A STUDY OF THE MACROFAUNA OF AN EXPOSED "IRON SAND" BEACH AND A NEARBY ESTUARY

by D. H. Wood

An investigation of the faunas inhabiting an exposed sandy beach and the intertidal flats of an estuary is of interest because :-

1. unprotected sandy beaches are exposed to severe batterings by waves while the sandy flats of small estuaries suffer no such pounding;
2. the composition of the banks of an estuary varies from a coarse sand (similar to that of an open beach) at their seaward limits to a fine mud upstream; and
3. the salinity of the interstitial water of estuarine sand banks decreases from about that of the open sea at the mouth of the river to that of fresh water upstream beyond the influence of the sea.

Marakopa was a particularly suitable locality in which to study the macrofauna of these two environments since there occurred there both an open beach and a small meandering estuary with extensive sand and mud banks. A quantitative survey was carried out on the exposed beach of the fauna and two of the physical factors (grade and water content of the sand), and a qualitative survey was made of the fauna in the estuary together with a quantitative survey of the grade and water content of the sand and the salinity of the interstitial water.

THE OPEN BEACH

Location and Description

Marakopa beach is situated about 20 miles south of Kawhia on a straight stretch of the west coast of the north island of New Zealand. At the time of this study the beach extended 225 meters from Mean Low Water Neap to Extreme High Water Spring, and had a slightly convex profile becoming slightly concave about M. L. W. N.. A small sand dune backed the beach at the E. H. W. S. tide line.

Sampling Methods

Five main stations were investigated. These were spaced at intervals of 45

meters from ML. W. N. to about M. H. W. S.. At each of these a sample one squar meter in area and 20 centimeters deep was dug with a spade and sifted through a gar sieve with 1. 25 millimeter (1/20 inch) square mesh. The animals retained by the sieve were placed in bottles and later identified and counted (see Appendix I). Bet each of these main stations smaller samples (0. 5 square meter area and 20 centime deep) were taken and treated in a similar manner to the main samples. The count of the animals of the smaller samples were doubled to give the number per square meter recorded in Appendix I.

Also at each station (i. e. every 22. 5 meters) about 150 grammes of sand was collected from the top 7 centimeters, placed in an airtight bottle, and later analysed for water content and grade. The water content was estimated from the loss in we on drying the sample at 105°C. to constant weight, and was expressed as a percenta of the wet weight (see Appendix II). The dried sand was then mechanically shaken through a series of 6 sieves with square mesh of :-

2. 057 mm
1. 003 mm
0. 500 mm
0. 251 mm
0. 124 mm
0. 066 mm

The weights of the separated fractions were expressed as percentages of the dr weight of the sample (see Appendix II).

The Macrofauna

Only 13 species were collected on the beach (see Appendix I) :-

1 bivalve (tuatua),
1 menertine (proboscis worm),
4 polychaetes (bristle worms), and
7 crustaceans (which included 1 crab,
1 ghost shrimp, 2 isopods and 3 amphipods).

The distribution of these species on the beach is shown in figures 1 and 2.

Discussion of the Macrofauna

The tuatua (Amphidesma subtriangulatum) is a typical inhabitant of the intertida zone on less exposed beaches than Marakopa, the toheroa (Amphidesma ventricosum) more usually occurring on the most exposed beaches. The absence of any intertida bivalve population on Marakopa beach was unusual and was perhaps owing to human predation having decimated the population or merely to a natural patchy distribution.

It is interesting to note that the opheliid (Armandia sp.) was the only deposit feeder among the 4 polychaete species found on the beach. The small spionid (Pseudonerine sp.) feeds on plankton which it captures with the aid of its pair of long tentacles, and both the nephthydid (Aglaophamus macrura) and the glycerid (Glycera ?tesselata) are active carnivores. The absence of other deposit feeding polychaetes common on more sheltered beaches was probably due to the coarseness of the sand which was a result of the heavy wave action washing away the finer sand material and much of the organic debris.

