CONSERVATION
TE PAPA ATAWHAI

CONSERVATION ADVISORY SCIENCE NOTES

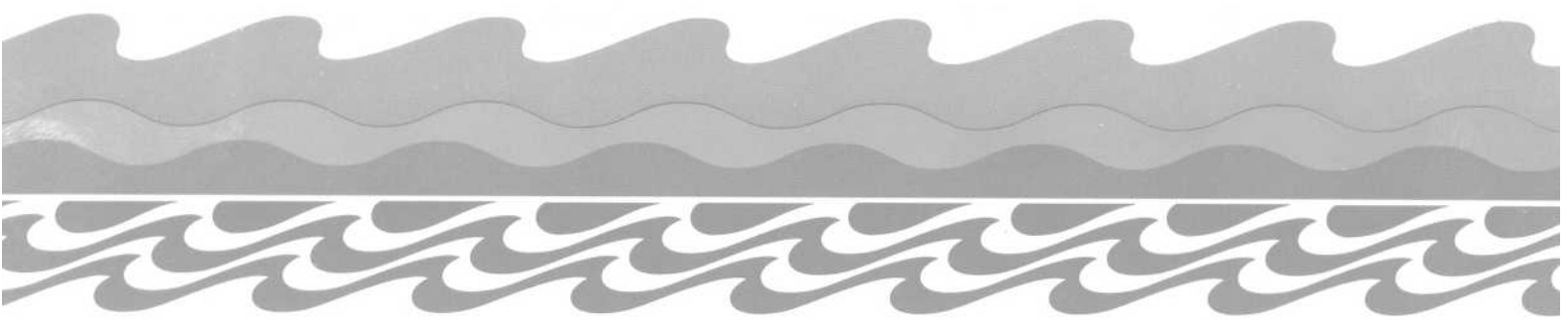
No. 39

EVALUATION OF SOUTHERN HAWKES BAY COAST INTERTIDAL DATA

(Short Answers in Conservation Science)

This report is published by Head Office, Department of Conservation, and presents the results of scientific services or advice purchased from a consultant outside the Department or provided by Departmental scientific staff. All enquiries should be addressed to the CAS Coordinator, S&R Division.

Department of Conservation, P O Box 10-420, Wellington, New Zealand



ISSN 1171-9834

Reference to material in this report should be cited thus:

Haddon, M., and Anderlini V., 1993.
Evaluation of southern Hawkes Bay coast intertidal data.
Conservation Advisory Science Notes No. 39, Department of Conservation, Wellington. 38p.

Commissioned by: Hawkes Bay Conservancy
Location: NZMS

Evaluation of Southern Hawkes Bay Coast Intertidal Data

Coastal Marine Research Unit Report No. 23

Prepared for

Department of Conservation
(Napier Conservancy)

Malcolm Haddon

Victor Anderlini

Island Bay Marine Laboratory
School of Biological Sciences
Victoria University of Wellington
P.O. Box 600, WELLINGTON

June 1993

SUMMARY

The Coastal Marine Research Unit of Victoria University of Wellington was contracted by the Department of Conservation, Napier, to prepare an accessible database of handwritten data collected by two contract workers who conducted a survey of intertidal reefs in Southern Hawkes Bay in 1990.

This report presents an evaluation and preliminary analysis of the data and provides recommendations for further, more advanced statistical comparisons.

I. 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).

The above report presented a description of the occurrence and subjective estimates of relative abundance of intertidal flora and fauna observed within each of the seven locations plus an overall description of the distribution patterns of species found at all locations. The extensive original quantitative raw data were not entered into a database, and more advanced comparative quantitative or statistical analyses were not made at the time. These data were re-examined in 1993 and it was decided that they should be entered into a suitable spreadsheet/database which would allow comparative statistical analyses.

The Coastal Marine Research Unit was contracted by DOC Napier to undertake the preparation of an accessible database, to make an evaluation and, if time allowed, first order analyses of these data. This report presents an evaluation and preliminary analysis of these data, and provides recommendations for further, more advanced statistical comparisons.

1.2. Scope of Work

The CMRU was contracted to

1. Review the raw data from the above survey and enter the data into a computer-based database using the EXCEL spreadsheet programme;

2. Provide summaries of all data with respect to relative abundance or percent cover of intertidal flora and fauna along each transect at the seven locations;

3. Provide summary comparisons of major differences and similarities between reef systems, and provide text summaries of major ecological trends noted;

