Evaluation of Southern Hawkes Bay Coast Intertidal Data 11. The Use of Presence/Absence Data.

Coastal Marine Research Unit Report

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by

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SUMMARY

1) The use of presence/absence data is a valid method for comparing communities from hard shore marine environments where the biota is relatively sessile. It is an extensively used method in botanical surveys and its use should be extended into the marine environment.

2) Blackhead had the highest species richness and the widest range of species diversity, suggesting a diversity of habitats. Kairakau also appears to be of relatively high value (in terms of richness and diversity). On the other hand. the diversity values suggest that Paoanui is of relatively low ecological value. It should be clearly noted, however, that the differences between transects and sites are minor and that preferred site selection should probably not rest on the criteria of species richness, species diversity, or species evenness.

3) Almost all correlations between transects were highly significant. Also, the correlation coefficients between transects within sites tended to be greater than those between transects between sites. Thus, transects within sites tended to be more similar to each other than they were to transects from other sites. Overall, the frequency of occurrence data led to consistent answers and an ability to recognise within group similarities. A high degree of similarity between sites was found.

4) No useful conclusion could be drawn from attempting to group individual quadrats. A useful alternative would be to attempt to discover associations between the species present.

5) When all sites were considered (considering only Blackhead and Aramoana would not have provided enough contrast in the available data) only two of the 'New Habitat' types of Creswell & Warren (1991) exhibited any degree of agreement based on their associated biota. However, the mixing of New Habitats that was observed assisted in making re-assignments of these New Habitat types to a revised set of CMRU habitats. Once this was done then it was possible to see a degree of CMRU habitat fidelity in relation to their associated biota. Of all the habitats suggested it was concluded that four appeared to have a relatively distinct biota. These were the Upper Intertidal. the Intertidal Reef Platforms, the Reef Edge, and the Rocky Intertidal plus Pools.

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1. INTRODUCTION

1.1. Background to Original Survey

In 1990, The Department of Conservation's Napier Conservancy commissioned two contract workers to carry out a survey of southern Hawkes Bay intertidal platforms as part of an investigation of areas considered for marine reserve status. These workers surveyed 35 transects spread among seven different intertidal reef systems between Kairakau and Whangaehu during March-June 1990 (Fig. 1). Counts of individuals, or percentage cover, of all species were recorded within paired 0.1 m^2 quadrats located at set intervals along the transects. The data obtained from the 1816 quadrats were recorded by hand and these field notes were used to prepare a final report (Creswell and Warren. 1990).

Creswell and Warren (1990) presented subjective estimates of the relative abundance of intertidal biota observed at each of the seven locations. plus an description of the distribution patterns of species found at all locations. At the time, the extensive quantitative data collected were not entered into a database, and comparative quantitative or statistical analyses were not made at the time. These data were re-examined by DOC Napier staff in 1993 and it was decided that they should be entered into a suitable spreadsheet/database which would allow comparative statistical analyses.

1.2. Preliminary Re-Assessment

The Coastal Marine Research Unit was contracted by DOC Napier to undertake the preparation of an accessible database, to make an evaluation of the ecological value of the data and, if time allowed, first order analyses of these data. The preliminary analyses carried out in that work (Haddon & Anderlini, 1993) indicated that the design of the initial survey was less than optimal. The original survey data was quantitative but was made up of actual counts, estimates of percent cover, or even, for a few species, a mixture of the two. In order to use this information for comparing the communities present at different locations, a method of utilizing these disparate data types together was required. The only method suitable was to record the presence or absence of each species in each quadrat and use those observations for any of the comparisons desired. To produce the information necessary for such comparisons the frequency of occurrence of each species would need to be determined (the number of quadrats in which a particular species occurs) either at each location, or in each transect. or in each habitat type.

Haddon and Anderlini (1993) carried out comparisons of the frequency of occurrence of all the species present at the seven different locations. This suggested that, generally, areas which were geographically close were most similar biologically. Whangaehu proved to be an exception to this rule in that it appeared to be most closely related to the most distant localities. As a result the biological similarity was considered to be most likely related to the general substrate type and not similarity geographic proximity (though geographically close regions can often have similar substrata).

These preliminary analyses were only tentative and it was suggested that some further consideration of the data were required to confirm their validity and perhaps the extent of the conclusions. To that end DOC Napier have contracted the Coastal Marine Research Unit to expand and elaborate the analyses carried out upon the databases created from the original survey data. Of the further analvses recommended in the first CMRU report (Haddon and Anderlini, 1993) it was decided to carry out the two which would provide information about the validity of using the data in the form of presence/absence and to determine whether the quadrat data from Aramoana and Blackhead reflected any of the habitat types proposed by Creswell and Warren and by Haddon and Anderlini. This report presents the results of those analyses plus conclusions relating to the biotic communities present at each of the seven sites originally surveyed.

1.3. Scope of Work

Using the Southern Hawkes Bay Coast data, entered into databases earlier, the CMRU was contracted to carry out the following analyses

1. Between transect comparisons, testing the assumption that transects are representative of each location.

2. Inter-quadrat comparisons within locations, solely for the Aramoana and Blackhead locations - to determine natural groupings of species within these locations.

The first of these analyses provides a test of whether the transects from a particular site are more similar to each other than they are to transects from other locations. This tests how homogeneous the data are from each site.

The second analysis is more complex and was approached in two ways. The first was to attempt to cluster the data from individual quadrats to see whether the most similar quadrats (collected into discrete groups) reflected available information about the physical environment of the intertidal platforms. The second approach was to characterize the presence and absence of different species in the quadrats from the different habitat types and determine whether they were significantly different from each other.

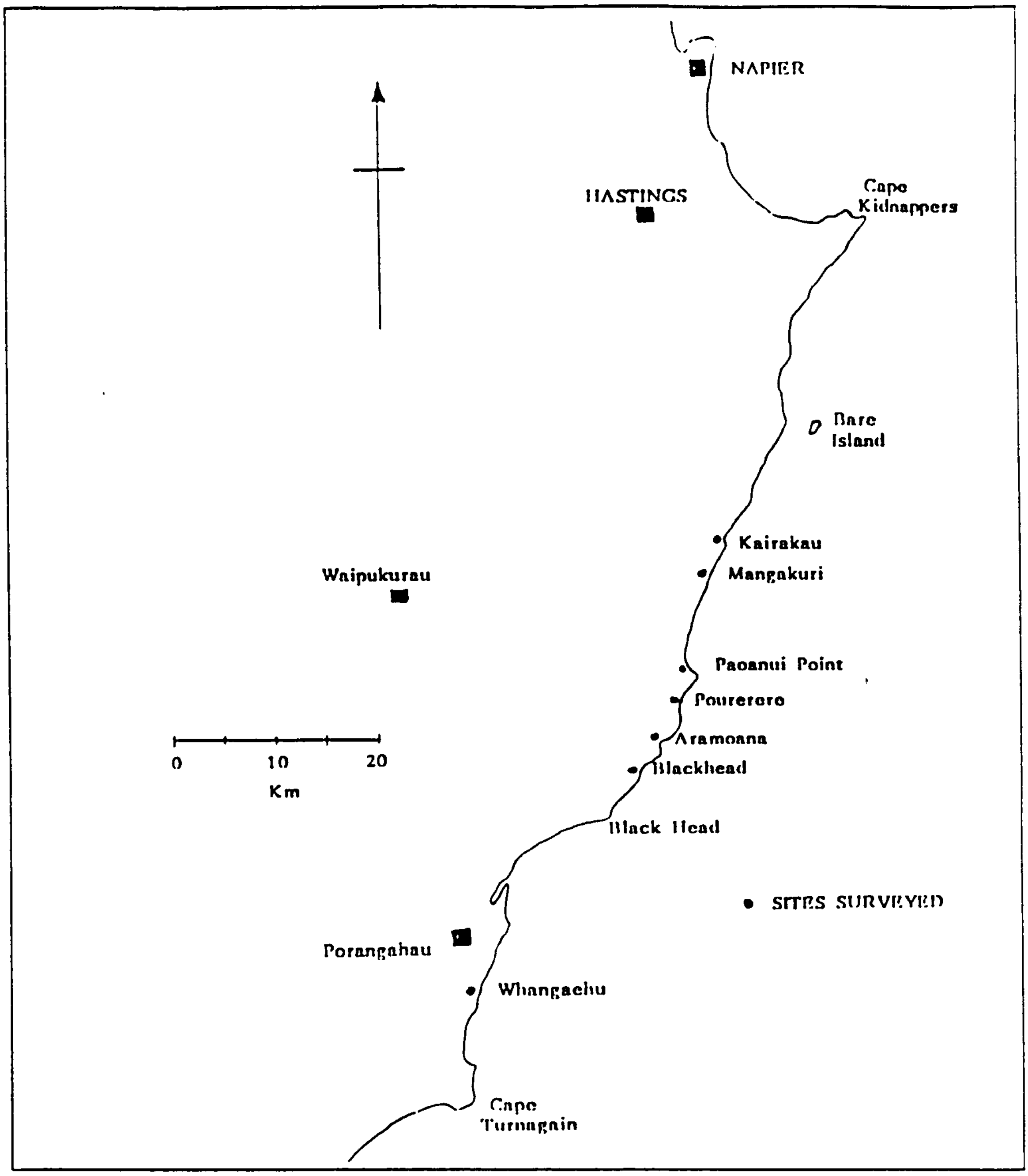


Figure 1. Southern Hawkes Bay survey sites (after Creswell & Warren 1990).

