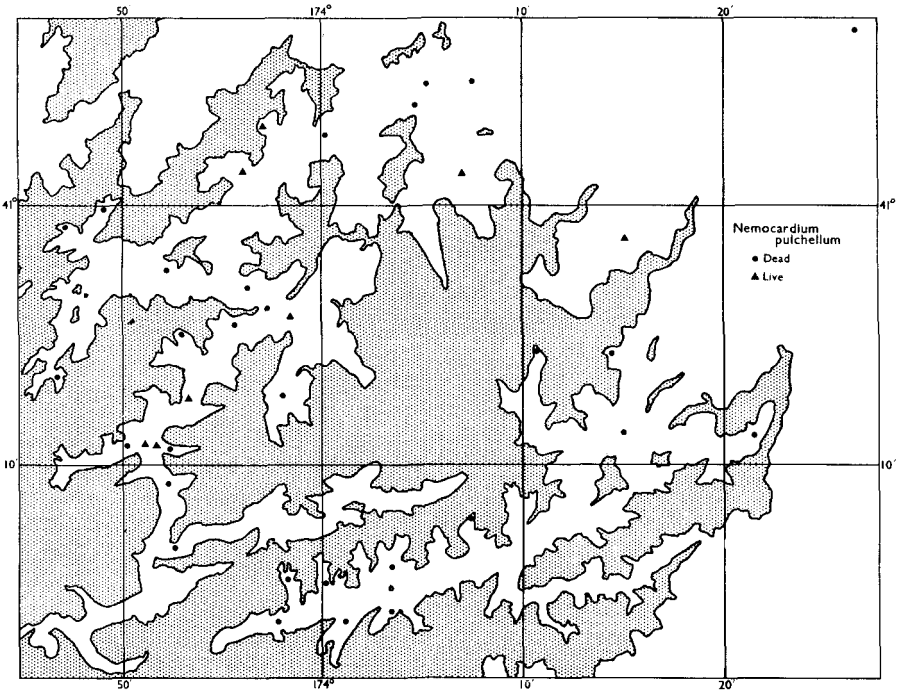

FIG. 4—The distribution of live specimens and dead shells of *Nemocardium pulchellum*.

1, 1, 3, 1. The population densities appear to be too low to be satisfactorily sampled and it is concluded that more intensive sampling would show that all the species mentioned occur live over the range of occurrence of their dead shell. For example, it is most unlikely that *Nemocardium pulchellum* does not live anywhere in Queen Charlotte Sound (Fig. 4).

Musculus impactus and *Terebratella haurakiensis* are exceptions to this. Their dead shell distribution appears to reflect the nearness of rocky habitats to muddy bottom areas throughout the Marlborough Sounds.

RELATED SPECIES WITH COMPLEMENTARY DISTRIBUTIONS

Three examples of this were evident. Only station numbers are given here but the details of depths and sediment grades can be obtained from Table 1 and geographical distributions from Fig. 1.

The ophiuroid *Monamphiura alba* occurred at Sta. C 909, C 910, and C 916 in the muddy sediments of the inner part of Pelorus Sound. *Monamphiura spinipes* (Mortensen) occurred at Sta. C 863 and C 936

which have higher current velocities and coarser sediments. *Monamphiura pusilla* (Farquhar) occurred at Sta. C 921 and C 906 where the sediment is finer but current velocities still high.

Golfingia cantabriensis (Sipunculoidea) was found at Sta. C 911, C 917, C 937, and C 938 while *Golfingia novaezelandiae* occurred only at Sta. C 936.

Glycera lamellipodia (Polychaeta) was found at Sta. C 919, B 693, E 85, C 938, C 939, C 943, C 945, B 838, and B 839. *Goniada maorica* was found at Sta. C 929, C 935, C 937, C 938, and C 866, while *Goniada emerita* was found only at Sta. C 906. *Goniada maorica* and *Glycera lamellipodia* occurred together at Sta. C 938.

The general pattern in these three cases is of one species in the inner muddy part of the Sounds more or less separated from another in more open, less muddy outer areas.

The following species were represented only by dead shells or fragments of test and spines. They cannot be important components of the benthos and have been excluded from the analysis.