4. Provide data files on IBM PC compatible disks which are suitable for further analyses.

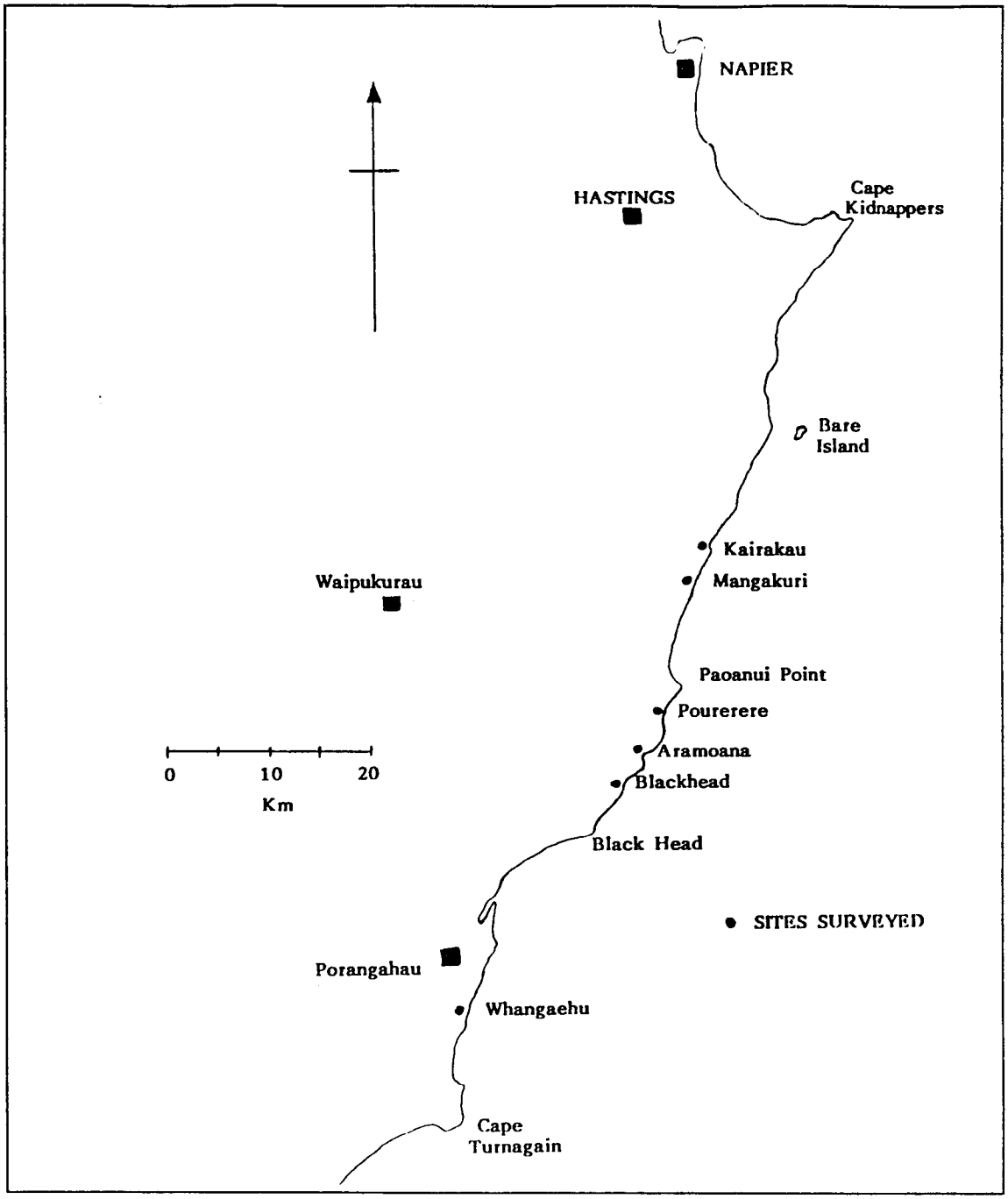


Figure 1. Southern Hawkes Bay survey sites (after Creswell & Warren 1990).

2. METHODS

2.1. Data Entry

Raw, handwritten data were provided for 1816 paired 0.1 m^2 quadrats set at regular intervals (3, 4, or 5 m) along transects at seven geographic locations (Table 1).

Table 1. 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

The original data included the position of the quadrats along the transect (recorded in metres from the top of the reef platform to low water), a written habitat classification for the quadrat, counts of macrofauna and percent cover estimates of macroflora and some faunal species (such as barnacles) within each quadrat, and occasional comments on species noted outside of the quadrats.

The species present in the quadrat pairs were generally very similar but their relative abundance often varied greatly between quadrat pairs. Thus, the paired quadrat survey design did not reduce data variability but only appeared to add statistical noise. The data for each quadrat pair were, therefore, pooled and transformed to per m^2 values by either summing the abundance data and doubling the result or by averaging the percent cover data. The recalculated species data for each quadrat were then entered into separate EXCEL files for each location with the relative position of the quadrat along its transect, the transect number, date of survey (if known), habitat classifications, and any relevant comments. Extra notes were added in the spreadsheets (as indicated by the red dot in top right of the cell).

At least three species *(Zeacumantus, Littorina,* and *Spirobis)* were found to have mixed methods of density estimation, that is their density was estimated using both absolute counts as well as percent cover. As this would preclude any form of analysis (except presence/absence methods) the values of percent cover were converted to an abundance estimate based on the average of counts in adjacent quadrats.

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.). An attempt was also made to classify the quadrats on the basis of their position along the transects from the high intertidal zone to the sublittoral (edge of reef).

Prior to CMRU receiving the original data, DOC Napier requested clarification of the habitat classification system used by the original researchers. They subsequently provided a revised habitat classification system (New Habitat in the database) which grouped the original 41 habitat types into 20 classifications. This reclassification was believed, by us, to be too complex and unsuited to the available data. Therefore, the 20 habitat types were further grouped into 5 general habitat types (CMRU Habitats in the database) and summary frequency of occurrence of species data vs CMRU Habitat type were prepared for each location. An additional table summarizing the total number of occurrences of each species at each location was also prepared.

2.2. Data Summary

The original raw data were not in a suitable form for simple data entry or statistical analysis. However, the converted data were entered into separate EXCEL format files and some data summaries prepared for each location (see Appendices). Inter-quadrat and inter-transect comparisons were limited owing to the fact that the data available from each quadrat were a mixture of abundance and percent cover. Some kind of standardization of these two types of data would have been necessary prior to any between-quadrat or transect comparisons. An alternative would be to treat the data as presence/absence information. Other problems with the data, presented in the Discussion, restricted the analyses that were possible in the time available.

2.3. Community Comparisons

The data entry took far longer than anticipated so data analyses were limited to illustrating what was possible. While the quantitative data are suitable for comparison of the distributions of particular species, there are many problems

associated with them for comparing the locations or transects in terms of the communities present.

The original report presented reef profiles which were presumably based on measurements taken along the transect at each of the quadrat positions down the reef. However, subsequent enquiry revealed that these profiles were sketch maps and were only indicative of the general slope of the reef. This severely restricted the immediate value of the data and limited the possibilities for inter-transect or inter-location comparisons.

The major assumption of the analyses presented in this report is that the quadrats taken in any geographic location adequately sampled the biological communities present. This implies both that the transects were representative of all habitats, and that the regularly spaced quadrats did not introduce any bias, and were sampled with equal efficiencies both through time and in different habitats. Some of these assumptions are testable.

Comparisons between locations were made by assuming the above, and determining the proportion of quadrats in which each species occurs in each location. This ignores the quantitative nature of the raw data. In effect, it treats the data as if it were composed of presence/absence records (see Appendix 8).

The analyses presented were obtained by amalgamating all data from each location. Strictly, prior to this analysis, a similar analysis should have been carried out treating each separate transect as an independent location, so as to test whether they were representative of each geographic site. The analyses presented are only examples of what is possible, and should be corroborated by other detailed analyses before being used for management purposes.

Selected frequency of occurrence data were subjected to some multi-variate statistical analyses using the SYSTAT programme. The data were suitable for cluster analyses and a comparison was made using two different measures of ecological distance: the Euclidean distance and the Pearson Correlation Coefficient.

In order to take account of the different sample sizes at each location the frequency of occurrence information had to be standardized relative to the number of quadrats present at each location prior to the Cluster Analysis on Euclidean distances. The cluster analysis using the correlation coefficient is, of course, identical irrespective of whether proportions of actual counts are used.

3. RESULTS

3.1. Data Entry

Data conversion and entry into EXCEL files consumed the majority of the time allocated to this project. Approximately 30 hours were required to make the necessary calculations and to physically enter the data into a format which would allow further analyses.

As mentioned above, the 20 "New Habitat" types suggested by Creswell & Warren (DOC, Napier file RES910), were grouped into five CMRU habitat types with the following codes: 1 = Upper intertidal, 2 = Rocky intertidal, 3 = Intertidal reef platforms, 4 = Pools, 5 = Lower intertidal/ Reef edge.