2. METHODS

2.1. Data Selection.

In the original data, fish were not included in the databases so the analyses do not reflect any fish fauna of the areas. Ten other species (Table 1) were excluded from the following analyses because they only occurred in one quadrat throughout the study (that is they occurred in one quadrat in one transect) and thus only contribute statistical noise. As well as these species it was decided to remove the category 'Isopods' as this only occurred in two quadrats throughout the study and could have included more than one species (Table 1).

Table 1. Species omitted from the analyses due to their being present in only one quadrat, or being possibly of mixed species and only present in two quadrats.

Species	Quadrats
Acanthochiton zelandicus	1
Buccinulum multilineum	1
Carodiloma coracina	1
Diloma spp.	1
Grey Lichen	1
Mytilus edulis aoteanus	1
Orange Anemone	1
Phlyctenactis tuberculosa	1
Topshells	1
Tunicates	1
Isopods	2

Comments on the impact of these omissions are included with the analyses. A total of 94 different species are listed in the databases relating to the Southern Hawkes Bay Intertidal platform surveys. Thus, after removing the eleven species listed above, the frequency of occurrence of 83 different species were compared in the following analyses.

2.2. Data from the 35 Transects

A total of 35 transects were derived from the seven sites sampled, providing a total of 908 quadrats (Table 2). Each transect had, therefore, an average of approximately 26 quadrats. The frequency of occurrence of each of the 94 species for each transect was determined by suitable database extracts (Appendices 1 - 7).

Table 2. Number of transects and quadrats at seven locations within Hawkes Bay.

	Kairakau	Mangakuri	Paoanui	Pourerere	Aramoana	Blackhead	Whangaehu	Total
Transects	5	5	5	5	5	8	2	35
Quadrats	113	104	129	149	184	189	40	908

2.3. Habitats.

The original data included a classification of habitat type within each quadrat based on the researchers own system of 41 different habitat types. Their system attempted to differentiate subtle changes in these relatively homogeneous reef systems by classifying the quadrats on the basis of substrate type (mudstone. sandstone, rock, etc.), major features included in the quadrat (pool. rocks. large rock), whether or not the area was covered by water during mid to low tide periods. and various combinations of the above factors (uncovered mudstone. covered pool, etc.). They also attempted to classify the quadrats on the basis of their position along the transects from the high intertidal zone to the sublittoral.

Realizing the potential for redundancy within the original classification of habitats, DOC Napier requested clarification of the habitat classification system used by the original researchers. Creswell and Warren (1991) subsequently provided a revised habitat classification system (NewHab in the database) which grouped the original 41 habitat types into 20 classifications. Haddon and Anderlini (1993) considered this reclassification to be still too complex and unsuited to the available data. Therefore, they grouped the 20 habitat types into 5 general habitat types (CMRU Habitats in the database) each with different general description (Tables 3 & 4).

It should be noted that in the current document and in the databases, CMRU habitat #5 refers to all kinds of Pools while CMRU habitat #4 refers to the Lower Intertidal/Reef edge. In Haddon and Anderlini (1993), however, the descriptions of CMRU habitats 4 and 5 were mistakenly reversed.

In the attempts to determine natural groupings in the data the original 41 habitat types of Creswell and Warren (1990) have not been used. Instead their new list of 20 habitats and the five suggested by Haddon and Anderlini (1993) have been used as the basis for the frequency of occurrence of the different species present.

In the process of analyzing which habitat types had similar biota, it was found that the original assignment of the 20 'New Habitat' types to the five 'CMRU Habitat' types did not reflect the biotic community associated with those habitat types. Therefore, re-assignments were made and a further cluster analysis carried out to test the new 'CMRU Habitat' types for homogeneity of biota.

Table 3. Comparative lists of the three different arrangements of Habitats for the Southern Hawkes Bay Coast data.

Creswell & Warren (1990)		Creswell & Warren (1991)		Haddon & Anderlini (1993)	
1	Uncovered Sand + rock	1	Uncovered sand + rock	1	Upper Intertidal
2	Uncovered sand	2	Sand + Mudstone	2	Rocky Intertidal
3	uncovered rock surface	3	Uncovered Sand	3	Intertidal reef platforms
4	uncovered flats	4	Uncovered (rock surface)	4	Lower Intertidal/Reef edge
5	uncovered	5	Uncovered flats	5	Pools
6	uncovered rock and pool	6	Uncovered rock + pool		
7	pool and uncovered	7	Pool + uncovered		
8	uncovered flats and rocks	8	Uncovered flats + rock		
9	uncovered rock	9	Uncovered rock		
10	uncovered rocks, sand	10	Rock + uncovered rock		
11	mudstone (uncovered)	11	Uncovered (washed)		
12	rock and uncovered rock	12	Washed		
13	uncovered mudstone	13	Covered		
14	uncovered (washed)	14	Covered + rock		
15	washed	15	Covered rock		
16	mudstone (washed)	16	Covered pool		
17	covered	17	Slightly covered		
18	covered mudstone	18	Edge of reef		
19	covered and rock	19	Subtidal (reef edge)		
20	covered rocks and rock	20	Pool/reef edge		
21	covered rocks				
22	covered pool				
23	slightly covered				
24	partially covered				
25	rock				
26	rocks (boulders)				
27	boulder (s)				
28	broken boulders				
29	broken rocks				
30	mudstone				
31	sand and mudstone				
32	back of rock				
33	pool				
34	rock and pool				
35	pool and side of rock				
36	rocks and pool				
37	mudstone and pool				
38	pool/reef edge				
39	subtidal (i.e. reef edge)				
40	edge of reef				
41	sand				

Table 4. Equivalence list of the codes for each of the different habitat types.

CMRU Habitat	20 New Habitats	41 Old Habitats
1	1	10
1	2	31
1	3	41
1	3	2
2	5	4
2	5	5
2	5	11
2	5	13
2	5	30
2	8	8
2	13	17
2	13	18
2	17	23
2	17	24
3	9	9
3	9	25
3	9	26
3	9	27
3	9	28
3	9	29
3	10	12
3	10	20
3	14	19
3	15	21
4	11	14
4	12	15
4	18	40
4	19	39
4	20	38
5	6	6
5	6	34
5	6	35
5	6	36
5	7	7
5	7	37
5	16	22
5	16	33

2.4. Analytical Methods

2.4.1. Between Transect Comparisons

2.4.1.1 Species Diversity and Evenness

An attempt to estimate species diversity and species evenness was made using the frequency counts from each transect (Appendices 1 - 7). This was the standard Shannon - Weiner diversity index.

$$H = -\sum p_i \ln(p_i)$$ **Equation (1)**

where H is the Shannon-Weiner index of species diversity and p_i is the proportion of the total sample belonging to the i th species.

H_{max} is the maximum possible species diversity = Ln (S), where S is the number of species present. Given this value, Evenness or Equitability is defined as

$$E = \frac{H}{H_{max}}$$ **Equation (2)**

The relation between species diversity and number of species present in a sample was investigated by plotting the two variable against each other.

2.4.1.2 Correlations and Clusters between Transects

In order to take account of the different sample sizes the frequency of occurrence information was standardized. This was done by dividing each count by the total number of quadrats in each of the respective transect (this would be the maximum frequency possible). Standardization is especially necessary prior to cluster analysis on Euclidean distances. The result of cluster analysis when using the correlation coefficients as a measure of distance is identical irrespective of whether proportions or actual counts are used.