Gastropoda
- *Baryspira novaezelandiae*
- *Maoricolpus roseus*
- *Melagraphia aethiops*
- *Zeacolpus vittatus*

Bivalvia
- *Aulacomya maoriana*
- *Barbatia novaezelandiae*
- *Cardita aoteana*
- *Cuspidaria trailli*
- *Limatula maoriana*
- *Modiolus areolatus*
- *Myadora novaezelandiae*
- *Mytilus* sp.
- *Nuculana bellula*
- *Pallium convexum*

Echinoidea
- *Evechinus chloroticus*
- *Fellaster zelandiae*

Species such as *Melagraphia aethiops,* the mussels (*Aulacomya, Modiolus, Mytilus*), and *Evechinus chloroticus* probably live along the rocky shores and dead shells and tests fall to muddy bottom areas. *Maoricolpus roseus, Cuspidaria trailli,* and *Nuculana bellula,* for example, live in mud and there are two possible explanations for the absence of live specimens. The species may no longer live in the area or their population densities may be so low that none of the samples happened to contain a live specimen although dead shells of *Maoricolpus roseus* were a major part of the sample at many stations.

ASSOCIATIONS OF SPECIES

SHELTERED WATER MUDDY-BOTTOM ASSOCIATION

Most of the stations within the Sounds had similar sediments, and similar faunas which are referred to a single *Asychis–Echinocardium–Amphiura* association. The species in the second group (restricted to depths of less than 65 m and to sediments with over 60% $<64\ \mu$ particles except at four stations) were taken as indicators of the association and all stations at which any of these species occurred live were included in it. This association was present at 44 stations.

The remaining stations C 906, C 907, C 908, C 921, C 863, C 936, C 940, C 948, and C 949 belonged to several distinct associations described further on.

The species composition of the sheltered water muddy-bottom association is detailed in Table 3, which includes all species found at three or more stations belonging to the association. Only live occurrences have been counted but molluscs and echinoids with one live plus two or more dead occurrences have been included (as in the analysis of depth-sediment relationships p. 356).

The number of stations at which each species occurred is listed for the whole 44 stations (Sounds area) and separately for Pelorus Sound, the inner part of Pelorus Sound, and for Queen Charlotte Sound. For this purpose Pelorus Sound was taken as 29 stations, from C 909 to C 935 and B 837, and the Pelorus inner area as Sta. C 909 to C 920 inclusive. The geographically intermediate stations C 937, B 838, and B 839 were omitted, leaving the Queen Charlotte area with 12 stations.

TABLE 3—Species occurrences in selected areas (see text for explanation)

	Sounds area (44 sta.)	Pelorus (29 sta.)	Pelorus inner (13 sta.)	Queen Charlotte (12 sta.)
Asychis theodori	13	3	—	9
Asychis trifilosa	25	15	9	9
Aglaophamus macroura	7	2	1	4
Capitellethus dispar	7	—	—	5
Clymene (Euclymene) insecta	7	6	2	—
Glycera lamellipodia	9	3	1	4
Goniada maorica	5	2	—	2
Heterospio sp.	20	17	10	3
Lumbrinereis sp. A	8	5	4	1
Lumbrinereis sp. B	6	5	—	—
Lumbrinereis sphaerocephala	9	5	2	3
Lysilla sp.	3	3	1	—
Nicomache sp.	4	4	—	—
Onuphis aucklandensis	14	14	6	—
Owenia fusiformis	5	4	2	—
Pherusa kerguelarum	4	2	1	1
Phyllochaetopterus socialis	14	7	1	6
Phylo felix	12	7	5	3
Pista cristata	6	6	3	—
Polynoid	9	7	4	2
Prionospio pinnata	6	2	—	1
Urechis novaezelandiae	3	2	1	1
Golfingia cantabriensis	4	2	2	2
Priapulus australis	11	10	6	1
Callianassa filholi	7	5	2	2
Hemiplax hirtipes	7	4	4	2
Baryspira mucronata	1	1	—	—

