The Macrofauna of an Excellently Sorted Isolated Beach at Kaikoura: And Certain Tidal Observations

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By

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Abstract

Jimmy Armer's Beach is isolated from other beaches and its deposits are presumably recruited from the infratidal: though normally well sheltered it may be strongly disturbed on occasion by heavy north-easterly seas. Beach profile, texture and macrofaunal distribution were investigated at three transects in relation to a common bench-mark. Observation of certain spring tides suggests that the special datum proposed in this work corresponds with tidal datum to an inch or two; that the mean Kaikoura tide level corrections were more applicable than the Spring tide corrections during the spring tides concerned, and that tides usually occur 20 minutes later than at Lyttelton. Beach texture is almost uniform, 80% being fine sand. The macrofauna divided sharply into that of the supralittoral fringe and that of the lower intertidal zone with a barren region between. The lower intertidal fauna was dominated by polychaetes and extended upwards to varying degree from the infratidal. Although differing in detail, the supralittoral fringe and lower intertidal faunas are basically similar to those of Gooch's Beach. The more sheltered the beach the more abundant and varied the species present, probably due to lack of beach disturbance, but no obvious climax community can be defined and a patchiness in distribution of species is evident. Distribution of the species of the lower littoral macrofauna appears to be less dependent on details of substratum texture than on opportunity for colonisation and on subsequent substratum stability.

Introduction

Jimmy Armer's Beach, on the northern side of the Kaikoura Peninsula by the Old Wharf, is a small sandy beach favoured for bathing. It lies at the head of an inlet (used as a fishing boat anchorage) among extensive siltstone reefs and is isolated from all other sandy beaches. Armer's Beach is separated from Gooch's Beach by 1$\frac{1}{8}$ miles of rough, mostly limestone coastline impassable to any southerly movement of greywacke beach deposits that may contribute to Gooch's Beach (Morgans, 1967). There is no significant sandy beach east of Armer's Beach on the peninsula. The deposits of Armer's Beach are continuous with those of the bed of the Old Wharf anchorage but the beach is considerably restricted by siltstone outcrops in the lower half of the intertidal zone, and undoubtedly much of the lower beach is a shallow deposit of sand upon siltstone. The supralittoral consists of a narrow and rather flat Marram grass sand-dune community abutting a narrow grassy picnic area with small, planted trees struggling for survival. The Wai-o-puka Stream passes through a culvert beneath the road and empties to the north-western end of the beach. Normally this little stream sinks through the sand of the upper beach and seeps to the surface lower down but after heavy rains is may cut a surface channel. The course of the stream through and across the beach is a little variable but usually the seepage fan is to the north-western side of the beach, impinging on the rocks there.

The siltstone outcrops in Armer's Beach force one to recognise a main, or western beach and a minor, or eastern, beach for purposes of investigating beach fauna, the two regions being connected by a broad band of sand above about M.S.L. and by a narrow band of beach that is exposed below the rocky outcrops at mean low spring tides (Fig. 1). The gradient of the lowest part of the beach is so flat that a broad band of beach may be exposed below the outcrops during extremely low spring tides. The north-western part of the main beach is influenced by the stream and has been ignored. The minor, eastern beach is called "Old Tree Beach" by the author because of the bleached trunk of a great old tree lying there.

Two transects of the western beach and one of Old Tree Beach were made in May, 1955, to determine beach profile, substratum texture and the macrofauna present by the general methods used for Gooch's Beach (Morgans, 1967).

The levels of the three transects (Fig. 1) were related to a common bench-mark, i.e., the top of the circular concrete pipe carrying the Wai-o-puka Stream from beneath the road. All levels in this paper are related to a "special" datum arbitrarily defined as 9.6ft below the Wai-o-puka culvert bench-mark: this special datum appears to be within an inch or so of tidal datum (see section below).