Direct comparisons, between transects were made using Pearson's Product Moment correlation coefficients on the standardised data. With multiple comparisons, the standard significance tests are not valid so the significance of each pairwise comparison was tested using Bonferroni-adjusted probabilities. In this way, we were less likely to make a type 2 error of considering a comparison to be significantly different when it was not.

The standardised frequency counts were also used with a hierarchical cluster analysis using both the Correlation Coefficient and Euclidean distance as measures of distance, using the Average Linkage method of combining groups.

The matrix of correlation coefficients derived from these comparisons were used as the basis of a Multi-Dimensional Scaling analysis in an attempt to visualize the relationships between the various transects.

2.4.2. Between Quadrat Comparisons

The presence/absence data from the quadrats taken at Aramoana and at Blackhead were subjected to hierarchical cluster analysis without preliminary labelling. In this way, it was hoped that if any natural groupings were detectable in the data set they would become apparent.

The quadrats from different transects were added to the analysis sequentially (i.e. first from Aramoana, transect 1 and 2 were analysed, this was repeated for transects 1 to 3, then 1 to 4 and then 1 to 5, and then transects from Blackhead were added sequentially. The stability of any grouping could thus be assessed.

2.4.3. Between Habitat Comparisons

For each of the seven sampling sites, frequency counts were made of the species occurring in the various habitat types present at each site (Tables 3 & 4). As the 20 New Habitat types were made up of combinations of the old 41 habitat types, no analysis on the old habitats was made. Thus, frequency counts were made only for the 20 New Habitat types and for the five suggested CMRU Habitat types. The cluster analysis on the CMRU habitats tested how well the original assignments fitted the biological reality.

Hierarchical cluster analyses were made using the Pearson Correlation Coefficient as a distance measure and the Average Linkage method of joining groups. This provided a visual arrangement of the species found in each habitat type to see if they were biologically distinct.

After the analysis above it was decided to re-assign the 20 'New Habitat' types to the 'CMRU Habitat' types in an effort to better reflect the associated biotic communities. New frequency counts were then made on the revised 'CMRU Habitats' (NewCMRU in the databases) and these were subjected to cluster analysis as before to test for their success in reflecting the biotic communities associated with the habitat types.

3. RESULTS

3.1. Between Transect Comparisons

3.1.1. Diversity and Evenness

All sampling sites, when taken as a whole, had relatively high species diversity. with Kairakau and Whangaehu both having values greater than 3.4 and Aramoana being lowest with 3.1. (Table 5). There appears to be a relation between species diversity and evenness (equitability) as the highest equitability was at Whangaehu and the lowest at Aramoana (Table 5).

Table 5. Sampling and Biotic Characteristics of each sampling site

Sampling Site	Quadrats	Nos Species	Diversity	Evenness	Transects
Aramoana	184	51	3.100	0.788	5
Blackhead	189	65	3.393	0.813	8
Kairakau	113	61	3.464	0.843	5
Mangakuri	104	52	3.325	0.842	5
Whangaehu	40	49	3.435	0.883	2
Pourerere	149	59	3.308	0.811	5
Paoanui	129	53	3.255	0.820	5

As would be expected, the species diversity estimates from the individual transects exhibit a greater range than that shown by the sites when taken as a whole. The fifth transect a Blackhead had a diversity of only 2.44 while the highest diversity was also found at Blackhead (transect 3) with 3.36 (Table 6). In this case there was a distinct relationship between species diversity and species richness (Fig. 2). No such relation exists between evenness and species richness and only a weak link is suggested between species diversity and evenness.

Table 6. Sampling and Biotic Characteristics of each transect. AR - Aramoana, BL - Blackhead, KA - Kairakau, MA - Mangakuri, PA - Paoanui, PO - Pourerere, WH - Whangaehu.

Transect	Quadrats	Nos Species	Diversity	Evenness
AR1	41	37	3.118	0.863
AR2	37	39	3.109	0.849
AR3	34	37	3.061	0.848
AR4	39	25	2.686	0.834
AR5	33	26	2.733	0.839
BL1	38	43	3.244	0.863
BL2	34	44	3.194	0.844
BL3	24	43	3.366	0.895
BL4	16	30	3.029	0.891
BL5	24	18	2.443	0.845
BL6	21	37	3.147	0.871
BL7	19	35	3.154	0.887
BL8	13	34	3.097	0.878
KA1	23	39	3.266	0.891
KA2	26	39	3.325	0.907
KA3	28	37	3.134	0.868
KA4	23	39	3.307	0.903
KA5	13	29	3.085	0.916
MA1	18	34	3.167	0.898
MA2	20	26	2.799	0.859
MA3	24	33	3.182	0.910
MA4	21	36	3.212	0.896
MA5	21	33	3.161	0.904
PA1	36	32	2.923	0.843
PA2	28	31	2.958	0.861
PA3	22	30	2.953	0.868
PA4	19	24	2.878	0.906
PA5	24	30	2.972	0.874
PO1	31	33	3.025	0.865
PO2	35	38	3.088	0.849
PO3	28	38	3.190	0.877
PO4	34	31	2.918	0.850
PO5	21	41	3.352	0.903
WH1	19	37	3.298	0.913
WH2	21	35	3.226	0.907

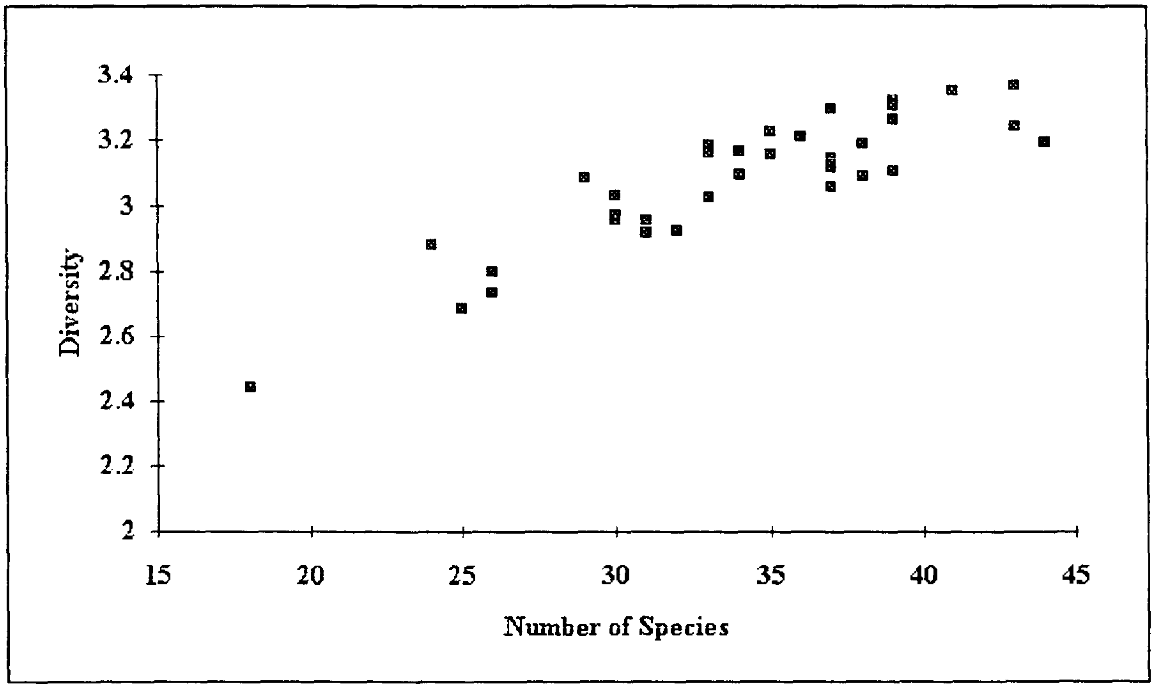


Figure 2. Relationship between the Species Diversity of separate transects and their species evenness.

3.1.2. Correlations Between Transects.

Almost all correlations between pairs of transects were significant (Appendix 8). This implies that the intertidal platform biota of southern Hawkes Bay is likely to be similar irrespective of site. The correlation coefficients are actually larger and more significant when the rare species are included in the analysis than when they are excluded. This is because there would be a large agreement between zero values for most of the extra data.