Armandia sp. itself was strikingly limited in its distribution to a narrow band high up the beach (well above M. H. W. N.), and the main factor causing this localisation would seem to be the grade of the sand. All specimens of Armandia sp. which were collected had their gut packed with black sand grains, and the highest density (40 per square meter) of Armandia sp. occurred where the sand contained the highest percentage (15%) of very fine sand. * That Armandia sp. did not occur further up the beach, where the sand grade was only slightly less fine, was probably owing to the lower water content of the sand there, less than 6% compared with about 10% in the region where it did occur.

The harsh environment offered by this exposed type of beach also appeared to be unsuitable for both A. macrura and G. ?tesselata. All the specimens taken were short (less than 2 millimeters wide) compared with much larger specimens (up to 15 centimeters long and 5 millimeters or more wide) collected in the sheltered estuary.

Crustaceans are a group of animals many species of which are well adapted to the intertidal zone of exposed sandy beaches. It was on the distribution of crustacean species that E. Dahl (1952) showed that (exposed) sandy beaches on a world wide basis could be divided into 3 main zones similar to the 3 world wide zones on rocky shores demonstrated by T. A. and Anne Stephenson in 1948.

On the dry upper beach at Marakopa where the water content of the sand was less than 5%, there occurred the talitrid amphipod Talorchestia sp. (sand flea). This amphipod is an active scavenger coming out of its short burrow mainly at night in quest of food (plant and animal debris) left by the ebbing tide. A large oniscoideid isopod (Scyphax ornatus) had a similar distribution to the sand fleas. The occurrence of a burrowing semiterrestrial isopod on a sandy beach is unique to New Zealand so far as is recorded.

An isopod and 2 amphipod species were present in the midbeach area. The isopod, a truly marine species Pseudaega punctata of the family Eurydicidae, is fiercely carnivorous biting any animal it comes upon including humans. When the tide is in it actively swims about hunting food, but while the tide is out it lies buried in the sand. Amphipod "B", possibly a haustoriid, had an extremely limited distribution