Transect I was established near to the stream but clear of significant influence by it: its bearing was 057° T. Transect II was roughly parallel to I and Station II/14 was 24ft from Station I/14, at virtually the same level. Transect II ran close to siltstone outcrops in the lower littoral where the sand appeared in many places to be only a shallow layer upon rock. Thus the lower half of Transect II could be expected to differ from Transect I at that level. Transect III was oblique to the beach axis because of adjacent rocks and its bearing was 015° T. The stations of this transect were listed alphabetically. Station III/C was 44.0ft from the lowest fence post of a line of sturdy old fence posts running down westward of Old Tree Beach. Station III/M was next to an old tree stump embedded in the Marram grass bank and about a chain east of where a culvert under the road opens on to the beach: the bed of the culvert was merely damp and carried no flowing water, though it would undoubtedly do so after rains.

Beach Profile and Texture

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Figures 2, 3 and 4 show beach profiles; note that Transect III is exaggeratedly flattened due to Old Tree Beach running oblique to the shoreline.

The profiles show an inflexion a little below apparent M.S.L. that separates a flatter lower intertidal from a steeper upper littoral beach. The inflexion is at 3ft in Transect I, 2.4ft in Transect II and 2ft in Transect III relative to special datum. A prominent crest above observed H.W.S.T. (at about the 7.6ft level) must reflect the normal limit of wave upwash and beyond this crest a slight dip characterises the profile of the main part of Armer's Beach. The lower limit of the Marram grass is at the 8.6ft level. The progressive shortening of the supralittoral beach from Transect I to Transect III presumably reflects decrease in high tide wave force, a presumption explicable in view of the reef formation.

That Transect II is steeper than Transect I might be regarded as conflicting with the assumption that wave action is rather heavier on Transect I. It is certain, however, that run-off from waves breaking over the reef outcrops in Armer's Beach would scour Transect II more than Transect I and thus produce the steeper profile.

Substratum samples were taken from alternate stations of both Transects I and III and analysis shows (Table I) the texture to be almost identical everywhere from E.L.W.S. to the foot of the Marram grass dunes. Thus the whole of the surface of Armer's Beach may be assumed to be remarkably uniform in texture. The substratum is excellently sorted, with over 80% in the fine sand grade and a maximum range of only 11 microns in median diameter. The Phi quartile skewness is zero in every sample. Very fine sand, whilst negligible, is chiefly at Stations I/5 and the lowest four samples of Transect III, i.e. at and below M.S.L. Medium sand, also negligible, is present at Stations I/1, I/3 and III/A, C, E, and K.

Coarser grades are even less prevalent than the very fine and medium sand grades and, where present, consist of broken shell (e.g., *Protothaca, Zeacumantus*). Such a shell content, less than 10%, was only characteristic of Transect III, presumably reflecting proximity to the rocks so well inhabited by *Zeacumantus*. This minor feature is the only characteristic of substratum texture that may be said to distinguish one part of Armer's Beach from another: Table I shows that it influences the median diameters of Transect III samples.

When considering the severe restriction in the range of particle size at Armer's Beach in conjunction with its isolation from suitable beach-forming materials and from other beaches one can only conclude that beach deposits here are almost entirely recruited from the sublittoral of the Old Wharf anchorage at times of heavy seas. As a test of this conclusion a substratum sample was taken from the bed of the Old Wharf anchorage on 10 May 1966: approximately two quarts were scooped into a plastic bag by diving at a position a few yards from the south-east corner of the wharf, at a depth of some 7ft below low tide level. Analysis of this sample showed it to be even better sorted than the best intertidal beach sample of Armer's Beach, 98.3% being fine sand (median diameter of sample was 170 microns). It can therefore be accepted that the sand of Armer's Beach is mostly derived from the infratidal with slight augmentation by broken shell near to the reef. Thus, the uniformity of texture reflects limited recruitment and gives no indication of the degree of wave action at different parts of the beach. It is obvious that the increased shelter afforded by emergent reefs at low tide cause the lower littoral levels to be more sheltered than the higher. Around mid-tide one could expect Transect I to be more subject to wave action than Transect III whilst Transect II is anomalous due to stronger scour. The situation at high tides appears to be a gradation from maximal exposure to wave action at Transect I to minimal exposure at Transect III.