3.1.3. Cluster Analysis of the 35 Transects using Correlation Coefficients.

The two measures of ecological distances used (correlation coefficients and euclidean distance) produced comparable results. With the correlation coefficients none of the groups found are significantly different from any of the other groups. However, the groups found do express the relative similarity. Generally, there were three major groups identified with a number of outliers.

The first group consisted of four of the Mangakuri and four of the Kairakau transects. Within this group the Mangakuri transects cluster together and the Kairakau transects cluster together (Fig. 3).

The second group consisted of four of the transects from Blackhead combined with one from Whangaehu. The other Whangaehu transects was one of the outliers which separated from the rest (Fig. 3).

The third, and largest group was a mixture of the other sites where all the transects were relatively similar to each other. Within that limitation the five Aramoana transects were all clusters close together, three of the Pourerere transects came close to one another, and three of the Paoanui transects finished close together (Fig. 3).

There were four transects which were outliers to these three groups. The Whangaehu transect has already been mentioned. There were also a pair of Paoanui transects which, while similar to each other were relatively dissimilar to other transects. The most dissimilar transect of all was the first at Mangakuri. In the table of correlation coefficients (Appendix 8) 'MAI' was one of the few transects which was significantly different from many other transects.

With the correlation coefficient analysis, within-site similarity appeared greater than between site similarity in many cases. With inspection, even the outlier transect had closer correlation coefficients with its co-site transects than with elsewhere (Appendix 8).

3.1.4. Cluster Analysis of 35 Transects using Euclidean Distance

The mixing of transects between sites is rather greater in the clustering produced using Euclidean distances, than with the Pearson correlation coefficients. Roughly four major groups can be recognised with fewer outliers.

The first group consists solely of the four Blackhead transects (3, 4, 6, & 7) which also clustered together with the correlation coefficient (Fig. 4).

The second group is a mix of both transects from Whangaehu, the two Paoanui transects which formed an outlier with the other clustering, and a single transect from Mangakuri (Fig. 4).

The third group contain all the Aramoana transects (not so close as previously), the remaining three Paoanui transects (closer than before), and a mixture of the remaining Blackhead transects and four of the Pourerere transects (Fig. 4).

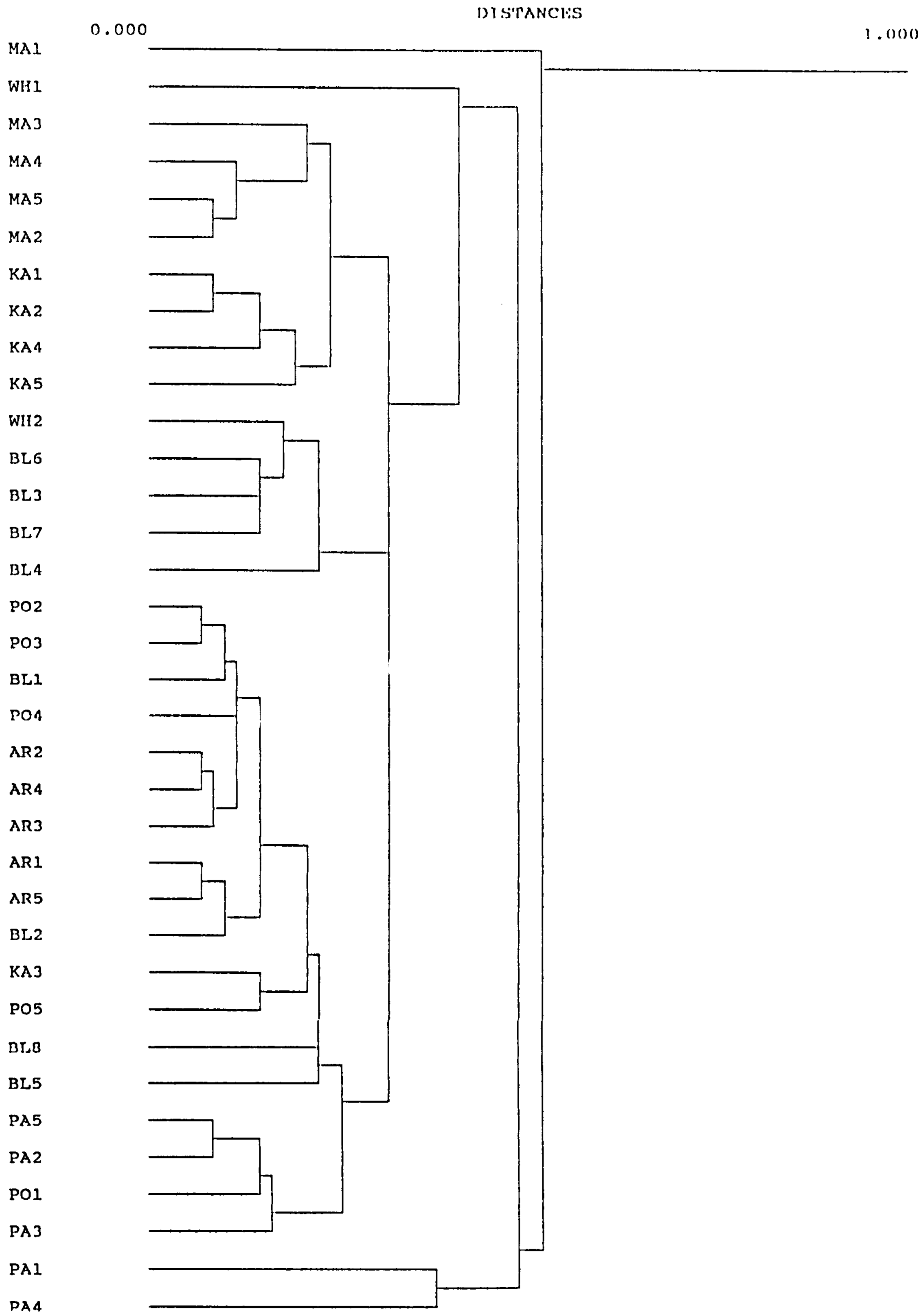


Figure 3. Hierarchical Cluster diagram of the 35 transects from all seven sites. The ecological distance measure was 1 - Pearson Correlation Coefficient and the Average Linkage method was used. Ar - Aramoana, BL - Blackhead, KA - Kairakau, MA - Mangakuri, PA - Paoanui, PO - Pourerere, W H - Whangaehu.

The fourth group is similar to one of the groups from the previous clustering, in that it contains the same four transects from Kairakau (1, 2, 4, & 5), but only three of the transects from Mangakuri (Fig. 4).

Outliers, from this analysis, included a single Pourerere transects which attached to the present fourth group, a single Blackhead transect, which attached to the present third group, and 'MA1' again, which separated from all the rest (Fig. 4).

Although one cannot place a significance value of a Euclidean Distance it is clear from the cluster diagram (Fig. 4) that many of the connections are made within a narrow distance band. Thus, none of the pairs are very close to zero (meaning extremely similar) but all connections occur within a narrow range. This implies, once again, that all transects, except perhaps for Mangakuri 1 (MA1), were relatively similar in there biological composition.

3.1.5. Multi-Dimensional Scaling of the 35 Transects

The two axes derived from the Multi-Dimensional Scaling accounted for 88.25% of the information within the matrix of correlation coefficients. It was not possible to back-correlate the axis scores to physical factors of the environment as only limited information is available.

The groupings seen in the MDS plot have strong similarities to the clusters seen in the hierarchical cluster analysis. Geographical proximity may explain some of the groupings (Fig. 5). The Mangakuri group of transects and the Kairakau transects form up each with a single outlier (very like the cluster diagrams) and these two sites are closest to one another. Aramoana forms a reasonably distinct group but as it is in the centre of transects from Pourerere, Blackhead, and some of Paoanui. Given this similarity, one can appreciate why the cluster procedure tended to mix these sites. As with the cluster diagrams, Paoanui has three similar transects with two outliers off by themselves.