* Very fine sand = 0.124 - 0.066 fraction

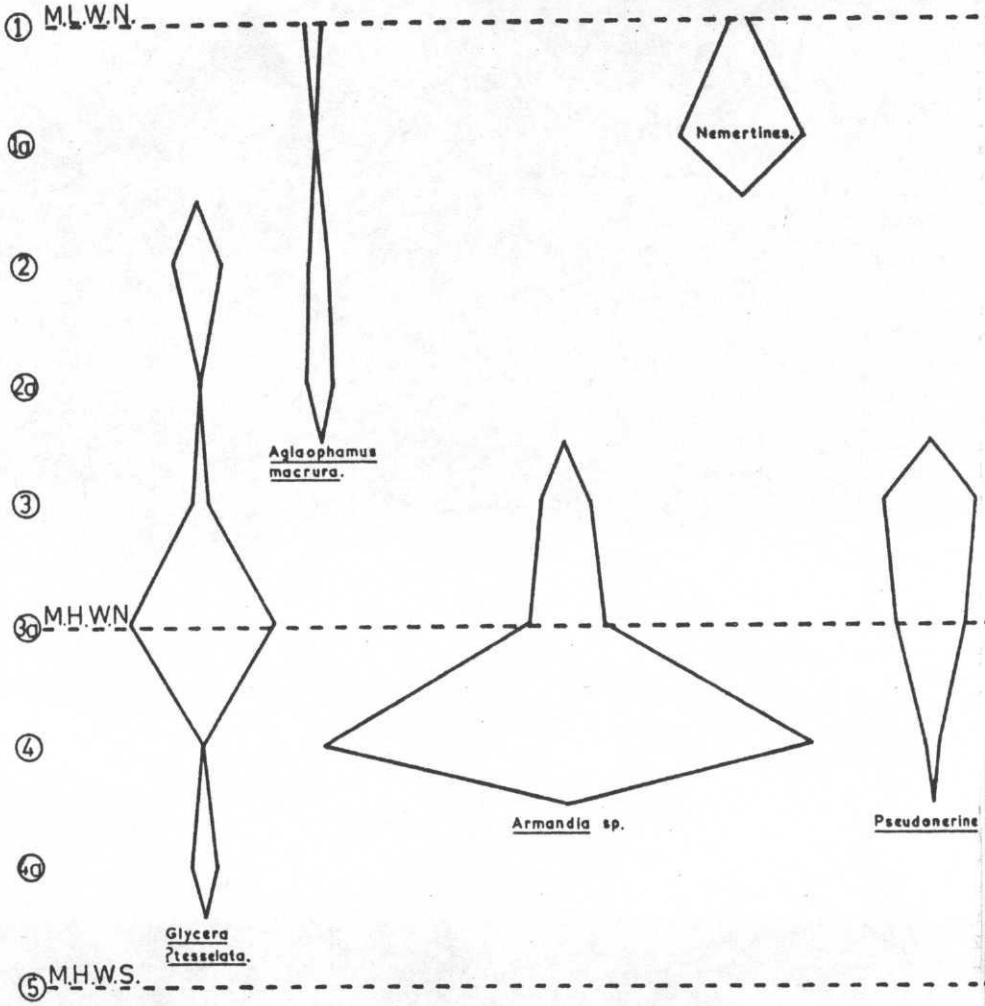

FIG. 1. DISTRIBUTION KITES OF POLYCHAETES AND NEMERTI
ON THE OPEN BEACH.

being found only at station 4 (above M. H. W. N.) where 30 individuals per square meter were recorded. No obvious reason could be found for its restricted occurrence. The other haustoriid amphipod occurred in large numbers only below station 2a. Its range extended down to M. L. W. N., the lowest part of the beach it was possible to sample during the period this work was carried out. This amphipod probably belongs to the "sand licking" assemblage of animals which feed on the micro fauna and flora which flourish in the surface strata of the sand on the lower reaches of beaches where danger of dessication is much less than higher up in the intertidal area.

The swimming crab Ovalipes bipustulatus commonly occurs low down the intertidal zone of open beaches. The two flattened, paddle-like hind legs enable it to swim well and to dig itself into the loose sand where it lies buried while the tide is out.

Callianassa filholi (ghost shrimp), a thalassinid, was present in small numbers around M. L. W. N.. This species was more common in the sheltered estuary where also much larger specimens occurred. C. filholi thrives better and is more commonly found in areas where the sand grade is finer or muddier than is usually found on an open beach.

The zonation pattern of sandy beach crustaceans shown to exist by Dahl, viz.

1. a subterrestrial fringe in which talitrid amphiopods are the commonest inhabitants in temperate climates;
2. a midlittoral zone characterised by the presence of cirolanid isopods, and
3. a sublittoral fringe in which haustoriid or phoxocephalid amphipods occur in temperate dimates, can be clearly seen on Marakopa beach.

There are however, two variations from Dahl's generalised picture. The occurrence of an amphipod, possibly of the family Haustoriidae, with a very restricted distribution in the midlittoral zone, and the absence of phoxocephalid amphipods from the beach. In the south temperate regions, Dahl states, phoxocephalid amphipods usually replace haustoriids in the sublittoral fringe zone of sandy beaches but also makes it clear that his data was collected almost exclusively from Chile. In New Zealand haustoriid amphipods are present in the sublittoral fringe on open beaches while phoxocephalids are present in this zone only on more sheltered, muddier beaches.