Poirieria zelandica	1	1	—	—
Struthiolaria papulosa	2	2	—	—
Struthiolaria (Pelicaria) vermis	2	1	—	—
Zegalerus tenuis	2	1	—	—
Atrina zelandica	2	2	1	—
Austrovenus stutchburyi	1	—	—	1
Dosinia lambata	8	4	—	1
Dosinula zelandica	2	—	—	2
Gari stangeri	1	—	—	—
Leptomya retiaria	1	—	—	—
Linucula gallinacea	13	7	5	5
Neilo australis	3	2	1	—
Nemocardium pulchellum	8	7	3	—
Notocallista multistriata	6	4	1	1
Notocorbula zelandica	3	1	—	—
Pecten novaezelandiae	2	2	1	—
Pleuromeris zelandica	1	1	1	—
Tellina charlottae	8	5	3	1
Thyasira (Parathyasira) resupina neozelanica	2	1	1	—
Zenatia acinaces	4	3	1	—
Amphiura rosea	17	14	6	3
Amphiura norae	6	2	—	4
Monamphiura alba	3	3	3	—
Ophiocentrus novaezelandiae	5	5	3	—
Echinocardium cordatum	20	13	5	7
Pseudechinus albocinctus	1	—	—	1
Paracaudina chilensis	3	3	2	—
Pentadactyla longidentis	9	5	3	—
Protankyra uncinata	12	12	9	—

The most common species from each area are listed in Table 4 with the number of occurrences converted to percentages. All species which occurred at 25% or more of the stations are included, making these lists equivalent to the lists of characterising species of Thorson (1957).

The tables highlight the comparative numerical unimportance of molluscs in the fauna. At most stations the scarcity of live specimens formed a remarkable contrast with the amount and variety of dead shell.

Of the 56 species (Table 3) only 29 occurred in Queen Charlotte Sound. Four species from Queen Charlotte Sound were not found in Pelorus Sound, while 26 Pelorus species did not occur in Queen Charlotte Sound. The common species extend throughout the Sounds but their relative frequency changes from place to place (Table 4). All the species listed in Table 4 are detritus feeders as far as is known or can reasonably be inferred—except *Glycera lamellipodia*, which may be a carnivore.

The greater number of species found in Pelorus Sound suggests some major environmental difference between the two sounds. It is

not due merely to the greater size of Pelorus Sound and the large number of samples taken (see Longhurst (1958) for relation between number of samples and number of species found) for there is still a marked difference when the Pelorus inner area is compared with the whole of Queen Charlotte Sound. The 13 stations in the small Pelorus inner area gave 37 species against 29 from the 12 stations in Queen Charlotte.

There are only minor differences betwen the two areas in depths and sediments. The freshwater inflow of the Pelorus and Kaituna Rivers is the only apparent major difference. The innermost reaches of the Pelorus (Sta. C 909 was near the limit for M.V. *Taranui,* which draws 4 m) are composed of intertidal sand and mudbanks, and narrow channels. The author has observed large areas of the banks densely covered with attached algae. This heavy growth is presumably supported by nutrient salts from the rivers (Emery and Stevenson, 1957) and the high light intensity in shallow water. It is suggested that detritus from breakdown of this growth distributed by tidal currents supports the greater variety of detritus feeders in Pelorus Sound. The organic matter content of the sediment samples was not determined.

TABLE 4—Most frequent species from selected areas (figures are percentage frequencies of occurrence)

Sounds area	Pelorus
Asychis trifilosa (57)	*Heterospio* sp. (57)
Heterospio sp. (45)	*Asychis trifilosa* (60)
Echinocardium cordatum (45)	*Amphiura rosea* (47)
Amphiura rosea (39)	*Onuphis aucklandensis* (47)
Onuphis aucklandensis (32)	*Echinocardium cordatum* (43)
Asychis theodori (29)	*Protankyra uncinata* (40)
Linucula gallinacea (29)	*Priapulus australis* (33)
Phylo felix (27)	
Protankyra uncinata (27)	
Priapulus australis (25)	
Queen Charlotte	Pelorus inner
Asychis trifilosa (75)	*Heterospio* sp. (76)
Asychis theodori (75)	*Asychis trifilosa* (69)
Echinocardium cordatum (58)	*Protankyra uncinata* (69)
Linucula gallinacea (42)	*Amphiura rosea* (46)
Amphiura norae (33)	*Onuphis aucklandensis* (46)
Aglaophamus macroura (33)	*Priapulus australis* (46)
Glycera lamellipodia (33)	*Echinocardium cordatum* (38)
	Phylo felix (38)
	Linucula gallinacea (38)