Generally speaking Armer's Beach is sheltered but the heavy north-easterly seas that can occur off Kaikoura sometimes disturb it considerably. The author can recall a whale skull that was almost completely buried in the main part of the beach in 1962 being covered in 1963. Presumably it was subsequently exposed because it now decorates the entrance to the nearby farm. Further, there was very considerable erosion between September, 1965, and January, 1966, that caused great areas of siltstone reef to be laid bare, especially in the region of Transect II, and a mid-littoral belt of surface cobbles and pebbles to appear upon what was left of the sandy main part of Armer's Beach.

Tidal Observations

These are of interest not only in direct relation to this work but in regard to the published tidal corrections based on predicted Lyttelton tides.

Conditions for observation were good: wind and sea were negligible but a slight swell caused surges in level. Surge was estimated as +3.1 inches and —1.4 inches relative to true water level as observed at Transect III. Tidal levels were taken as the most characteristic extreme levels during some 30 minutes' observation of each turn of the tide.

Applying the 30 minutes correction to Lyttelton tides to obtain predicted Kaikoura times it was found that observed tides were either when predicted or, more usually, 5–10 minutes earlier. (Further experience at Kaikoura suggests that tidal times are from 12 to 30 minutes later than Lyttelton, typically 20 minutes later.)

Tidal levels were observed on the transects at the dates shown. The correspondence between the three observed tidal ranges (Table II) suggests that observation was quite accurate.

Observed ranges were 0.5 to 0.9ft greater than predicted and this discrepancy appears to be equally due to rise above predicted high tide and drop below predicted low tide. This suggests that the special datum adopted is effectively level with tidal datum.

The excessive observed ranges suggest that mean high and low tide Kaikoura corrections (e.g., as in the Tide Tables for 1964) would have given truer predicted levels on these dates than the spring tide corrections indicated by the Tide Tables for 1965. Lack of any other pattern in the discrepancies suggests purely local tidal anomalies that could not be met by constant corrections.

Faunal Distribution

Macrofaunal distribution is represented quantitatively in Figures 2, 3 and 4. It is clear that, as at Gooch's Beach, the beach fauna divides into that of the lower intertidal zone and that of the supralittoral fringe with a barren region between.

A.—*Macrofauna of the lower intertidal zone (Table III).*

(i) The main or western part of Armer's Beach (clear of the stream) has a fauna that is rather sparse both in variety and abundance of any species. It is therefore to be expected that several species show apparently disrupted, or patchy, vertical distribution and comparison of Figures 2 and 3 suggests that the two transects do not differ significantly in their faunas. It is reasonable to augment our knowledge by considering similar diggings made on 27 August 1965 around L.W.S.T., predicted then as being at +0.1ft (relative to tidal datum), which is considerably further down the beach than Station I/1. The August diggings found the following: *Axiothella* (very common), *Lumbrineris* (common), *Callianassa* (fairly common), *Orbinia* (few), one blind amphipod (K.642 M) (Morgans, 1965) and other amphipods (K.642 L and K.643 C–F) (few), *Perinereis nuntia* var. *brevicirrus* (present), *Abarenicola* (present), *Aglaophamus* sp. (present) and an ostracod (K.643 B). These records are not only valuable in filling out knowledge of vertical distributions but they show that this beach may have quite a rich if rather undiverse fauna a few inches above datum level.