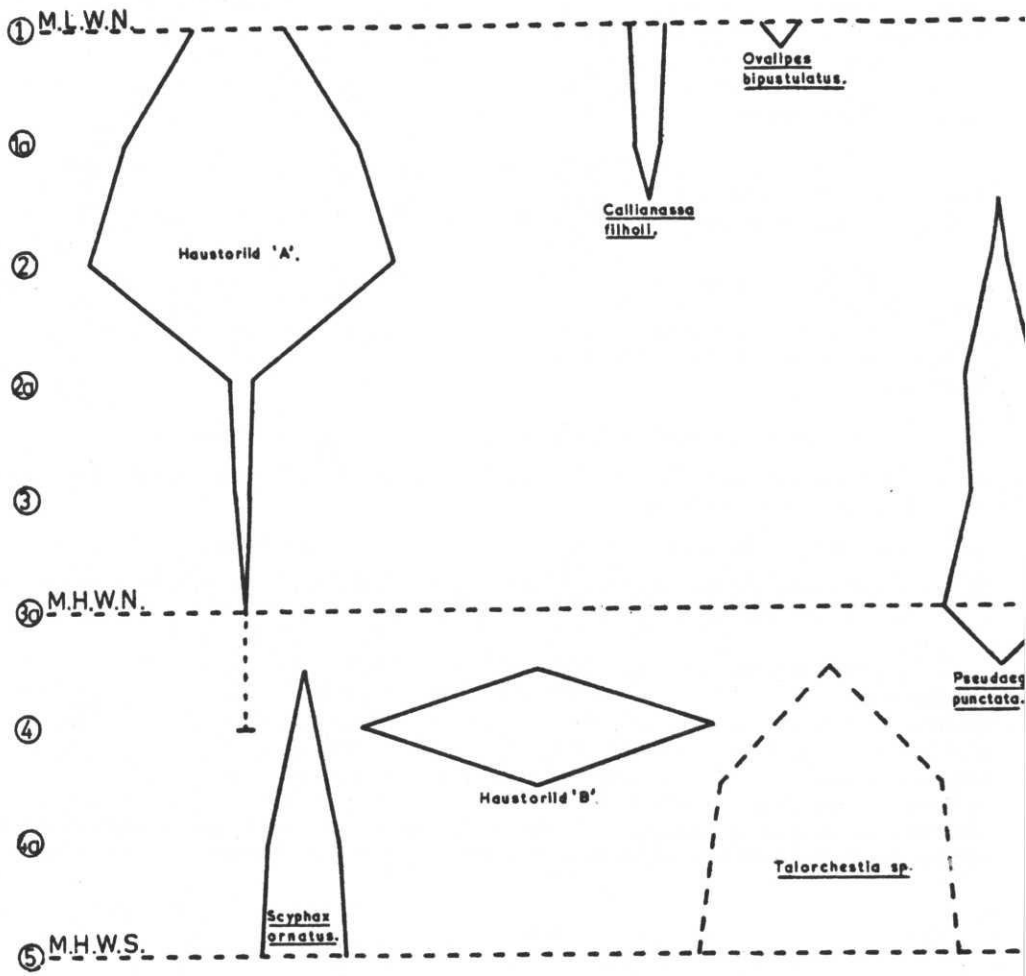

FIG. 2. DISTRIBUTION KITES OF CRUSTACEANS ON THE OPEN BEA

THE RIVER ESTUARY

Location and Description

The Marakopa river runs into the sea a half mile to the north of the exposed beach which was investigated. A large sand dune forms a spit across the original mouth of the river so that it meanders more or less parallel to the coast for the last three-quarters of a mile of its length (see figure 3).

Sampling Methods

Nine stations were examined at varying distances apart up the estuary. At each station several sieve fulls of sand were dug and sifted from 2 or 3 locations between L. W. N. and H. W. S. approximate to the station. The same sieve as was used on the open beach was used in this survey, and the animals collected were placed in bottles and later identified but not counted (see Appendix III). Animals from rocky areas were also collected.

Samples of the top 5 centimeters of sand from about L. W. N. were collected at each station except station 7, and later were analysed for grade and water content (see Appendix IV) by the same method as described for the open beach samples. A representative number was calculated for each sample (see Appendix IV) so that the coarseness of the sand at the different stations could be graphically represented (see figure 3). To obtain this number the weight of sand retained by each sieve was multiplied by the mesh size of the sieve, and the sum of the products divided by 100. The weight of the sand which passed through the finest sieve (0.066 millimeter mesh) was multiplied by the figure 0.033 (half way between 0.066 and zero).

To obtain samples of the interstitial water for salinity determinations a small hole was dug in the sand a little above L. W. N. level and the interstitial water draining into it was collected into air-tight bottles. The salinity of the samples (see Appendix IV) was later determined by the Mohr method (see Barnes 1959).