3.2. EXCEL File Format

Table 2. Format of EXCEL files. Columns described below are followed by the data relating to the species present in each quadrat.

Column	Title	Explanation
1	Pos	Distance down each Tansect in metres.
2	Trans	Transect number at that location.
3	Location	The geographic place name, this was included in case, at a later date, the data for a set of or single species was extracted and information from different locations amalgamated.
4	Habitat	Code number for the original 41 habitat types produced by Creswell & Warren.
5	NewHab	Code for the revised 20 habitat types devised by Creswell & Warren.
6	CMRUHab	Codes for the 5 habitat types proposed by the present authors.
7	Comment	Original comments from the raw data books, plus notes regarding the occurrence of fish, anomalies, and other un-usable data.

In each EXCEL file the database has been defined to include all data. Criteria have been set to the right of the database in the top few rows. The usual extract commands are used to summarize the data in the manner desired.

On the disk, each location has a separate file with a mnemonic name. There is also a file termed HABITATS.XLS which contains a listing of all of the habitat types and their equivalents. The file SPLIST.XLS contains an EXCEL version of the general species list with the frequency of quadrats in which each species occurs at each location (Appendix 8).

3.3. Data Summary

The data files were summarized to produce frequency of occurrence tables indicating the distribution of each species (number of quadrats in which each species occurs) in each of the five CMRU habitat types, within all transects at each location. These data are presented in Appendices 1 - 7. A summary table indicating the total number of quadrats each species occurred in, by location, is presented in Appendix 8.

3.4. Community Comparisons.

The hierarchical cluster analysis produced by comparing the euclidean distances between locations (using standardized data) has a very similar structure to that produced by comparing the distance derived from one minus the Pearson correlation coefficient (1 - r). The only significant difference between the structures was in the manner in which Whangaehu associated with the other areas (Figs 2 & 3).

Using Euclidean distances suggests there are two groups of locations. The first group includes Aramoana, Pourerere, Blackhead, and Paoanui, while the second group incudes Mangakuri, Kairakau, and Whangaehu. With the Pearson correlation coefficient, however, there is a suggestion of three groups. One is identical to that derived from the Euclidean distance and is comprised of Aramoana, Pourerere, Blackhead, and Paoanui, a second group comprises Mangakuri and Kairakau, with Whangaehu forming a group of its own.

A detailed consideration of the data may provide an explanation for these groupings. It should be noted that if the transects are not representative of each location (assumption to be tested) then the groupings would not be valid.

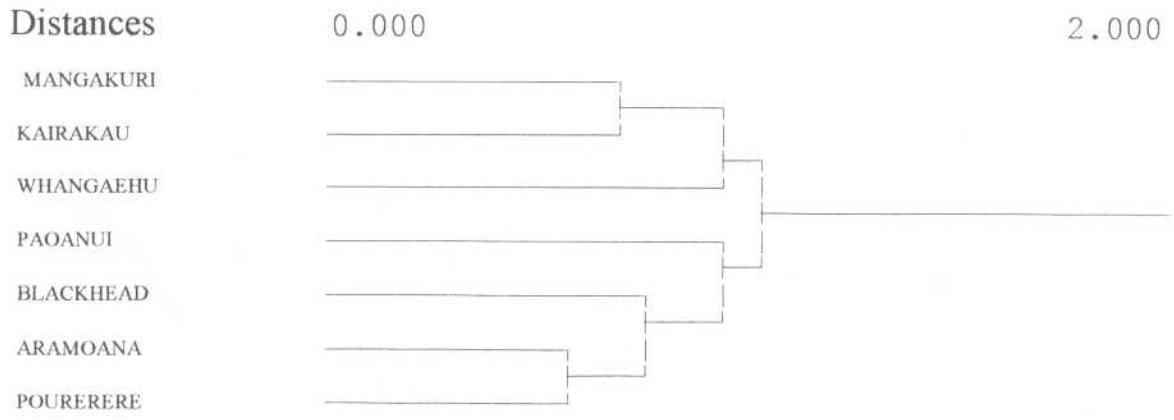


Figure 2. Tree diagram of a cluster analysis of the frequency of occurrence in quadrat data (standardized to proportion at each location). The distance metric used was the euclidean distance, and linkage was made using the average linking criteria.

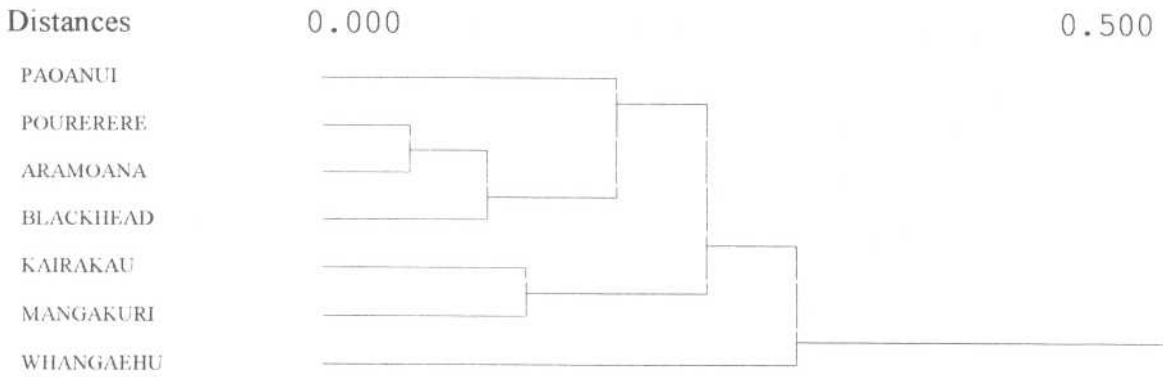


Figure 3. Tree diagram of a cluster analysis of the frequency of occurrence in quadrat data. The distance metric used was 1 minus the Pearson correlation coefficient (which meant that standardization was un necessary). The linkage was made using the average linking criteria.

4. DISCUSSION

4.1. Evaluation of Original Data.

The format of the data received did not allow direct data entry into a database and required a large amount of time to convert the observations from each quadrat into a suitable format. The handwritten data were often difficult to decipher and contained numerous ambiguous references to species such a "green carpet 5%", "hermit crab", etc. which could refer to more than one species. The recording of abundance as numbers for some species and percent cover for others, especially algae, is common practice and it should be possible to use these data for intraspecific comparisons, and interspecific comparisons of like data. Unfortunately, a few species (especially *Zeacumantus* and *Littorina* species) had their relative abundance estimated both in terms of estimated numbers in some quadrats and percent cover in others, within the same transect. Such an approach would preclude any analyses which use the data in any but a presence/absence manner.