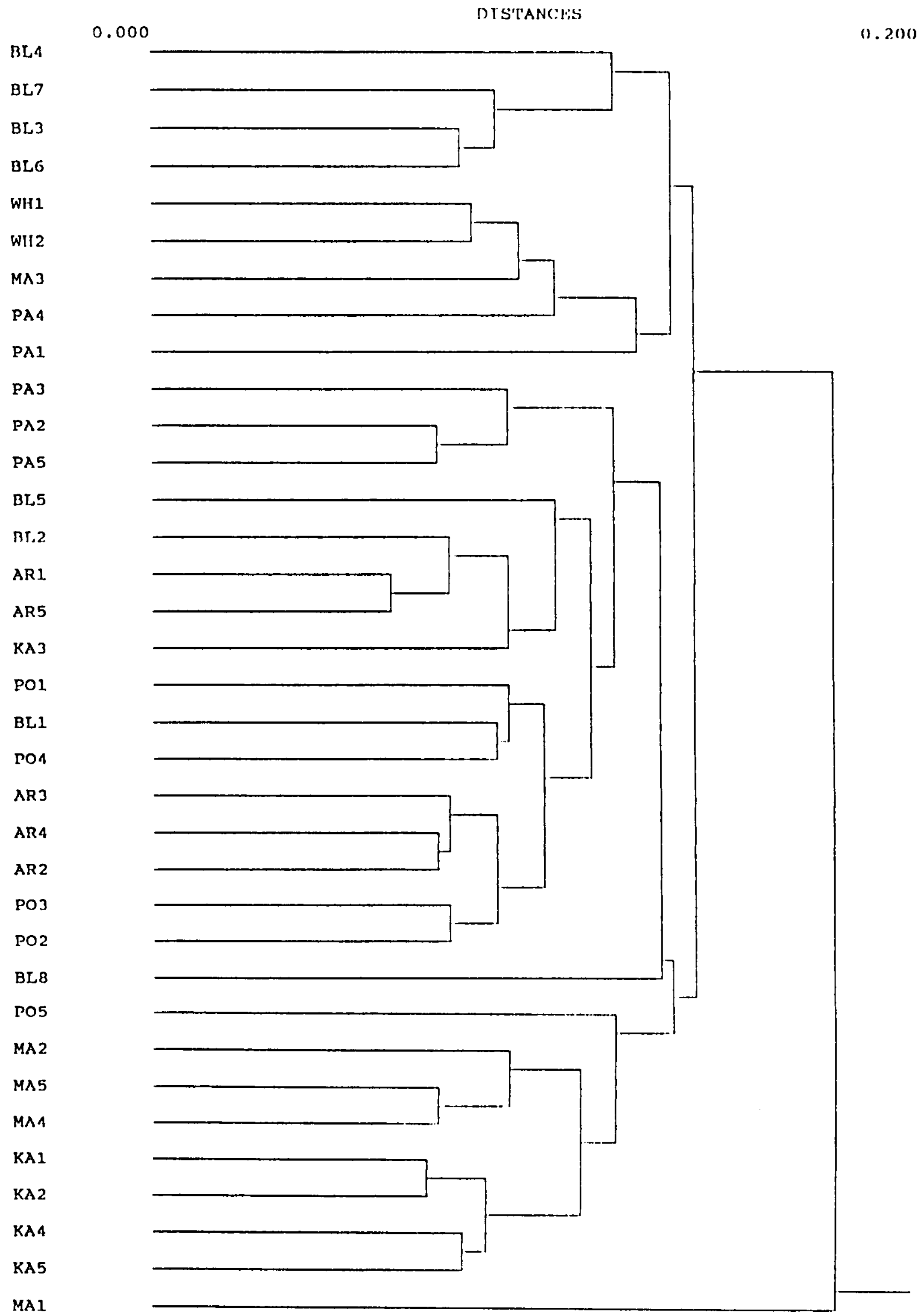
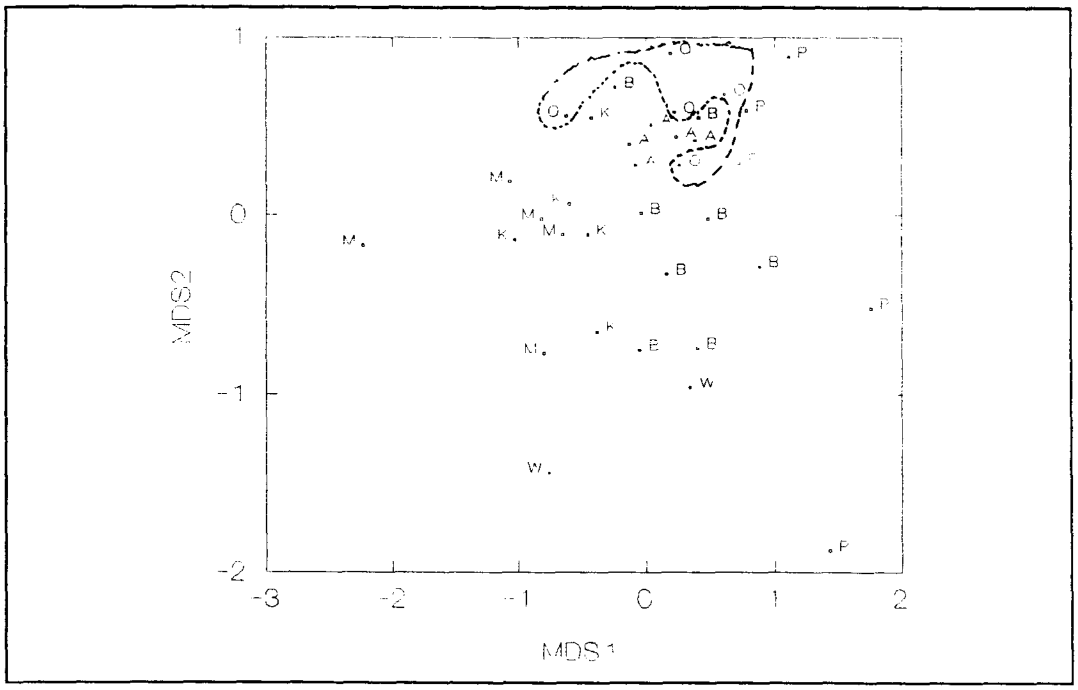


Figure 4. Hierarchical Cluster diagram of the 35 transects from all seven sites. The ecological distance measure was the Euclidean Distance and the Average Linkage method was used. Ar - Aramoana, BL - Blackhead, KA - Kairakau, MA - Mangakuri, PA - Paoanui, PO - Pourerere, WH - Whangaehu.



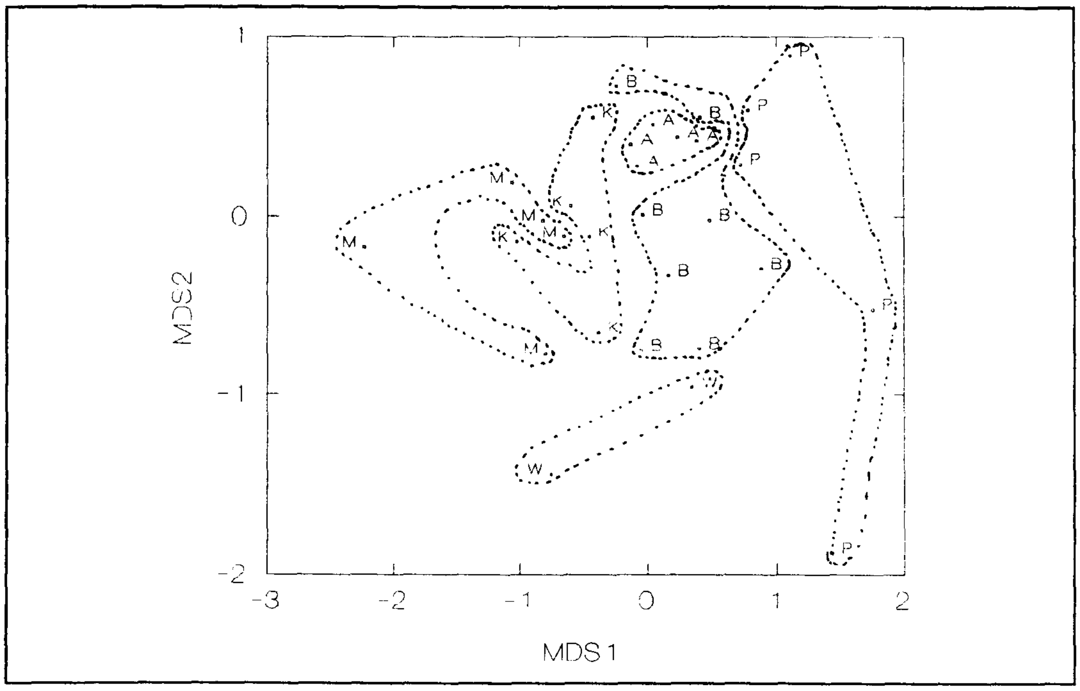


Figure 5. Multi-Dimensional Scaling applied to the matrix of correlation coefficients for the 83 species found in the 35 transects made at the seven different sampling sites. A - Aramoana, B - Blackhead, K - Kairakau, M - Mangakuri, P - Paoanui, O - Pourerere, W - Whangaehu. The top figure has the MDS scores for all transects plotted while the lower figure omits Pourerere for increased clarity. The outlines in the lower figure are simply guidelines.