The macrofauna is apparently an upward and, in general, diminishing extension of certain infratidal species, mostly polychaetes. *Arabella, Axiothella, Orbinia* and *Scolecolepides* have upper limits at 1 to 2ft above special datum: *Lumbrineris, Perinereis, Scoloplos* (only in Transect I), and *Callianassa* rise to about a foot higher than the previous group while *Abarenicola* and *Nerine* (together with a single specimen of *Nicon*) rise to 4 or 5ft above datum. It seems that species generally rise a foot higher on Transect I than on Transect II. *Aglaophamus,* the ostracod and the amphipods *Heterophoxus* and a blind species (K.516 G and K.642 M) seem limited to low spring tide levels whilst the isopods *Isocladus armatus* and *Exosphaeroma ? lanceolatum* may be occasionally found at any level occupied by this fauna. *Scoloplos* (*Leodamas*) sp. is the only species that is significant in Transect I but absent from II; while *Nerine antipoda* is notable for its relative abundance at the highest levels of this fauna. No *P. nuntia* var. *vallata* was taken on the main part of Armer's Beach.

It is worth remarking that a students' survey of this part of Armer's Beach on 7 May 1962 found only the following: *Scolecolepides benhami, Perinereis nuntia, Orbinia papillosa* and *Lumbrineris brevicirra.* The first three of these rose to about 4ft above tidal datum (assuming low tide to be as predicted) which is significantly higher than their upper limits shown in Figures 2 and 3. The absence of such conspicuous species as *Abarenicola, Nerine, Axiothella* and *Callianassa* is also significant.

(ii) Although time was only available to examine the fauna of the lower half of the intertidal zone of Old Tree Beach it is thought that the most useful differences from the main part of Armer's Beach have been determined. Station III/A was dug below low tide level of that occasion and diggings were made around this level during the lower spring tides of 27 and 28 August 1965. The August diggings found the following: *Axiothella* (common), *Callianassa* (common), *Orbinia* (fairly common), *Syllis brachyola* (fairly common), blind amphipod (cf. K.642 M) (fairly common), elongate white isopods (K.654 B) (fairly common), *Lumbrineris* (present), *Ovalipes* (present) and six species of amphipods (K.654 F–J, N, U). Records on other occasions note *Abarenicola* as common and *Callianassa* as fairly common "around L.W.N.T. level".

With the possible but unlikely exception of *Arabella* sp., taken only at Stations III/E and F, the fauna here is also apparently an upward and diminishing extension of certain infratidal species, mostly polychaetes. A small group of species including the blind amphipods, the ostracod *Cylindroleberis* sp. and stomatopod *Lysiosquilla spinosa* may be limited to lowest spring tide levels but most species extend up to about the 1ft level. *Polydora, Lumbrineris* and *Callianassa* rise about 6 inches higher; *Axiothella* and *Nerine* rise a few inches higher still. At about 2.6ft above datum (III/G) only three worms are found, viz., *Abarenicola, Orbinia* and *Perinereis nuntia.* The last occurs most often as the variety *brevicirrus* but var. *vallata* and forms intermediate between these two varieties may be found over the range of Old Tree Beach examined. (Comment was made on these varieties in Morgans, 1967).

The lower intertidal of Old Tree Beach is richer in variety than the main part of Armer's Beach and some of the species occur in considerable numbers, especially *Axiothella, Scolecolepides* and *Polydora. Callianassa, Abarenicola* and *Perinereis* are commoner than at similar levels on the main beach: on the other hand *Nerine* and *Orbinia,* of modest importance on the main beach, are more poorly represented on Old Tree Beach.

(iii) While considering this fauna it is relevant to record that the substratum sample taken from the bed of the Old Wharf anchorage at about 7ft below low tide level (see "Beach Profile and Texure") contained the following animals: *Scolecolepides benhami* (75), *Axiothella* (2), *?Haploscoloplos cylindrifer* (K.901 E) (2), a sipunculid (K.901 J), a pagurid (K.901 A), amphipod (K.901 B) (32), and amphipod (K.901 L) (17).

B.—*Macrofauna of the supralittoral fringe (Table IV)*

The supralittoral beach at Transect I bore scanty pieces of dry flotsam: sparse grass and *Cotula* plants were present between Stations I/14 and I/15 and Marram grass commenced sharply immediately above Station I/17. The amphipod *Talorchestia* was found from 7ft to 8.4ft: at the supralittoral dip (7.4ft) pupae (Coelopid?) were fairly common and slightly up the beach (reaching 8.0ft) small numbers of various other insects were found (Fig. 2) and an oligochaete worm.