Interpretation of the field notes of other people is notoriously difficult because of information not written out explicitly but kept in memory. In the study being reported upon this is especially the case with habitat definitions. Evaluation of the distribution of species across habitats was prevented by inconsistency of habitat definitions. The consistent inclusion of substrate type, sandstone or mudstone or rock, would have been far more valuable (and less frustrating) than ambiguous references to "covered" or "uncovered".

Data for an unlisted "transect 5" was found in the original data sheets but its geographical location was not stated and could not be deduced from the sampling date. These data have, therefore, not been included either in the database or the summaries.

4.2. Evaluation of Original Survey Design.

In general, we believe the researchers examined far too many quadrats in too much detail. It would have been better to have taken larger, random quadrats along more transects or, preferably, within distinct habitat types at each location, with a standardized method for recording each species. A standardized species checklist would also have been useful for recording species counts and percent cover after an initial preliminary survey of the overall area to determine the most common species present.

There appears to have been much effort expended to collect quantitative data with little thought as to how the data could be analyzed beyond a qualitative estimate of abundance. The only way in which the quantitative data appears to have been used is to provide statements of whether a species is rare, common, or abundant.

For community comparisons, more value may lie in the large number of quadrats taken and not the numbers within them. That is, given the assumptions listed in section 2.3 (p 9) the data can be used to compare the frequency of occurrence of a species at any one location by habitat type or between transects and locations. Examples of such analyses are given in this report.

The creation of an array of habitat types which attempted to combine characteristics such as substrate, tidal height, exposure, and specific features, instead of recording these characters separately, detracted from the value of the data. Quadrat descriptions would have been more useful if attributes such as relative height had actually been measured separately. The failure to correlate quadrat position with the major environmental factor of tidal height, precluded valuable information from being used in valid inter-transect comparisons. Overall, we believe that, although the researchers clearly expended a great deal of time and energy on this project, much of the effort was wasted through lack of forethought regarding subsequent data analyses.

4.3. Data Summary and Community Comparisons

We have prepared the data, given the limitations discussed above, in a format which will be amenable to further more advanced analyses which were beyond the scope of work of this current report. The frequency of occurrence tables (Appendices 1 - 8) illustrate the type of summaries which can be prepared for each transect so that individual species or groups of species recorded as either counts or percent coverage can be compared. More detailed analyses of species groups by habitat types can also be compared using the frequency data.

We believe the habitat types into which we have grouped the original data may be more appropriate for combining similar quadrats and thus could be used for inter-location comparisons. However, it would require actual site visits to confirm the validity of our groupings.

Comparisons of individual species can be made validly, but community analyses will be complex without detailed consideration of the limits of the data. The cluster analyses presented are preliminary and the assumptions underlying their

validity (that the transects adequately represent the community present) require testing. Despite this they do suggest some initial conclusions.

There appears to be a relation between the clusters identified and geographic proximity. Pourerere is geographically close to Aramoana which is close to Blackhead, and Paoanui is close to Pourerere. Also, Kairakau is close to Mangakuri and is somewhat separated from the previous four localities. However, using euclidean distance (Fig. 2), the clustering suggests that Whangaehu is most similar to those localities which are most removed geographically. The use of Pearson's correlation coefficient, however, suggests that Whangaehu may form the basis of a separate group with only one representative.

This relation is more likely to be related to the general substrate type than simple geographic proximity (though geographic proximity often relates to substrate). The link between Mangakuri and Kairakau may well be related to the reported fact (Creswell & Warren, 1990) that their physical habitat is similar, being made up of sandstone platforms covered in broken rocks and boulders.

Paoanui, Pourerere, Aramoana, and Blackhead were all reported (Creswell & Warren, 1990) to be made up of mudstone reef platforms with some rocky outcrops. Paoanui was reported as being the most different, physically, from the other three sites and was the last location to join with this cluster.

Whangaehu was reported as being made up of mudstone platforms but with many broken rocky reefs and boulders (Creswell & Warren, 1990). This might be part of the explanation for the instability of the links made by Whangaehu with the other groups in the cluster analyses.

4.4. Recommendations for Further Analyses

As mentioned above, the mixed form of data recording for different species (i.e. both abundance counts and percent cover estimates in the same database) makes comparisons between locations of the total communities difficult. Comparisons of individual species between sites will be valid, however, and could provide interesting information on how the relative abundance of particular species varies geographically and by habitat.

The lack of adequate information regarding the physical habitat at each quadrat (relative height, precise substrate type, and exposure) limits the type of conclusions that can be derived from the biological data. Without such

information detailed analysis of this data may be of limited management value. However, further analyses of the data in the databases provided could include:

1) Single species comparisons between transects, locations, habitats, and position along transect.

2) Multi-species comparisons within taxonomic groups. This is possible because generally the method of density estimation used (absolute abundance or percent cover) tended to be the same within a single taxonomic group. Thus, gastropods were generally counted directly. All algal species were estimated using percent cover.

3) Total community comparisons between locations and transects. This would require using the large number of quadrats taken at each location to be representative of the whole community. If this were the case then the frequency of quadrats in which each species occurs could be used in standard multi-variate analyses. Such analyses could be carried out by location (as in the cluster analyses in this report) or by transect (required to test the assumption that the quadrats represent the area), but not by quadrat.

4) Inter-quadrat comparisons within locations. An attempt could be made to determine natural groupings (possibly relating to habitat) of species within any one location. This would involve using presence/absence information from each quadrat in multi-variate analyses to find similarities and dissimilarities.

4.5. Recommendations for Future Survey Designs

Future surveys should be designed with clearly defined objectives along with criteria for achieving those objectives which reflect the importance of the question being answered by the survey. The survey design will be determined by the objectives (the questions the study is attempting to answer). The design, in turn, will determine which criteria, for achieving the objectives, are selected. Criteria should include a completion date and the level of precision required.

Surveys designed to characterize coastal locations to enable comparisons to be made between biological communities and permit an evaluation of the ecological significance of each location, might include objectives such as:

a) Determine the types, areal extent, and character of different physical habitats at defined coastal locations (character to include substrate type, exposure, relative height).

b) Determine the presence/absence of all taxonomic groups within particular habitats at defined locations.

c) Determine the relative abundance of all species present in terms of predefined categories of abundance which can then be ranked (each taxonomic group would require different categories).

d) Determine the species, in each habitat type, which dominate either in terms of numbers, cover, or biomass.

Data from a survey such as this would include answers to

1) Which locations contain the highest diversity of habitats?

2) Which habitats contain the highest number of species?

3) Which species occur and are dominant, in which habitats, at different locations?

4) Are uncommon, rare, or endangered species present?

The answers to the above could then be interpreted by marine ecologists and resource managers to help them make decisions on the ecological significance of particular locations.