3.2. Between Quadrat Comparisons.

With the sequential addition of transects to the cluster analysis no consistent groupings of quadrats formed. With every new addition the configuration of quadrat clusters changed. Without the formation of such stable groups it was not possible to suggest any 'natural' groupings.

No useful biological information was thus forthcoming from the simple comparison of whole data from quadrats made at Aramoana and Blackhead. No attempt was made to add data from outside these sites.

3.3. Between Habitat Comparisons.

3.3.1. Between the 20 New Habitat Comparisons.

Not all sites had representatives of all 20 of the New Habitat types devised by Creswell & Warren (1991). Each group of counts was identified with a letter denoting the site and a number denoting the 'New Habitat' type. If the habitats identified are associated with distinctive biotas then in the cluster diagram, groups should be found where the members all have the same numbers.

A number of clusters were found but few of them exhibited any degree of agreement between the habitats represented from different sites. This implies that there is not necessarily any similarity of biota between the same habitats from different sites (Fig. 6). However, a few exceptions were found and some of these were associated with some of the identifiable groups.

The first, and most obvious group is an outlying cluster of five members which only attaches to the rest at a low level of similarity (Fig. 6). This contains representatives from Whangaehu, Blackhead, and Kairakau within the 'New Habitat' types 18, 19, and 20. These are all very similar habitats and include the edge of reef, the subtidal (reef edge), and pool/reef edge (Table 3).

The second group includes a cluster of 'New Habitat' 9s from all seven sites which are associated with all of the 'New Habitat's 10s present and three of the four 'New Habitat' 14s present. 'New Habitat' 9 is 'Uncovered Rock' while 10 is 'Rock + Uncovered Rock', and 14 is 'Covered + Rock'. At Mangakuri there was some 'New Habitat' 15 (Covered Rock) but this did not associate with the other 'Rocky' type habitats (Fig. 6).

A group of 'New Habitat' type 16 (covered pool) associated with type 6 (uncovered + pool) and other wetter habitats such as 12 and 17 (Washed and Slightly covered, respectively).

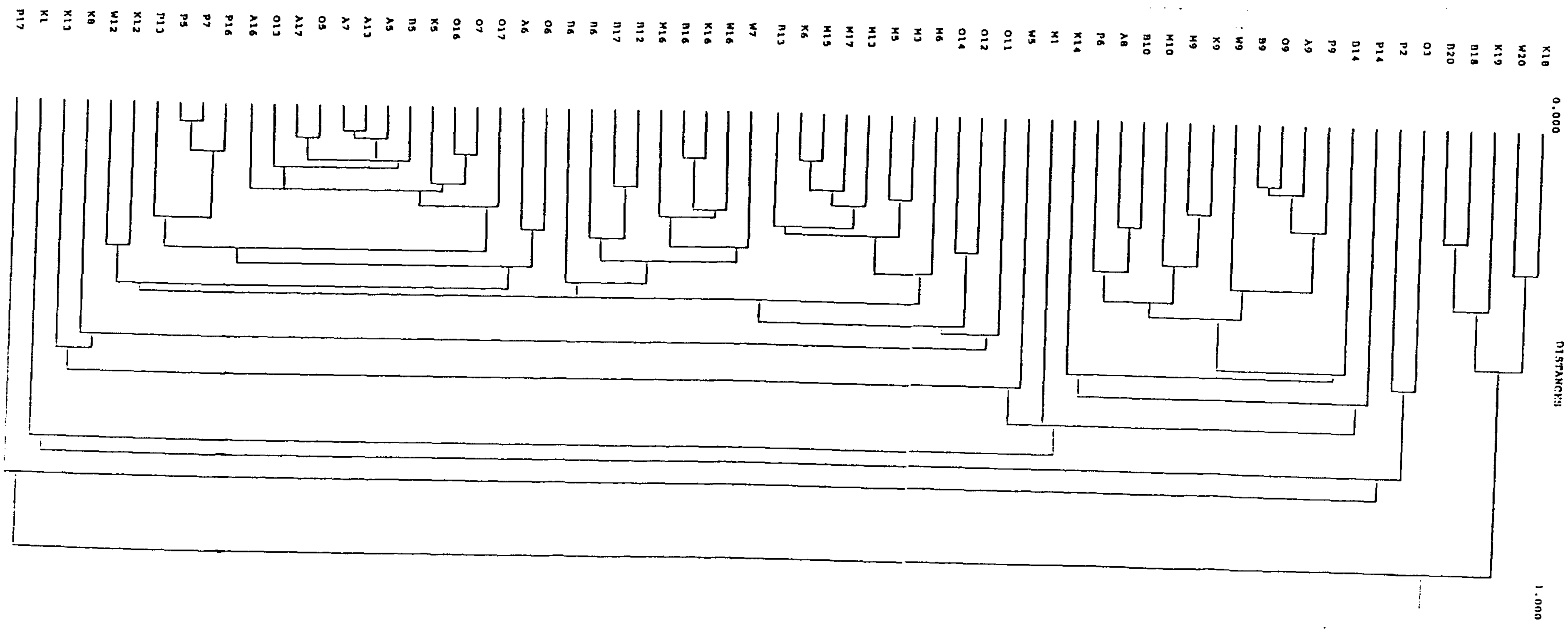


Figure 6. Hierarchical Cluster diagram of the 20 New Habitat type from all seven sites. The ecological distance measure was 1 - Pearson Correlation Coefficient, and the Average Linkage method was used. A - Aramoana, B - Blackhead, K - Kairakau, M - Mangakuri, P - Paoanui, O - Pourerere, W - W hangaehu.

3.3.2. Between CMRU Habitat Comparisons.

Not all sites had representatives of the five CMRU Habitat types devised by Haddon & Anderlini (1993). As with the New Habitat types each group of counts was identified with a letter denoting the site and a number denoting the 'CMRU Habitat' (CMRU-H) type. Thus, if the habitats identified are associated with distinctive biotas then in the cluster diagram, groups should be found where the members all have the same numbers.

Five of the seven CMRU-H type 3 (intertidal reef platform) were clustered into a distinct group. The remaining two type 3 were linked to CMRU-H type 1 (Upper- Intertidal) suggesting a link between these two habitat types (Fig. 7).

The CMRU-H types 2 and 5 (Rocky intertidal and Pools, respectively) appeared to be associated, with two of the four type 4 (Lower intertidal/reef edge) mixing in (Fig. 7).

3.3.3. Revision of CMRU Habitats.

The analyses of the 'New Habitat' types and the 'CMRU Habitats' suggested that some of Haddon & Anderlini's (1993) combinations were invalid. This may have been due to a misunderstanding of the terms used by Creswell & Warren (1991). Whatever the case, the analyses above suggest that a revision of the CMRU Habitats might produce a more satisfactory identification of habitat - biota associations. With these analyses in mind the following combinations of 'New Habitats' are suggested:

Table 7. New assignments of 'New Habitat' types to CMRU Habitats.

NewCMRU	'NewHabitat' equivalents	Sites	Mean Nos Species
1: Upper Intertidal	1, 2, 3	4	7.5
2: Rocky Intertidal	4, 5, 8, 11, 12, 13, 15, 17	7	36
3: Intertidal Reef Platform	9, 10, 14	7	31.9
4: Reef Edge	18, 19, 20	3	7
5: Pools	6, 7, 16	7	39.1

The cluster analysis of the revised CMRU habitats leads to a much closer agreement between habitat type and grouping. The habitat type 4 all group together separately from the rest (Fig. 8). Habitat 3 clusters together and may have some association with habitat type 1, however, habitat 1 mostly just chains on to the rest of the groups with no real associations evident. Habitat type 2 and 5 form small within type groups but these are well mixed with each other (Fig. 8). The average number of species found in each habitat may have influenced the associations into groups (Table 7).