Despite the differences in frequency and in species composition betwen Pelorus and Queen Charlotte Sounds a large number of species extend right through the area (see Table 3) and it is not possible to divide it into more than one association. The Marlborough Sounds are a single geographical unit and the similarities between the benthic faunas of the Pelorus inner area and Queen Charlotte Sound far

outweigh the differences. The characterising species of the *Asychis–Echinocardium–Amphiura* association of sheltered water muddy-bottom areas in the Marlborough Sounds are listed under "Sounds area" in Table 4.

Sta. C 940 and C 949 also belong to this association. Their sediments were similar to those at nearby stations, and their sparse faunas included *Asychis trifilosa* and *Echinocardium cordatum* although none of the species used as indicators when deciding the limits of the association were living at either of them.

The remaining Queen Charlotte station, C 948, had a sandy sediment. The analysis was incomplete but the dominant fraction was fine sand. *Callianassa filholi* and *Echinocardium cordatum* were present but none of the common polychaetes occurred. A single live specimen was found of *Soletellina siliqua* which did not occur at any other station.

Two previous stations in Queen Charlotte Sound, B.S. 102 and B.S. 103 of Dell (1951), which were described as *Echinocardium* communities belong to the *Asychis–Echinocardium–Amphiura* association defined here.

The *Echinocardium* Formation described by Powell (1937) from Auckland Harbour is similar to the *Asychis–Echinocardium–Amphiura* association of the Marlborough Sounds. Comparison of the list of species given by Powell (p. 370) with Table 3 shows 18 species in common as well as several instances where a genus is represented by different species. It is not possible to equate Powell's division into dominants, subdominants, and secondary species with the listing in order of frequency of occurrence used here, but *Echinocardium cordatum* (*E. australe* of Powell) and *Amphiura rosea,* Powell's first and third dominants, are third and fourth in order of frequency in the Marlborough Sounds. His other dominant, *Dosinia lambata,* is significant only if dead shell occurrences are counted. When this is done the most frequent mollusc is *Nemocardium pulchellum,* which is not listed by Powell. Dell (1951) also noted this and it seems to be a major difference between Auckland Harbour and the Marlborough Sounds. The most frequent polychaetes in the Marlborough Sounds, *Asychis trifilosa, A. theodori* and *Heterospio* sp., are not listed by Powell although they may have been among his unidentified polychaetes. However, it seems that molluscs are relatively more and polychaetes relatively less important in Auckland Harbour than in the Marlborough Sounds.

The *Echinocardium* community from Milford Sound described by Hurley (1964) resembles that from the Marlborough Sounds in the occurrence of *Nemocardium pulchellum.* However, *Glycera americana* which was important in Auckland Harbour and Milford Sound, did not occur in the Marlborough Sounds. Here *G. lamellipodia* was the common glycerid. Hurley noted that *Amphiura rosea,* one of the dominants in Auckland Harbour, was replaced by *Amphiura norae* in the south. Both are present in the Marlborough

Sounds (Tables 3, 4) but *A. rosea* occurred more frequently in Pelorus Sound, while *A. norae* was more frequent in Queen Charlotte Sound. The two species occurred together at only one station.

OTHER ASSOCIATIONS

The two outstanding stations within the Marlborough Sounds, C 921 and C 863, were both in places where tidal currents are very strong. Their faunas showed some similarities but also enough differences to prevent the two being described as a single association.

Sta. C 921 had a large amount and variety of species of dead shell. The fauna was characterised by the presence of live *Musculus impactus, Ostrea lutaria,* and *Venericardia purpurata.* The following echinoderms did not occur at any other station: *Allostichaster insignis* (Farquhar), *Patiriella regularis* (Verrill), *Ophionereis fasciata* Hutton, *Ctenamphiura dawbini, Pectinura gracilis,* and *Pectinura maculata. Petrolisthes novaezelandiae* was also present.