5. REFERENCES

Creswell, P.D. & E. J. Warren (1990) The Flora and Fauna of the Southern Hawkes Bay Coast. (Unpublished manuscript prepared for Department of Conservation, Napier).

APPENDICES

Appendix l. Aramoana Site: Frequency of Occurrence by CMRU Habitat.						
	Total	1	2	3	4	5
Habitats	184	0	123	7	0	54
Actinothoe albacincta	3	0	2	0	0	1
Adenocystis ultricularis	22	0	12	0	0	10
Amaurochiton glaucus	6	0	2	0	0	4
Anthopleura aureoradiata	8	0	5	0	0	3
Apophloea sinclairii	18	0	14	1	0	3
Black Lichen	10	0	1	6	0	3
Chamaespiho brunnea	5	0	0	3	0	2
Chaemosipho columna	10	0	1	6	0	3
Cellana flava	2	0	1	1	0	0
Cominella glandiformis	30	0	24	0	0	6
Cominella maculosa	30	0	11	1	0	18
Cellana ornata	3	0	1	2	0	0
Carpophyllum plumosum	3	0	0	0	0	3
Cellana radians	11	0	4	6	0	1
Cystophora retroflexa	12	0	4	0	0	8
Cystophora torulosa	18	0	3	0	0	15
Codium adhaerans	103	0	77	1	0	25
Colpomenia sinuosa	81	0	43	0	0	38
Cookia sulcata	1	0	0	0	0	1
Corallina spp	158	0	103	3	0	52
Cyclograpsus laevauxi	2	0	0	0	0	2
Epopella plicata	4	0	0	3	0	1
Evechinus chloroticus	2	0	0	0	0	2
Hemigrapsus edwardsii	3	0	1	1	0	1
Halicarcinus whitei	2	0	0	0	0	2
Halopteris spicigera	1	0	0	0	0	1
Haustrum haustorium	22	0	10	3	0	9
hermit crab	30	0	7	1	0	22

Appendix 1. Aramoana Site: Frequency of Occurrence by CMRU Habitat.						
	Total	1	2	3	4	5
Haliotis iris	2	0	0	0	0	2
Hormosira banksii	153	0	102	3	0	48
Ischnochiton maorianus	6	0	0	0	0	6
Isactinia sps	9	0	8	0	0	1
Isocradactis magna	1	0	1	0	0	0
Jania micrarthroidia	2	0	1	0	0	1
Lepsiella scobina	33	0	14	6	0	13
Littorina spp	59	0	35	1	0	23
Melagraphia aethiops	120	0	77	4	0	39
Notomithrax ursus	2	0	0	0	0	2
Patelloidia corticata	1	0	0	0	0	1
Patierella regularis	6	0	1	0	0	5
Pomatoceros cariniferus	1	0	0	0	0	1
Sargassum sinclairii	1	0	0	0	0	1
Scutus breviculus	1	0	0	0	0	1
Scytothamnus australis	16	0	8	4	0	4
Spirobis sp	33	0	12	0	0	21
Sypharochiton sps	56	0	40	5	0	11
Turbo smaragdus	109	0	57	0	0	52
Ulva lactuca	7	0	4	0	0	3
Zeacumantus subcarinatus	58	0	30	0	0	28
Zonaria angusta	6	0	1	0	0	5
Zostera muelleri	22	0	15	0	0	7

Appendix 2. Blackhead Site: Frequency of Occurrence of CMRU Habitats

	Total	1	2	3	4	5
Habitat	189	1	112	26	17	33
Amaurochiton glaucus	4	0	2	0	0	2
Apophloea sinclairii	16	0	3	7	1	5
Black Lichen	9	0	0	8	0	1
Chamaespiho brunnea	13	0	0	12	1	0
Chaemosipho columna	19	0	0	17	0	2
Cellana denticulata	1	0	0	1	0	0
Cellana flava	8	0	5	3	0	0
Carpophyllum flexuosum	2	0	0	0	0	2
Cominella glandiformis	2	0	2	0	0	0
Cominella maculosa	24	0	17	0	0	7
Carpophyllum maschalocarpum	13	0	0	0	8	5
Cellana ornata	15	0	1	13	0	1
Carpophyllum plumosum	18	0	0	0	3	15
Cellana radians	27	0	6	18	1	2
Cystophora retroflexa	12	0	0	0	2	10
Cystophora torulosa	26	0	1	0	3	22
Codium adhaerans	70	0	53	6	5	6
Colpomenia sinuosa	54	0	28	1	9	16
Cookia sulcata	4	0	0	0	0	4
Corallina spp	158	0	102	9	14	33
Coscinasterias calamaria	2	0	0	0	0	2
Cyclograpsus laevauxi	1	0	0	1	0	0
Epopella plicala	10	0	0	9	1	0
Evechinus chloroticus	12	0	0	0	1	11
Glossophora kunthii	4	0	0	0	4	0
Halopleris spicigera	10	0	2	0	3	5

Appendix 2. Blackhead Site: Frequency of Occurrence of CMRU Habitats

	Total	1	2	3	4	5
Haustrum haustorium	19	0	4	5	0	10
hermit crab	16	0	6	1	0	9
Haliotis iris	3	0	0	0	0	3
Hormosira banksii	137	0	98	7	9	23
Ischnochiton maorianus	4	0	0	0	0	4
Isactinia sps	25	0	19	5	0	1
Isocradactis magna	1	0	1	0	0	0
Jania micrarthroidia	1	0	0	0	0	1
Lepsiella scobina	18	0	6	12	0	0
Lithothamnion spp	63	0	42	4	7	10
Littorina spp	56	0	39	13	0	4
Mitella spinosa	3	0	0	3	0	0
Melagraphia aethiops	78	0	55	9	1	13
Microzonia velutina	2	0	0	0	1	1
Nerita atramentosa milanotragus	2	0	0	2	0	0
Notomithrax ursus	4	0	0	0	0	4
Notheia anomala	18	0	12	0	3	3
Onchidella nigricans	9	0	3	4	0	2
Oulactis muscosa	26	0	24	1	0	1
Ozius truncatus	1	0	0	1	0	0
Petrolithes elongatus	3	0	1	0	0	2
Plagusia chabrus	2	0	0	0	0	2
Plocamium cosiatum	2	0	1	0	0	1
Pomatoceros cariniferus	3	0	3	0	0	0
Porphyra colombina	1	0	0	1	0	0
Pterocladia spp	1	0	0	0	0	1
Sargassum sinclairii	3	0	0	0	0	3
Scutus breviculus	1	0	0	0	0	1
Scytothamnus australis	12	0	2	6	1	3
Siphonaria zelandica	3	0	2	1	0	0

Appendix 2. Blackhead Site: Frequency of Occurrence of CMRU Habitats						
	Total	1	2	3	4	5
Spirobis sp	6	0	1	0	0	5
Sypharochiton sps	55	0	35	11	1	8
Thais orbita	1	0	0	1	0	0
Turbo smaragdus	115	0	71	5	11	28
Ulva lactuca	34	0	23	2	4	5
Xenostrobus pulex	2	0	0	2	0	0
Zeacumanius subcarinatus	24	0	20	0	0	4
Zonaria angusta	14	0	0	0	6	8
Zostera muelleri	16	0	11	0	0	5

Appendix 3. Kairakau Site: Frequency of Occurrence of the CMRU Habitat types.