The supralittoral beach of Transect II supported fair quantities of old flotsam and, perhaps in response to this, *Talorchestia* extended lower than in Transect I, from 5.8ft to 8.2ft; some 300 were taken in the 19in diameter quantitative sample between Stations II/14 and II/15. Insects and oligochaete worms again characterised the levels around 7.6ft to 8.0ft (Fig. 3) but there was some difference in the species found as compared with Transect I.

Discussion

At any level the macrofauna of different parts of Armer's Beach differs only in degree and clearly this is unlikely to be due to differences in substratum texture since this has been found to be virtually uniform. The lower intertidal fauna of Old Tree Beach is generally much richer than that of the main part of Armer's Beach and since this cannot reflect the very slightly different beach texture it must be considered as being directly due to the more sheltered conditions, i.e., the richer fauna is an older established community than found elsewhere because it has not been badly disturbed by heavy seas.

One suggestion concerning the Gooch's Beach transects was that they exhibit progression from a pioneer towards a climax community and a similar concept has now arisen for the Armer's Beach transects. Comparison of the (presumed) most stable and climactic transects (Morgans, 1967, Fig. 5A; and Fig. 4 here) shows *Abarenicola* to dominate the beach around M.S.L., with *Perinereis* also there: but there is no further agreement except, perhaps, for the importance of *Scolecolepides.* On the contrary, *Axiothella* and *Polydora,* so important at Old Tree Beach, are absent from Transect A of Gooch's Beach while that transect has *Scoloplos* and *Haploscoloplos* in abundance not shown at Old Tree Beach. So no obvious climax community for a Kaikoura fine sand beach can yet be defined beyond stating that it is a polychaete community with minor crustacean elements, lacking burrowing crabs, and devoid of bivalves. However, both Armer's and Gooch's Beach demonstrate a definite increase in abundance of species at sheltered localities: this is considered to be due chiefly to the lesser disturbance of the substratum rather than to subtleties of texture because the various species of the lower intertidal fauna have been shown both to tolerate a fair range of texture in these two beaches at Kaikoura and to vary in distribution over a beach of uniform texture.

Armer's Beach differs significantly from Gooch's Beach in its isolation and in the uniformity of its substratum texture. Only the lowest stations of the three Gooch's Beach transects have a predominance of fine sand comparable with that found over all of Armer's Beach. Only the most sheltered of the Gooch's Beach transects has a profile of similar gradient to that shown in Figure 2, the former rising from the 3.5ft (M.S.L.) to the 7.0ft level in 69ft horizontally and the latter in 64ft: each of these transects has an inflexion at about the 3ft level. Although these two transects have different aspects they are both normally sheltered but occasionally subject to severe wave action.

At both Armer's and Gooch's Beaches there is clear distinction between a supralittoral fringe fauna and a lower intertidal zone fauna with a barren stretch between. These two faunas are obviously of the same nature at the two beaches but differing in the abundance of this species or that; and the upper level reached by any species of the lower intertidal fauna seems more to reflect patchy distribution than preference for particular horizontal zones of the beach. It has been stated that the lower intertidal fauna is an upward extension of the immediately infratidal fauna but the bottom of the most sheltered transect of Gooch's Beach ends amongst rocks, demonstrating that strict physical continuity is unnecessary.

At Gooch's Beach the upper limit of the lower intertidal fauna was shown to rise as shelter increased but this has not been proved for Armer's Beach. It may be that beyond a certain degree of shelter the species with which we are concerned will rise no higher. It was noted at Gooch's Beach that there was a drop in lower limit of the supralittoral fringe fauna as shelter was gained but this phenomenon is not evident at Armer's Beach; this suggests similar remarks concerning a "threshold" minimal degree of exposure to wave action.