The presence of *Lumbrinereis* sp. A, *Lumbrinereis sphaerocephala, Protankyra uncinata, Notocorbula zelandica,* and *Linucula gallinacea* related it to the more muddy stations nearby.

Live *Musculus impactus* and *Ostrea lutaria* were also present at Sta. C 863 along with live *Chlamys gemmulata.* The fauna was dominated by *Petrolisthes novaezelandiae,* 95 specimens in the sample. Seven species of polychaetes were found only at this station. Unidentified sponges were a significant part of the sample. Live *Terebratella haurakiensis* were present.

These two stations show contrasting development of epifaunal organisms in situations where current velocities reduce the deposition of sediment. The epifaunal filter-feeding bivalves are shared, but at C 921 the ophiuroids were the major remaining element, while at Sta. C 863 *Petrolisthes* was the dominant organism.

Both have some similarity to the Foveaux Strait oyster beds (Fleming 1952). As well as *Ostrea lutaria* the following species are shared (dead shell occurrences included): *Aulacomya maoriana, Dosinula zelandica, Gari stangeri, Glycymeris laticostata, Modiolus areolatus, Musculus impactus, Nemocardium pulchellum, Pecten novaezelandiae, Venericardia purpurata, Maoricolpus roseus, Zegalerus tenuis, Patiriella regularis, Pectinura maculata.* Carnivorous gastropods are important in Foveaux Strait, but are not represented in the Marlborough Sounds samples. The major difference between the two areas is in the sediment. The Foveaux Strait oyster bed sediments are clean shell gravel and shell sand while the sediments from the two Sounds stations contained a large proportion of mud. All crevices and dead shells were filled with mud, and probably only objects projecting into the water would be swept clean by the currents.

Sta. C 936 was in a situation where tidal scour was most pronounced. The dominant animal was *Glycymeris laticostata* (12 live specimens). Live *Terebratella haurakiensis* and *Chlamys gemmulata* were present. One large (length 10 cm) specimen each of the polychaete *Euthalenessa digitata* and of the sipunculid *Golfingia novaezelandiae* were present. Species present here but also found at more muddy stations were *Aglaophamus macroura, Pherusa kerguelarum, Linucula gallinacea, Notocorbula zelandica,* and *Pleuromeris zelandica.* This station shows affinities with the brachiopod–*Chlamys* association described by Dell (1951) from Dominion Museum B.S. 101 in the outer part of Queen Charlotte Sound, and by Hurley (1964) from Milford Sound. It is a brachiopod–*Chlamys* association superimposed on a *Glycymeris* association which is reminiscent of Powell's *Tawera–Glycymeris* formation from channels in Auckland Harbour, and analagous to Dell's "Brachiopod–*Chlamys* formation superimposed upon a somewhat modified *Venericardia–Tawera* association."

The three stations in Cook Strait, Sta. C 908, C 907, and C 906, had sparse living faunas, but the dead shell present related them to the Sounds stations. *Asychis trifilosa* and live *Dosinula zelandica* were present at Sta. C 908. The only live macro-invertebrate present at C 907 was a single specimen of *Aglaophamus macroura.* The dominant fraction (64%) of the sediment here was fine sand (250–125 μ) noted by Powell (1937) as unfavourable for filter feeders. However, Sanders (1958) found it a most favourable environment for filter feeders in Buzzards Bay and Long Island Sound. Sta. C 906 had more live animals, *Owenia fusiformis* and *Monamphiura pusilla* both occurred here and at Sta. C 921. *Goniada emerita, Haploscoloplos cylindrifer,* and live *Nucula nitidula* were not found at any other station.

PARALLEL COMMUNITY

The *Asychis–Echinocardium–Amphiura* association found in the Marlborough Sounds closely resembles the *Maldane sarsi–Ophiura sarsi* community in Thorson's (1957) review of level bottom communities. The species and some of the genera are different but the general characteristics are the same. Work in progress suggests that the New Zealand association also occurs in off-shore muddy sediments.

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