	Total	1	2	3	4	5
Habitat	113	2	26	42	6	37
Acantochiton zelandicus	1	0	0	0	0	1
Amaurochiton glaucus	14	1	0	8	0	5
Anthopleura aureoradiata	1	1	0	0	0	0
Apophloea sinclairii	15	0	2	9	0	4
Black Lichen	8	0	0	7	0	1
Chamaespiho brunnea	7	0	0	7	0	0
Chaemosipho columna	11	0	0	9	0	2
Cellana denticulata	4	0	0	3	0	1
Carpophyllum flexuosum	3	0	0	0	1	2
Cominella glandiformis	4	0	4	0	0	0
Cominella maculosa	5	0	1	2	0	2
Carpophyllum maschalocarpum	5	0	0	0	2	3
Cellana ornata	11	0	0	10	0	1
Carpophyllum plumosum	18	0	1	1	3	13
Cellana radians	20	0	1	16	0	3
Cystophora retroflexa	5	0	0	0	0	5
Cystophora torulosa	26	0	5	3	2	16
Codium adhaerans	6	0	4	2	0	0
Colpomenia sinuosa	35	0	8	5	3	19
Corallina spp	69	1	17	14	2	35
Cyclograpsus laevauxi	1	0	0	1	0	0
Diloma bicanalicuta	4	0	0	4	0	0
Ddoma nigerrima	10	0	1	8	0	1
Epopella plicata	1	0	0	1	0	0
Forsterygion lapillum	5	0	0	0	0	511
Halopteris spicigera	4	0	0	0	1	3

Appendix 3. Kairakau Site: Frequency of Occurrence of the CMRU Habitat types.

	Total	1	2	3	4	5
Haustrum haustorium	6	0	1	3	0	2
hermit crab	10	0	2	1	0	7
Heterozius rotundifrons	3	0	0	2	0	1
Hormosira banksii	58	1	17	13	2	25
Ischnochiton maorianus	9	0	1	2	0	6
Isactinia sps	3	1	0	1	0	1
Isopods	1	0	0	1	0	0
Lepsiella scobina	8	0	0	8	0	0
Lithothamnion spp	4	0	0	1	0	3
Littorina spp	23	0	2	18	0	3
Mitella spinosa	1	0	0	1	0	0
Melagraphia aethiops	64	0	16	29	0	19
Microzonia velutina	3	0	0	0	2	1
Nerita atramentosa milanotragus	3	0	0	3	0	0
Notheia anomala	6	0	1	1	0	4
orange anemone	1	0	0	0	0	1
Ozius truncatus	12	0	0	9	0	3
Patierella regularis	3	0	0	2	0	1
Petrolithes elongatus	25	1	2	14	0	8
Plagusia chabrus	1	0	1	0	0	0
Pomatoceros cariniferus	11	0	1	5	0	5
Porphyra colombina	2	0	0	2	0	0
Pterocladia spp	3	0	0	0	0	3
Sargassum sinclairii	4	0	1	0	2	1
Siphonaria zelandica	2	0	0	2	0	0
Spirobis sp	11	0	1	4	0	6
Scytothamnus austrilis	38	1	8	15	0	14
Sypharochiton sps	15	0	3	4	1	7
Thais orbita	1	0	1	0	0	0
Tunicates	1	0	0	0	0	1

Appendix 3. Kairakau Site: Frequency of Occurrence of the CMRU Habitat types.

	Total	1	2	3	4	5
Turbo smaragdus	67	0	14	14	4	35
Ulva lactuca	1	0	1	0	0	0
Yellow Lichen	1	0	0	0	0	1
Zeacumantus subcarinatus	8	0	3	1	0	4
Zonaria angusta	6	0	0	1	2	3
Zostera muelleri	33	0	16	4	0	13

Appendix 4. Mangakuri Site: Frequency of Occurrence of CMRU Habitat types.

	Total	1	2	3	4	5
Habitat	104	12	23	53	0	16
Actinothoe albacincta	3	0	1	2	0	0
Amaurochiton glaucus	27	2	10	12	0	3
Apophloea sinclairii	13	1	0	10	0	2
Black Lichen	11	0	1	10	0	0
Buccinulum multilineum	1	0	0	1	0	0
Chamaespiho brunnea	3	0	0	3	0	0
Chaemosipho columna	13	0	0	13	0	0
Cellana denticulata	4	0	0	3	0	1
Cominella maculosa	3	0	0	3	0	0
Carpophyllum maschalocarpum	2	0	0	0	0	2
Cellana ornata	17	0	0	16	0	1
Carpophyllum plumosum	3	0	1	0	0	2
Cellana radians	33	2	2	26	0	3
Cystophora retroflexa	4	0	1	2	0	1
Cystophora torulosa	30	0	8	11	0	11
Codium adhaerans	8	0	4	3	0	1
Colpomenia sinuosa	4	0	1	3	0	0
Cookia sulcata	1	0	0	0	0	1
Corallina spp	65	3	21	31	0	10
Cyclograpsus laevauxi	6	1	3	2	0	0
Diloma bicanalicuta	1	0	0	1	0	0
Evechinus chloroticus	1	0	0	1	0	0
Hemigrapsus edwardsii	3	0	1	2	0	0
Halopteris spicigera	13	1	1	3	0	8
Haustrum haustorium	11	0	1	10	0	0
hermit crab	4	0	0	4	0	0

Appendix 4. Mangakuri Site: Frequency of Occurrence of CMRU Habitat types.						
	Total	1	2	3	4	5
Haliotis iris	1	0	0	1	0	0
Hormosira banksii	64	3	18	31	0	12
Ischnochiton maorianus	13	0	6	6	0	1
Isactinia sps	1	0	1	0	0	0
Isocladus armatus	1	0	1	0	0	0
Isocradactis magna	1	0	0	1	0	0
Lepsiella scobina	14	0	1	12	0	1
Lithothamnion spp	10	0	1	3	0	6
Littorina spp	18	2	6	8	0	2
Melagraphia aethiops	55	4	11	34	0	6
Microzonia velutina	1	0	0	0	0	1
Notomithrax ursus	1	0	1	0	0	0
Notheia anomala	5	0	4	1	0	0
Onchidella nigricans	3	0	2	1	0	0
Patelloidia corticata	1	0	0	1	0	0
Patierella regularis	3	0	0	3	0	0
Petrolithes elongatus	18	1	6	10	0	1
Plocamium costatum	1	0	1	0	0	0
Pomatoceros cariniferus	15	1	6	8	0	0
Sargassum sinclairii	2	0	0	2	0	0
Scytothamnus australis	42	1	6	26	0	9
Spirobis sp	31	1	14	13	0	3
Sypharochiton sps	57	3	10	37	0	7
Turbo smaragdus	60	2	14	34	0	10
Xenostrobus pulex	2	0	0	2	0	0
Yellow Lichen	10	1	1	6	0	2
Zeacumantus subcarinatus	7	1	4	1	0	1
Zonaria angusta	4	0	0	3	0	1
Zostera muelleri	9	1	0	7	0	1

Appendix 5. Paoanui Site: Frequency of Occurrence of CMRU Habitat types.