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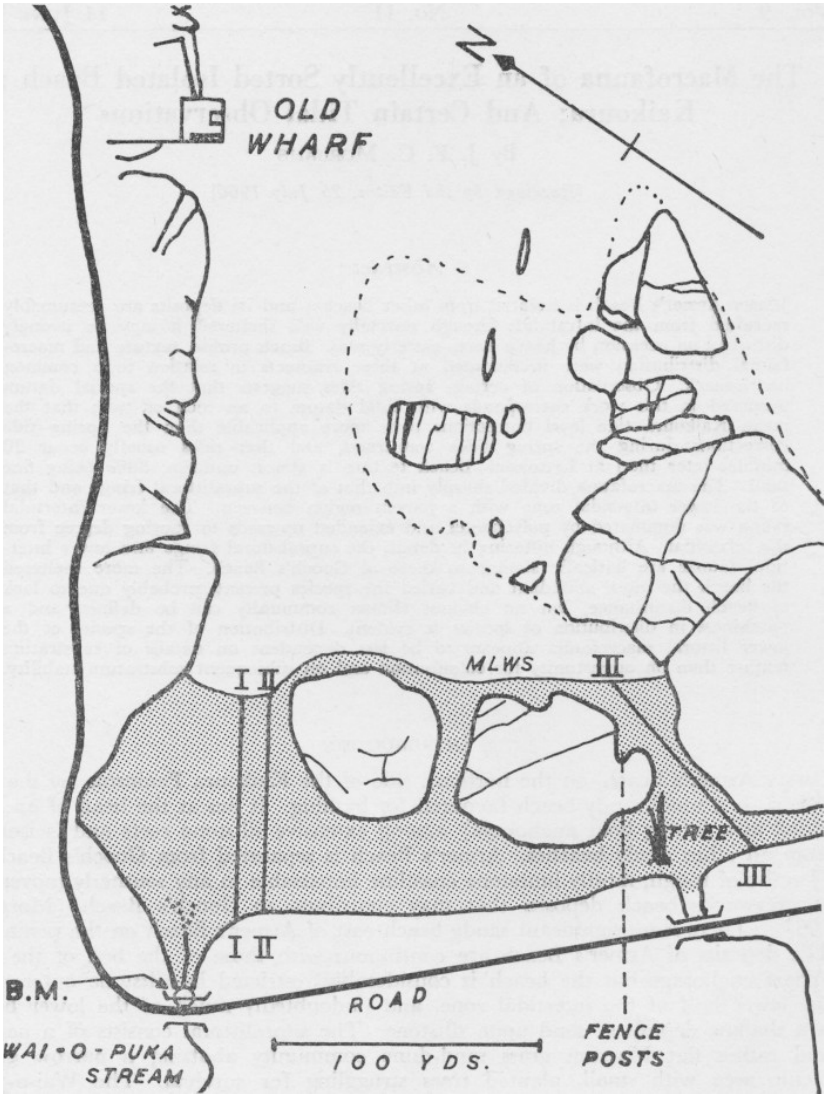

Fig. 1.—Jimmy Armer's Beach (sand is stippled) showing the positions of the transects, the special bench-mark ("B.M.") and general landmarks. (Sketch based on aerial photograph 563/14 of 10 December 1942 supplied by Lands and Survey Department, Wellington.)