Macrofauna

Twenty-four species were collected from the estuary :-

1 fish
1 bivalve (pipi)

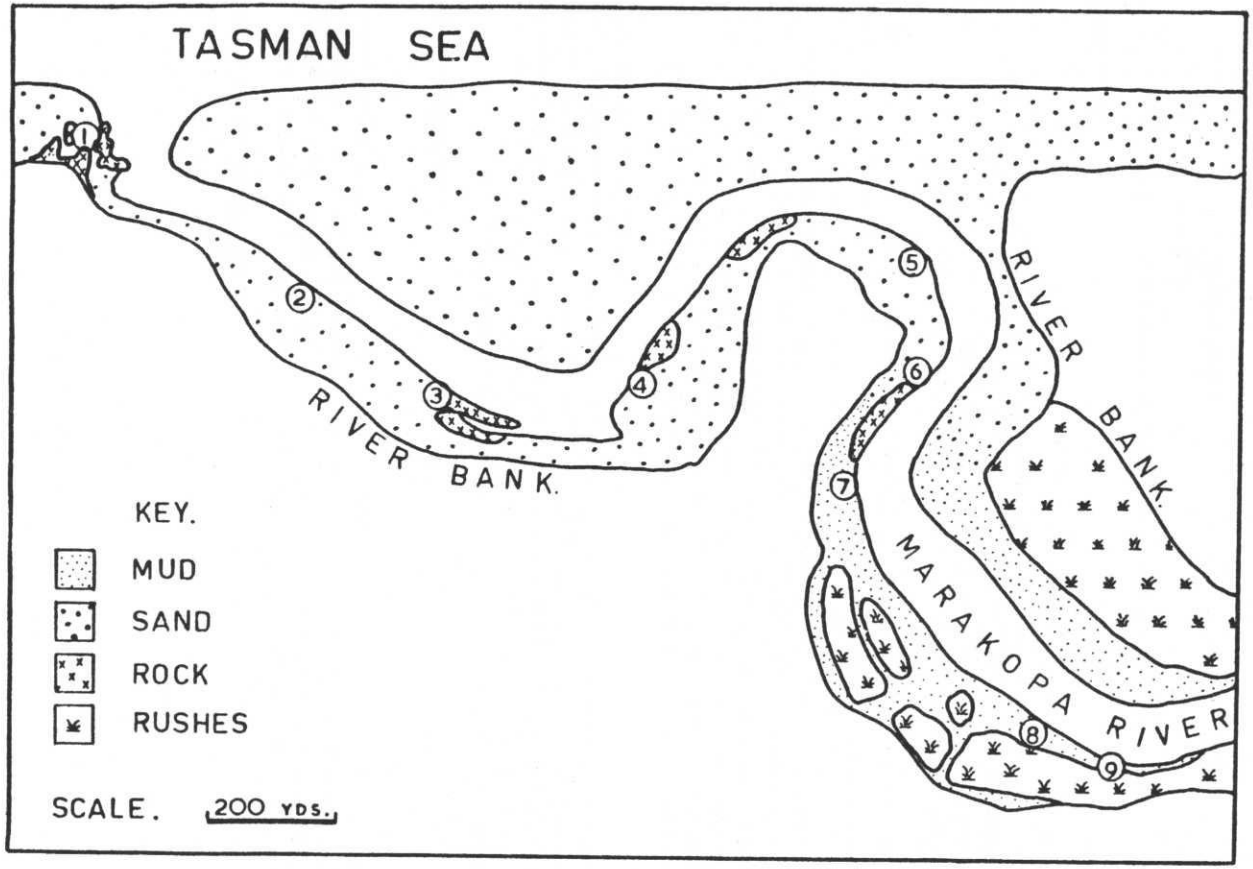

FIG. 3. MARAKOPA ESTUARY AT LOW TIDE SHOWING STUDY STATIONS.

3 polychaetes (bristle worms)
6 gastropods (various snails and periwinkles), and
13 crustaceans (3 crabs, ghost shrimp, barnacle, mysidacean, 3 isopods and 4 amphipods).

The extent of their occurrence up or down the estuary is shown in figure 4 together with graphs of the values of the water content and representative number of the sand and the salinity of the interstitial water at the various stations.