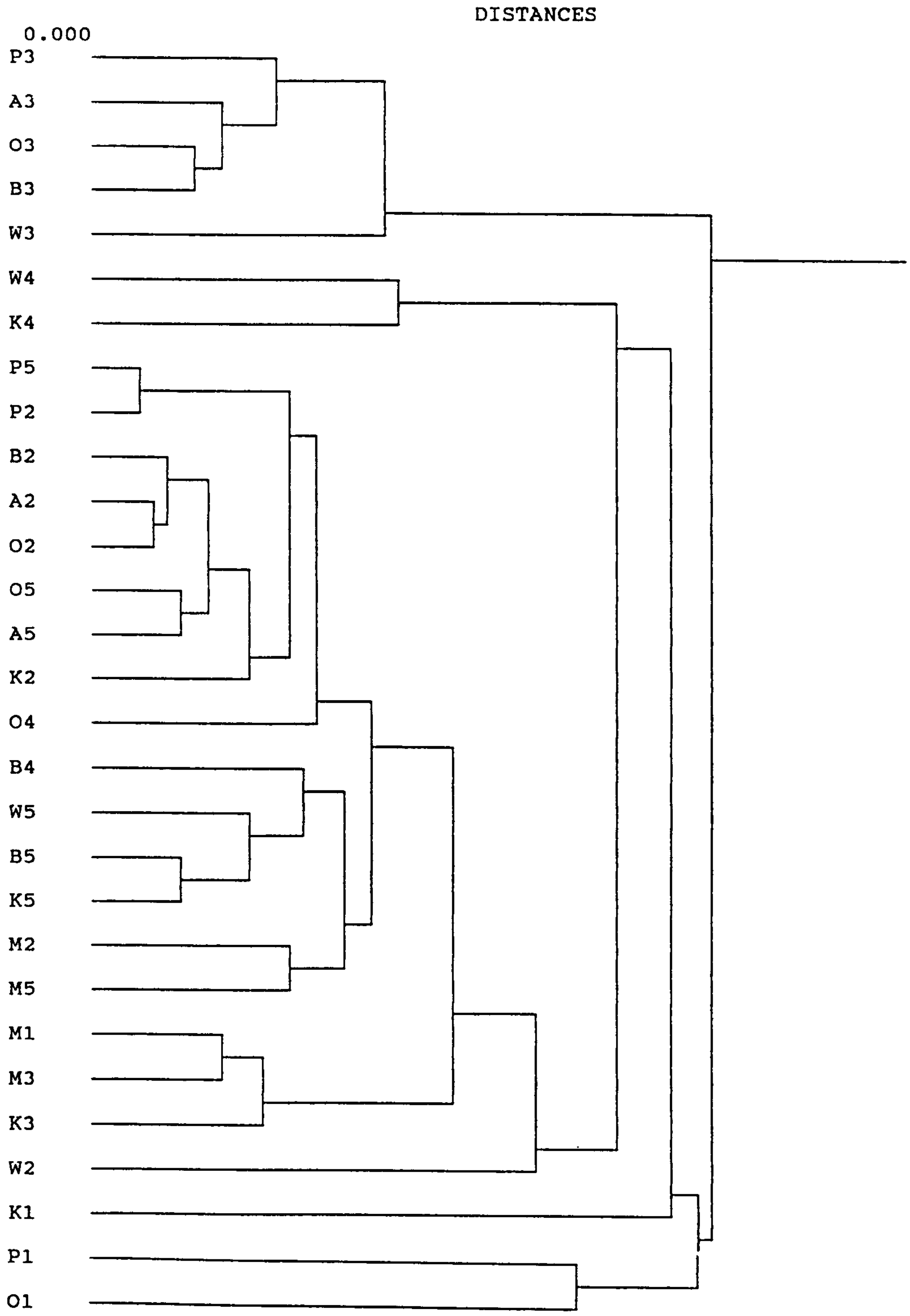


Figure 7. Hierarchical Cluster diagram of the 5 original CMRU Habitat types from all seven sites. The ecological distance measure was 1 - Pearson Correlation Coefficient, and the Average Linkage method was used. A - Aramoana, B - Blackhead, K - Kairakau, M - Mangakuri, P - Paoanui, O - Pourerere, W - Whangaehu.

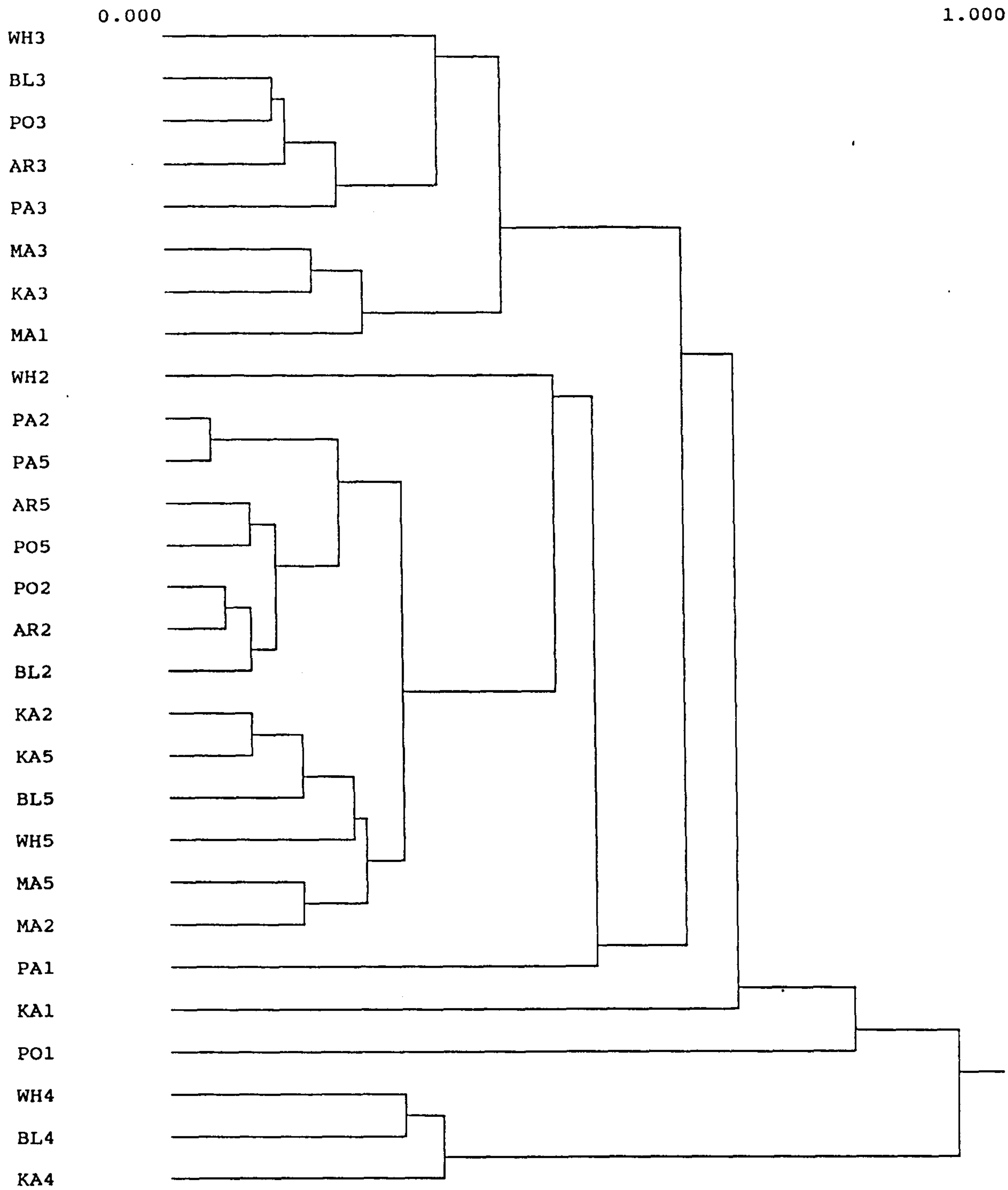


Figure 8. Hierarchical Cluster diagram of the 5 revised NewCMRU Habitat types From all seven sites. The ecological distance measure was 1 - Pearson Correlation Coefficient, and the Average Linkage method was used. A - Aramoana, B - Blackhead, K - Kairakau, M - Mangakuri, P - Paoanui, O - Pourerere, W - Whangaehu.

4. DISCUSSION

4.1. The Use of Presence/Absence Data.

Quantitatively sampling rocky shores in a valid way is a major practical problem for hard substrate marine ecologists. Within the same community there can be large, relatively uncommon species, as well as extremely numerous, and tiny species. The latter compound the frustrations of sampling by frequently preferring to congregate in cracks and crevices, especially during the low tide periods when most sampling is carried out.