	Total	1	2	3	4	5
Habitat	129	3	63	12	0	51
Adenocystis ultricularis	23	0	12	1	0	10
Amaurochiton glaucus	1	0	0	0	0	1
Anthopleura aureoradiata	10	0	4	0	0	6
Apophloea sinclairii	2	0	0	2	0	0
Black Lichen	5	0	0	4	0	1
Chamaespiho brunnea	4	0	0	4	0	0
Chaemosipho columna	14	0	0	12	0	2
Cellana flava	1	0	0	1	0	0
Cominella maculosa	17	0	7	0	0	10
Cellana ornata	7	0	0	7	0	0
Cellana radians	11	0	0	8	0	3
Cystophora retrofexa	8	0	3	0	0	5
Cystophora torulosa	19	0	5	1	0	13
Carpophyllum plumosum	2	0	0	0	0	2
Caulerpa brownii	7	0	5	0	0	2
Codium adhaerans	34	0	18	4	0	12
Cominella glandiformis	3	0	0	0	0	3
Colpomenia sinuosa	46	0	24	3	0	19
Cookia sulcata	1	0	1	0	0	0
Corallina spp	106	1	55	3	0	47
Cyclograpsus laevauxi	1	0	0	0	0	1
Epopella plicata	2	0	0	2	0	0
grey lichen	1	0	0	1	0	0
Glossophora kunthii	8	0	2	0	0	6
Halicarcinus whitei	2	0	1	0	0	1
Halopteris spicigera	10	0	8	0	0	2

Appendix 5. Paoanui Site: Frequency of Occurrence of CMRU Habitat types.

	Total	1	2	3	4	5
Haustrum haustorium	15	0	6	5	0	4
hermit crab	25	0	9	1	0	15
Hormosira banksii	74	0	30	5	0	39
Isactinia sps	18	0	6	0	0	12
Isocladus armatus	3	0	1	0	0	2
Isopods	1	0	1	0	0	0
Jania micrarthroidia	36	0	12	0	0	24
Lepsiella scobina	4	0	0	4	0	0
Littorina spp	40	0	19	2	0	19
Melagraphia aethiops	24	0	9	3	0	12
Notomithrax ursus	1	0	0	0	0	1
Onchidella nigricans	4	0	0	4	0	0
Petrolithes elongates	1	0	0	0	0	1
Plocamium costatum	13	0	7	0	0	6
Pterocladia spp	2	0	0	0	0	2
Sypharochiton pelliserpentis	15	0	1	10	0	4
Sargassum sinclairii	4	0	1	0	0	3
Scytothamnus australis	13	0	2	7	0	4
Spirobis sp	2	0	1	0	0	1
Splachnidium rugosum	2	0	0	2	0	0
top shells	1	0	0	1	0	0
Turbo smaragdus	50	0	23	3	0	24
Ulva lactuca	2	0	0	0	0	2
Xenostrobus pulex	3	0	0	3	0	0
Yellow Lichen	1	0	1	0	0	0
Zeacumantus subcarinatus	43	0	16	1	0	26
Zonaria angusta	3	0	1	0	0	2

Appendix 6. Pourerere Site: Frequency of Occurrence of CMRU Habitat types.						
	Total	1	2	3	4	5
Habitat	149	6	92	20	2	29
Adenocystis ultricularis	5	0	3	0	1	1
Amaurochiton glaucus	17	0	7	2	0	8
Apophloea sinclairii	31	0	19	8	0	4
Black Lichen	17	0	1	14	0	2
Chamaespiho brunnea	8	0	0	7	0	1
Chaemosipho columna	13	0	0	9	0	4
Cellana denticulata	6	0	1	4	0	1
Cellana flava	1	0	1	0	0	0
Cominella glandiformis	20	3	13	0	0	4
Cominella maculosa	20	0	14	1	1	4
Cellana ornata	8	0	0	7	0	1
Carpophyllum plumosum	1	0	1	0	0	0
Cellana radians	18	0	5	12	0	1
Cystophora retroflexa	5	0	0	0	0	5
Cystophora torulosa	15	0	2	2	0	11
Cantharidella tesselata	1	0	0	0	0	1
Codium adhaerans	78	0	53	8	2	15
Colpomenia sinuosa	44	0	33	3	1	7
Cookia sulcata	1	0	0	0	0	1
Corallina spp	129	2	87	10	2	28
Coscinasterias calamaria	3	0	0	1	0	2
Cyclograpsus laevauxi	1	0	1	0	0	0
Diloma arida	3	0	0	2	0	1
Epopella plicata	7	0	0	7	0	0
Evechinus chloroticus	2	0	0	0	0	2
Halicarcinus whitei	2	0	1	1	0	0
Haustrum haustorium	16	0	3	4	0	9
hermit crab	18	0	10	0	0	8

Appendix 6. Pourerere Site: Frequency of Occurrence of CMRU Habitat types.						
	Total	1	2	3	4	5
Hormosira banksii	118	0	78	9	2	29
Ischnochiton maorianus	22	0	7	3	0	12
Isactinia sps	5	1	3	1	0	0
Isocradactis magna	1	0	0	1	0	0
Lepsiella scobina	22	0	3	13	0	6
Lithothamnion spp	1	0	1	0	0	0
Littorina spp	93	0	69	10	0	14
Mitella spinosa	2	0	0	2	0	0
Melagraphia aethiops	73	0	48	6	1	18
Notomithrax ursus	4	0	1	1	0	2
Notheia anomala	22	0	14	0	0	8
Onchidella nigricans	4	0	1	2	0	1
Oulactis muscosa	9	0	9	0	0	0
Patierella regularis	5	0	3	1	0	1
Petrolithes elongatus	7	0	3	2	0	2
Phlyctenactis tuberculosa	1	0	0	1	0	0
Pomatoceros cariniferus	3	0	1	0	0	2
Sargassum sinclairii	2	0	0	0	0	2
Scutus breviculus	4	0	1	0	0	3
Scytothamnus australis	17	0	6	6	1	4
Siphonaria zelandica	6	0	3	3	0	0
Spirobis sp	22	0	12	2	0	8
Splachnidium rugosum	3	0	3	0	0	0
Sypharochiton sps	30	0	14	8	1	7
Turbo smaragdus	89	0	60	5	1	23
Ulva lactuca	6	0	5	0	0	1
Xenostrobus pulex	1	0	0	1	0	0
Xymene plebeius	2	0	0	0	0	2
Yellow Lichen	2	0	1	0	0	1
Zeacumantus subcarinaius	67	2	51	1	0	13
Zostera muelleri	39	0	23	2	0	14

Appendix 7. Whangaehu Site: Frequency of Occurrence of CMRU Habitat types.