Discussion of the Macrofauna

The fauna at the mouth of the estuary was little different in species content to that of the lower part of the open beach. The first effect of shelter on the fauna however, could be seen in the uncommon occurrence of the haustoriid amphipod "A" (completely absent at station 2) and in the increased size of A. macrura and G. ?tesselata (see open beach section) and the increase in commoness of C. filholi. The absence of P. punctata from the midbeach and Talochestia sp. and S. ornatus from the upper beach level was difficult to explain in view of their occurrence at these levels further up the estuary. At this seaward end of the estuary though there was very little if any debris left at the high tide mark, and this fact could account for the absence of Talorchestia sp. and possibly S. ornatus.

The pipi (Amphidesma australis), often found under slightly brackish conditions, occurred commonly at about the L. W. N. level between stations 2 and 5. Also buried in the sand of this area, when the tide was out, there was found a species of sphaeromid isopod and a mysidacean. In other parts of the world also, a few species belonging to these two groups of animals typically occur in brackish water (Emery et al. 1957). In this stretch of the estuary salinity of the interstitial water and the sand grade varied irregularly (see figure 4). These irregularities presumably resulted from local eddies and currents set up by the incoming and outgoing tide and the flow of the river.

Between stations 2 and 6 there were several areas of boulders and small stones. In these areas there occurred species not typical of sand flats but able to tolerate variable brackish conditions. A calliopiid amphipod was common under the rocks, and the crabs Hemigrapsus crenulatus and H. sexdentatus were also found here. The periwinkles Melarhaphe oliveri and M. cincta occurred on the larger rocks. This occurrence was surprising since the usual habitat of these 2 littorinids is high in the intertidal zone of exposed rocky shores. Also found attached to rocks was the small barnacle Elminius modestus.

From station 6 upstream the percentage of very fine sand, silt and clay in the surface strata of the soil was very much higher than at station 5 and downstream (see Appendix IV). It was at station 6 and above the "mud loving" species commonly occurred though a few specimens of the mud crab (Helice crassa) were present as far downstream as station 4. This crab feeds on small particles of organic matter which it picks out of the mud. When danger threatens it scuttles into tunnels which it con-