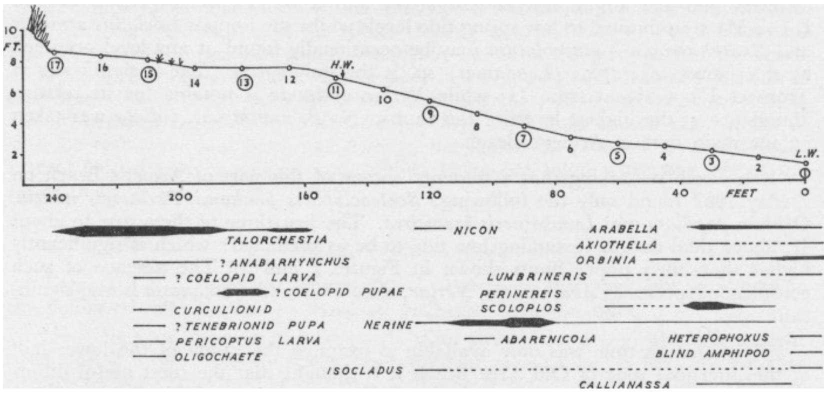

Fig. 2.—Profile of Transect I on 12.5.65 in relation to special datum (see text) and distance from observed low water; with distribution of macrofauna. Stations are numbered and those encircled were sampled for substratum texture. "H.W." and "L.W." show positions of observed High and Low Water. Flotsam was scanty and desiccated and its lower limit was at Station 12. Sparse *Cotula* and grass were present between Stations 14 and 15.

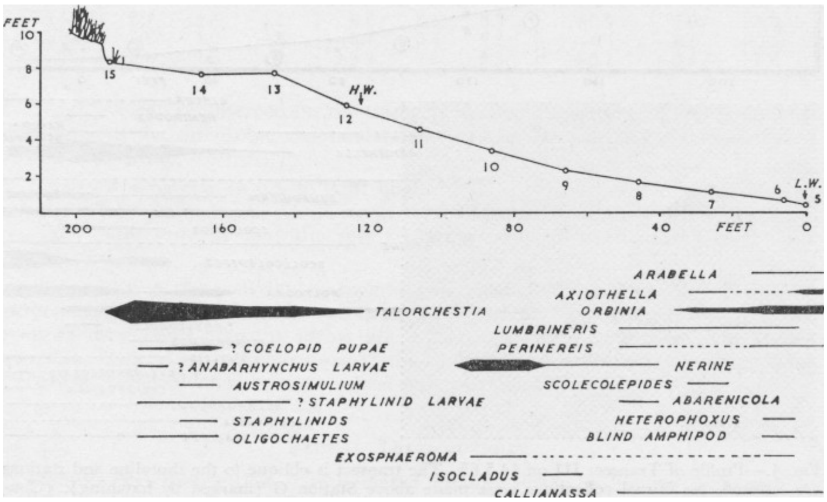

FIG. 3.—Profile of Transect II on 13.5.65 (conventions as Figure 2).

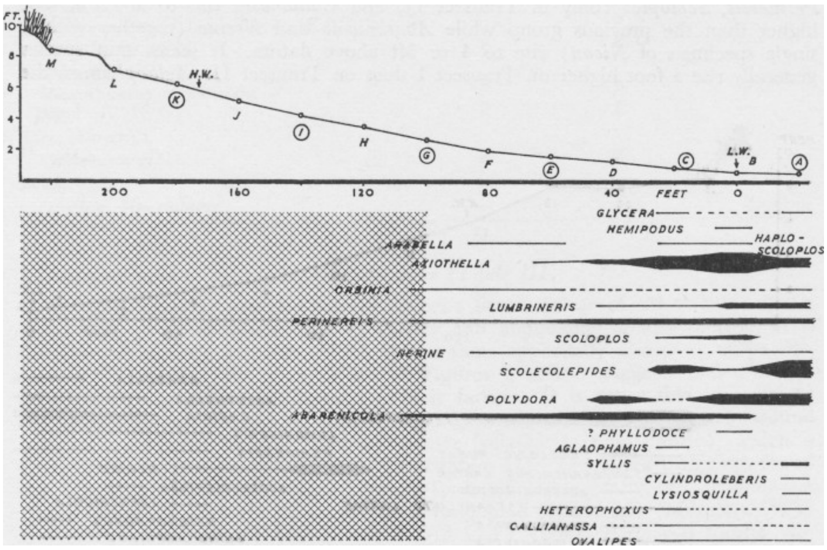

FIG. 4.—Profile of Transect III on 14.5.65. The transect is oblique to the shoreline and stations are lettered. No faunal collections were made above Station G (marked by hatching). (Conventions as Figure 2.) The dotted extensions of distribution of *Callianassa* are from records of other dates.