Using quadrats to isolate areas within which to estimate density is a commonly used method but this has a suite of particular problems if quantitative data are to be collected. The first is the matter of what area is actually being assessed for the density estimate. On flat rock surfaces or platforms, this may not appear to be a problem but most rocks are uneven and have cracks and cavities which effectively increase the area of substrate within the quadrat. If the scale of rock surface variation is on the same order of magnitude as the size of quadrat used taking a sensible measure of area sampled can become impossible. Further, the optimal quadrat size for producing un-biased estimates of density, is often a function of organism size. Thus, with larger or more sparse animals one requires a larger quadrat than with smaller or very abundant animals.

Traditionally, hard substrate marine ecologists have used density estimates based upon actually counts, where feasible, and upon percent cover of the substrate, as with algal species and such organisms as barnacles. This approach is quite adequate when one is considering single species or even related species (which tend to have the same growth form). However, when attempting to compare whole communities having data collected in both ways in the same data set precludes the use of any of the usual analytical methods.

Presence/absence data is commonly used in comparisons of botanical communities (Greig-Smith, 1964) but, so far, has not been commonly used in animal ecology (Seber, 1981, 1986, 1992). Hard substrate marine communities share many of the characteristics of terrestrial flora so it is surprising that this approach has not been used more often. With hard shore marine environments, it would appear that the optimum sampling strategy using a presence/absence method, would be to subdivide the area to be assessed into a few clear strata (such as upper shore, lower shore, and lower shore edge with the subtidal). Within each of these strata it would be necessary to score the species found in a relatively large number of quadrats. In this way one could produce information which could be used to compare different areas. This approach could be regarded as treating each stratum as a quadrat and determining the percent occurrence of each species within it.

4.2. Measures of Diversity

4.2.1. Between Site Diversity Values

By treating the frequency of occurrence within any one site as an indicator of relative abundance at that site it was possible to produce estimators of the species diversity for both the seven separate sites and the 35 separate transects.

All seven sites had high species diversity and evenness (Table 5). Species diversity combines species richness and relative abundance so it is not surprising that Whangaehu, with the lowest number of species (49), had one of the highest species diversity levels. This high diversity reflects the fact that the 49 species were found in only 40 quadrats whereas all the other sites had at least 100 quadrats. On the other hand, there were 184 quadrats taken at Aramoana and that site had the lowest overall species diversity and the lowest species evenness.

No single figure can be an adequate summary of the properties that lead to ecological value. The Blackhead site, for example, does not have the highest diversity but it does have the largest number of species present.

4.2.2. Between Transect Diversity Values.

The diversity measures for each transect taken separately do not necessarily relate to the diversity values derived for the sites taken as a whole (Table 6). Blackhead appears to be exceptional in that it has both the highest and the lowest diversity values. All transects from Paoanui had diversity values less than 3.0 which contrasts markedly with the site taken as a whole (diversity = 3.255). Kairakau is the only site whose transects all have diversity values above 3.0. The transects from all other sites have ranges from below 3.0 to above 3.0.

There was a strong relation between species richness (or number) and species diversity (Fig. 2). This is possibly related to the fact that there were strong correlations between almost all transects which means that the relative proportions of each species must have been similar.

In terms of species richness, species diversity, and species evenness if one were to attempt to decide upon which areas were to be preferred then one could pick Blackhead on the basis of species richness an the range of species diversity suggesting a diversity of habitats. Kairakau also appears to be of relatively high value (in terms of richness and diversity). On the other hand, the diversity values suggest that Paoanui is of relatively low ecological value. Having stated that, it should be clearly noted that the differences between transects and sites are, in all cases, minor and that preferred site selection should probably not rest on the criteria of species richness, species diversity, or species evenness.

4.3. Between Transect (Site) Comparisons.

Almost all correlations between transects were significant (a few outliers did occur). Also, the correlation coefficients between transects within sites tended to be greater than those between transects between sites. That is transects within sites tended to be more similar to each other than they were to transects from other sites (Appendix 8). This was conveyed visually in the tree diagrams deriving from the clustering of the correlation coefficients and euclidean distances (Figs. 3 & 4), and in the multi-dimensional scaling (Fig. 5).

The multi-dimensional scaling permits the production of a diagram which summarizes the relative distances each transect is from each of the other transects. This clearly reflects aspects of the cluster diagrams. Thus, the link between four of the Mangakuri transects and four of the Kairakau transects is resolved by the mutual surrounding of those groups in the MDS plot. The group of three Paoanui transects along with the mixture of Aramoana, Pourerere, and some of the Blackhead transects is seen as a complex intermixing of points in the MDS plot (Fig. 5). These areas and transects are so similar in overall biota that, while they exhibit a large degree of within site fidelity, their closeness to transects in other sites cannot be ignored.

Overall, the frequency of occurrence data led to consistent answers and an ability to recognise within group similarities. On such a uniform coastline it is not surprising that a high degree of similarity between sites was found.

4.4. Between Quadrat Comparisons

The large quantities of information available (hundreds of quadrats) and the small levels of difference between quadrats led to a lack of any obvious groups of quadrats being identifiable. This approach was not as productive as was expected.

An alternative approach would be to search for associations between species as opposed to quadrats. Searching for associations between species relies on presence/absence data and some 'classic' work has been done in that way (Agnew, 1961). One disadvantage is that it is very computer intensive work. Any associations discovered, assuming any exist, would be expected to be related to particular habitats.

4.5. Between Habitat Comparisons

The comparison of the biota associated with each of the 20 'New Habitat' types led to certain of the physical habitat categories appearing to reflect a biological association. Largely, however, there was a great deal of mixing of habitat categories, implying that they shared a similar biota (Fig. 6).

The particular mixings observed, however, were useful because they assisted in a revision of the original CMRU habitat types suggested by Haddon & Anderlim (1 993). When the biota associated with the original CMRU habitat types were clustered (Fig. 7) some of the categories were less distinct than would be desirable (suggesting that the associated biotas were also not distinct). By comparing the original assignment of 'New Habitat' types to the CMRU Habitats with the cluster analysis of the 'New Habitat' types it was possible to refine the allocation and thereby to devise a new set of CMRU habitats.

When the biota associated with the new CMRU habitats were analysed by clustering (Fig. 8) the habitats associated more cleanly.

The Upper Intertidal was a relatively sparse community which, because of the paucity of species tended not to associate with other groups but rather to chain onto the end of the tree diagram. This indicates that while they may be closest to each other they are not really close to any other group.

The Reef Edge group of habitats grouped together and apart from the rest. These also had only a low species count, but in this case, these were all relatively similar.

The Intertidal Reef Platform forms a relatively distinct group which separated from the other habitats. The reef platforms are distinct habitats in terms of the physical habitat that is expressed under such conditions. That the fauna and flora associated with such areas is similar reflects the dependence that intertidal organisms often have on their physical environment.

The last two habitat type, that is the Rocky Intertidal and Pools, grouped together although there was a high degree of within habitat type clumping within the larger group. There appear to be two sub-sets of the 'Pools' (habitat 5) in the tree diagram. It is possible that what was originally considered to be a 'Pool' was a relatively loose collection of shallow to deep water collection sites. These might not differ too markedly from the lower shore rocky intertidal. However, the new CMRU Habitat 2, the Rocky Intertidal contains a mixture of Creswell & Warren's (1991) 'covered' and 'uncovered' New Habitat types. These were supposed to relate to whether the area was covered at mid tide or not. Thus, the relation between the biota of these two new CMRU habitat types is uncertain but appears to be relatively close.

The revised CMRU habitats plus their subsequent analysis suggests that there are onlv four habitat types, on the southern Hawkes Bay Intertidal reef platforms, which appear to have distinctive biological associations. The following description are only approximate and derive not from first hand experience but from the descriptions given in the original work and subsequently (Creswell & Warren, 1990, 1991).

Those habitats with distinct biota are:

1) the Upper Intertidal, probably above high water neaps.
2) the Intertidal Reef Platforms, the extensive flat, solid substrate platforms which are common on this coastline.
3) the Reef Edge, which includes the very bottom of the intertidal and the subtidal areas which are exposed occasionally on exceptional tides.
4) The Rocky Intertidal and Pools. Some of the deeper pools may form a separate sub-group, but generally the wet areas of the intertidal plus the boulders and outcropping rocks.

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APPENDICES

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