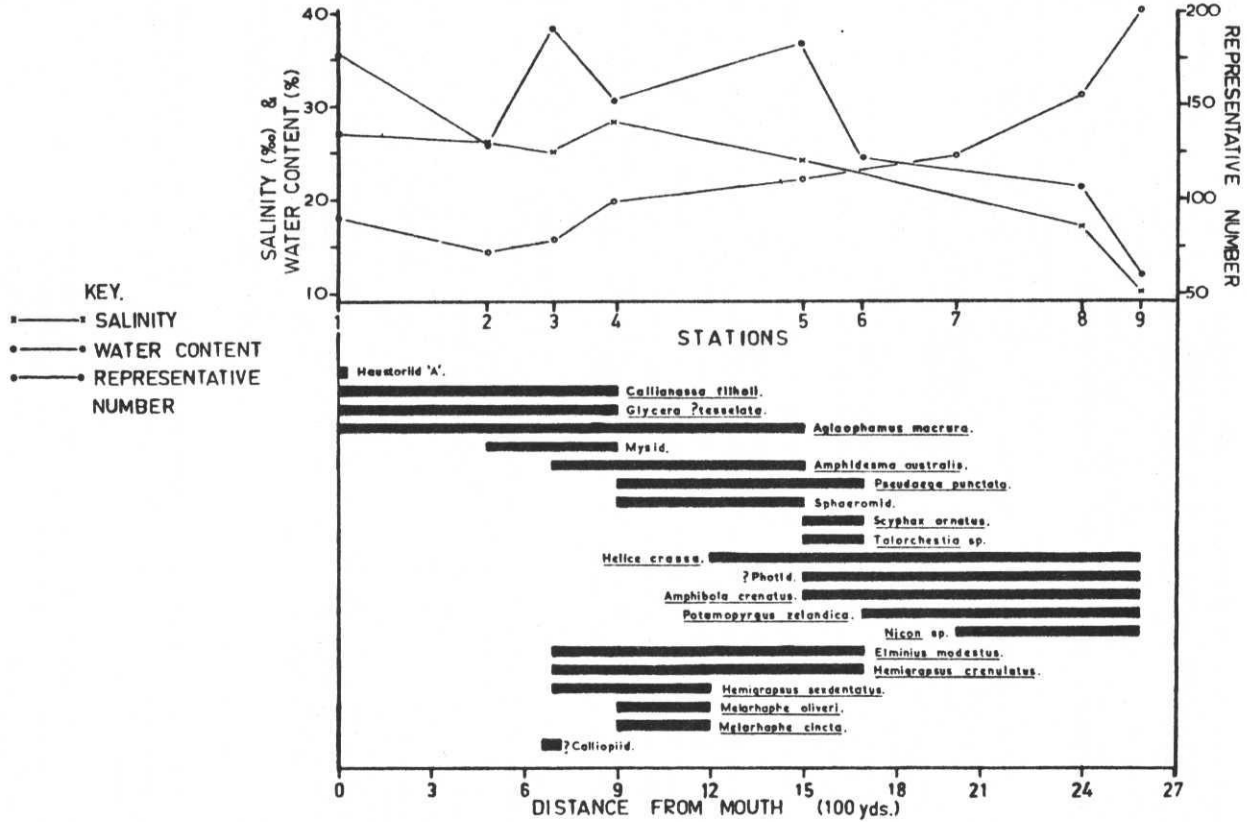

FIG. 4. GRAPHS OF THE WATER CONTENT AND REPRESENTATIVE NUMBER OF THE SAND, SALINITY OF THE INTERSTITIAL WATER, AND DISTRIBUTION OF THE SPECIES IN THE ESTUARY.

structs in the sand or mud. The mud snail (Amphibola crenatus) also occurred in these upper reaches of the estuary. It is a pulmonate and feeds by more or less continuously passing through its gut a stream of mud from which it extracts its food of living and dead organic matter. A species of fresh water snail (Potamopyrgus zelandica) was also very common crawling in the mud which often completely buried it.

The above 3 species occurred about the mid tide level and above while below the mid tide line to low water there occurred an amphipod (? photid) and a polychaete worm (Nicon sp.). The amphipod (? photid) is probably a brackish water species, the ecological equivalent of estuarine gammarid species of other parts of the world, and the nereid genus Nicon appears to occur in mud or sand only under the low salinity conditions of estuaries (Knox 1951).

It was interesting that the macrofauna of the estuary with the exception of P. antipoda (a freshwater snail) was all of marine origin, and that possibly 2 species (Nicon sp. and the amphipod ? photid) were characteristically brackish water animals. A similarly proportioned distribution of species was found in the Firth of Tay by Alexander, Southgate and Bassindale, and in the Bay of Kiel by Remane (Emery et al. 1957) and appears to be typical of estuarine environments.

Thus from the mouth of the estuary up to about station 5 there was present a marine fauna the species of which were able to flourish only under the more sheltered conditions of the estuary as compared with the open beach. To obtain this shelter these species also had to be able to tolerate the variable brackish conditions existing in the estuary. At about station 6 these species ceased to occur either because the salinity of the water was too low or the substratum too muddy or the water too turbid for them to tolerate, and they were replaced by species which required a muddy substratum and possibly in the case of Nicon sp. and the amphipod ? photid also required low salinity conditions.

ACKNOWLEDGEMENT

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REFERENCES

Barnes, H., 1959 — Apparatus and Methods of Oceanography, Part 1 : Chemical. George Allen and Unwin Ltd., London.

Dahl, E., 1952 — Some Aspects of the Ecology and Fauna of Sandy Beaches. Oikos, Vol. 4, No. 1, pp. 1-27.

Emery et al., 1957 — Estuaries and Lagoons, Chap. 23, Treatise on Marine Ecology and Paleoecology, Vol. 1, Ecology. Geol. Soc. America, Memori 67, Vol. 1, pp. 673 - 750.

Knox, G. A., 1951 — The Polychaetous Annelids of Banks Peninsula. Records of the Canterbury Museum. Vol. 5, No. 5, pp. 213 -229.

APPENDIX I

Table showing the number of individuals per square meter taken at the stations on the open beach.