TRANSECT I

Station	17	15	13	11	9	7	5	3	1
Median Diameter (microns)	170	170	170	170	170	171	170	175	175
Phi Quartile Deviation	0.285	0.275	0.285	0.27	0.255	0.26	0.26	0.255	0.26

TRANSECT III

Station	K	I	G	E	C	A
Median Diameter (microns)	181	179	174	171	175	179
Phi Quartile Deviation	0.285	0.285	0.315	0.325	0.355	0.32

TABLE I.—Median diameter and Phi quartile deviation of the substratum at alternate stations of Transects I and III.

	Predicted			Observed			Discrepancy from Prediction		
Date	H.W.	L.W.	Range	H.W.	L.W.	Range	H.W.	L.W.	Range
12.5.65	5.7	1.1	4.6	6.6	1.1	5.5	+0.9	0.0	+0.9
13.5.65	5.8	1.0	4.8	5.7	0.4	5.3	—0.1	—0.6	+0.5
14.5.65	5.8	1.1	4.7	5.9	0.6	5.3	+0.1	—0.5	+0.6

TABLE II.—Tidal levels and ranges in feet as predicted (relative to tidal datum) and as observed (relative to special datum) with calculated discrepancy of observation from prediction. For predicted levels the full spring tide Kaikoura corrections have been applied as in the 1965 N.Z. Tide Tables.

	Trans. I	Trans. II	Trans. III
NEMATODA (K.569 K)	—	—	P
POLYCHAETA			
Abarenicola affinis	P	P	C
Aglaophamus sp. (K.550 D)	—	—	P
Arabella sp. (K.467 C)	F	F	P
Axiothella sp. (K.008 C)	F	F	C
Glycera americana	—	—	F
Haploscoloplos cylindrifer	—	—	F
Hemipodus simplex	—	—	P
Lumbrineris brevicirra	F	F	FC
Nerine antipoda	FC	FC	FC
Nicon sp. (K.523 A)	P	—	—
Orbinia papillosa	FC	FC	F
Perinereis nuntia var. *brevicirrus*	F	F	FC
„ „ var. *vallata*	—	P	F
„ „ (intermediate)	P	—	F
?*Phyllodoce* sp. (K.557 D)	—	—	P
Polydora sp. (K.569 G)	—	—	C
Scolecolepides benhami	—	P	C
Scoloplos (*Leodamas*) sp. (K.455 F)	FC	—	F
Syllis brachyola (K.550 C)	—	—	F
OSTRACODA			
Cylindroleberis sp. (K.569 A)	—	—	P
STOMATOPODA			
Lysiosquilla spinosa	—	—	P
ISOPODA			
Exosphaeroma ? lanceolatum (K.540 B)	—	F	—
Isocladus armatus	F	F	—
AMPHIPODA			
Heterophoxus stephenseni	P	P	F
Blind (K.516 G)	P	P	—
THALASSINIDEA			
Callianassa filholi	F	F	F
BRACHYURA			
Ovalipes bipustulatus	—	—	F

TABLE III.—Macrofauna of the lower intertidal zone taken by quantitative and random diggings, and from substratum samples on 12, 13 and 14 May 1965. Abundance summarised thus: P = Present, F = Few, FC = Fairly Common, C = Common.

	Trans. I	Trans. II
OLIGOCHAETA (K.529 E)	P	F
AMPHIPODA		
Talorchestia quoyana	C	C
INSECTA: DIPTERA		
?*Anabarhynchus* sp. (larva) (K.528 B)	P	P
Austrosimulium australiense	—	P
?Coelopid larvae (K.529 C)	P	—
?Coelopid pupae (K.527 B, C)	F	F
BEETLES		
Curculionid (K.529 G)	P	—
Pericoptus truncatus (larva)	P	—
Staphylinids (K.543 A)	—	F
?Staphylinids (larvae) (K.542 B)	—	F
?Tenebrionid (pupa) (K.529 D)	P	—

TABLE IV.—Macrofauna of the supralittoral fringe.