Species	Stations								
	1	1a	2	2a	3	3a	4	4a	5
CRUSTACEA									
Ovalipes bipustulatus	2								
Callianassa filholi	3	2							
Haustoriid amphipod "A"	18	40	53	4	2		1		
Pseudaega punctata			1	6	5	10			
Amphipod "B" (? haustoriid)							30		
Talorchestia sp.							*	*	*
Scyphax ornatus							2	6	7
PELECYPODA									
Amphidesma subtriangulatum			1						
NEMERTEA									
Nemertine sp.	1	10							
POLYCHAETA									
Ageaophamus macrura	1		1	2					
Glycera ?tesselata			4		1	12		2	
Pseudonerine sp.					8	6	1		
Armandia sp.					4	6	40		

* Very numerous and too active to count.

APPENDIX II

Table showing the percentage of the various grades of sand and the percentage water content of the sand at the stations on the open beach.

Particle Size	Stations 1	1a	2	2a	3	3a	4	4a	5
2.057	-	0.05	-	-	-	-	-	-	-
2.057 - 1.003	-	-	0.01	-	-	-	-	-	-
1.003 - 0.500	0.31	0.57	0.27	1.64	0.21	-	0.03	0.01	0.02
0.500 - 0.251	35.68	19.77	10.30	20.70	14.19	2.55	0.59	2.99	3.15
0.251 - 0.124	59.09	72.62	81.23	73.13	80.04	84.64	83.68	84.55	87.04
0.124 - 0.066	4.88	6.96	8.14	4.50	5.53	12.78	15.66	12.42	9.76
0.066	0.02	0.02	0.03	0.01	0.02	0.02	0.02	0.02	0.01
Water Content	17.8	15.0	15.0	13.2	11.9	10.8	9.8	5.9	1.8

APPENDIX III

Table showing species occurring at the stations in the estuary.

Species	Stations 1	2	3	4	5	6	7	8	9
CRUSTACEA									
Haustoriid amphipod "A"	x								
Callianassa filholi	x	x		x					
Mysidacean		x	x	x					
Calliopiid amphipod			x						
Hemigrapsus crenulatus			x	x		x			
Elminius modestus			x	x		x			
Hemigrapsus sexdentatus									
Helice crassa				x			x	x	x
Pseudaega punctata				x	x	x			
Sphaeromid isopod				x	x				
Amphipod (? photid)					x			x	x
Talorchestia sp.					x	x	x		
Scyphax punctata						x	x		
PELECYPODA									
Amphidesma australis			x	x	x				
GASTROPODA									
Cominella glandiformis				x					
Melarhaphe oliveri				x					
M. cincta				x					
Amphibola crenatus						x	x		x
Potamopyrgus zelandica						x	x	x	x
Ophicardelus costellaris							x		
POLYCHAETA									
Aglaophamus macrura	x	x		x	x				
Glycera ? tesselata	x	x	x	x					
Nicon sp.							x	x	x
PISCES									
Forsterygion varium			x						

APPENDIX IV

Table showing the percentage of the various grades of sand, the percentage water content, the representative number of the sand and the salinity of the interstitial water at the stations in the estuary.

Particle Size	Stations 1	2	3	4	5	6	7	8	9
2.057	0.08	-	-	0.09	-	1.93	-	-	-
2.057-1.003	0.10	-	0.02	-	0.19	0.06	-	0.06	0.05
1.003-0.500	1.56	0.07	0.75	0.39	3.76	0.10	-	0.12	0.23
0.500-0.251	38.93	7.24	50.45	21.99	35.19	4.65	-	0.79	0.15
0.251-0.124	52.73	82.69	47.29	72.76	57.74	60.82	-	66.59	17.49
0.124-0.066	6.45	9.95	1.48	4.77	3.03	23.18	-	25.14	27.34
0.066	0.02	0.03	-	0.06	0.06	9.22	-	7.30	54.74
Representative Number	0.177	0.127	0.191	0.152	0.182	0.146	-	0.105	0.059
Water Content	18.26	14.21	15.75	19.77	21.99	24.49	-	30.99	40.83
Salinity	26.89	25.97	25.17	28.68	24.22	-	-	16.78	9.18