	Total	1	2	3	4	5
Habitat	40	0	19	10	3	8
Amaurochiton glaucus	2	0	0	1	0	1
Apophloea sinclairii	4	0	0	3	0	1
Black Lichen	1	0	0	1	0	0
Chamaespiho brunnea	3	0	0	3	0	0
Chaemosipho columna	4	0	0	4	0	0
Cellana denticulata	1	0	1	0	0	0
Cellana flava	6	0	3	2	0	1
Cominella maculosa	1	0	1	0	0	0
Carpophyllum maschalocarpum	2	0	0	0	2	0
Cellana ornata	6	0	2	4	0	0
Carpophyllum plumosum	5	0	0	0	2	3
Cellana radians	10	0	5	3	0	2
Cystophora torulosa	3	0	0	0	0	3
Cantharidella tesselata	1	0	1	0	0	0
Carodiloma coracina	1	0	1	0	0	0
Colpomenia sinuosa	5	0	3	0	1	1
Corallina spp	21	0	10	2	1	8
Cyclograpsus laevauxi	1	0	0	1	0	0
Diloma spp	1	0	0	1	0	0
Epopella plicata	2	0	1	1	0	0
Enteromorpha spp	4	0	2	0	1	1
Evechinus chloroticus	1	0	0	1	0	0
Glossophora kunthii	1	0	0	0	0	1
Halopteris spicigera	3	0	0	0	0	3
Haustrum haustorium	3	0	1	1	0	1
hermit crab	1	0	0	0	0	1
Hormosira banksii	10	0	2	3	1	4

Appendix 7. Whangaehu Site: Frequency of Occurrence of CMRU Habitat types.

	Total	1	2	3	4	5
Ischnochiton maorianus	1	0	0	0	0	1
Isactinia sps	2	0	1	1	0	0
Isocradactis magna	1	0	1	0	0	0
Lepsiella scobina	3	0	0	2	0	1
Lithothamnion spp	12	0	4	3	0	5
Littorina spp	17	0	12	4	1	0
Melagraphia aethiops	14	0	7	3	0	4
Mytilus edulis aoteanus	1	0	1	0	0	0
Onchidella nigricans	4	0	0	4	0	0
orange anemone	4	0	4	0	0	0
Patelloidia corticata	1	0	1	0	0	0
Petrolithes elongatus	2	0	0	1	0	1
Pomatoceros cariniferus	1	0	0	1	0	0
Porphyra colombina	8	0	6	2	0	0
Scytothamnus australis	2	0	0	2	0	0
Siphonaria zelandica	1	0	1	0	0	0
Spirobis sp	1	0	0	1	0	0
Sypharochiton sps	9	0	4	1	0	4
Turbo smaragdus	15	0	4	3	1	7
Ulva lactuca	5	0	3	0	0	2
Xenostrobus pulex	1	0	1	0	0	0
Zonaria angusta	2	0	0	0	0	2

Appendix 8. List of Frequency of Occurrence of all species at each location. Aram - Aramoana, Black - BlackHead, Kairak - Kairakau, Mang - Mangakuri, Paoan - Paoanui, Pour - Pourere, Whan - Whangaehu.

	Aram	Black	Kairak	Mang	Paoan	Pour	Whan
Number of Quadrats	184	189	113	104	129	149	40
Acanthochiton zelandicus			1				
Actinothoe albacincta	3			3			
Adenocystis ultricularis	22				23	5	
Amaurochiton glaucus	6	4	14	27	1	17	2
Anthopleura aureoradiata	8		1		10		
Apophloea sinclairii	18	16	15	13	2	31	4
Black Lichen	10	9	8	11	5	17	1
Buccinulum multilineum				1			
Chamaespiho brunnea	5	13	7	3	4	8	3
Chaemosipho columna	10	19	11	13	14	13	4
Cellana denticulata		1	4	4		6	1
Cellana flava	2	8			1	1	6
Carpophyllum flexuosum		2	3				
Cominella glandiformis	30	2	4			20	
Cominella maculosa	30	24	5	3	17	20	1
Carpophyllum maschalocarpum		13	5	2			2
Cellana ornata	3	15	11	17	7	8	6
Carpophyllum plumosum	3	18	18	3	2	1	5
Cellana radians	11	27	20	33	11	18	10
Cystophora retroflexa	12	12	5	4	8	5	
Cystophora torulosa	18	26	26	30	19	15	3
Cantharidella tesselata						1	1
Caroddoma coracina							1
Caulerpa brownii					7		
Codium adhaerans	103	70	6	8	3	78	
Colpomenia sinuosa	81	54	35	4	46	44	5
Cookia sulcata	1	4		1	1	1	

Appendix 8. List of Frequency of Occurrence of all species at each location. Aram - Aramoana, Black - BlackHead, Kairak - Kairakau, Mang - Mangakuri, Paoan - Paoanui, Pour - Pourere, Whan - Whangaehu.

	Aram	Black	Kairak	Mang	Paoan	Pour	Whan
Corallina spp	158	158	69	65	106	129	21
Coscinasterias calamaria		2				3	
Cyclograpsus laevauxi	2	1	1	6	1	1	1
Diloma arida						3	
Diloma bicanalicuta			4	1			
Diloma nigerrima			10				
Diloma spp							
Epopella plicata	4	10	1		2	7	2
Enteromorpha spp							4
Evechinus chloroticus	2	12		1		2	1
grey lichen					I		
Glossophora kunthii		4			8		1
Hemigrapsus edwardsii	3			3			
Halicarcinus whitei	2				2	2	
Halopteris spicigera	1	10	4	13	10		3
Haustrum haustorium	22	19	6	11	15	16	3
hermit crab	30	16	10	4	25	18	1
Heterozius rotundifrons			3				
Haliotis iris	2	3		1			
Hormosira banksii	153	137	58	64	74	118	10
Ischnochiton maorianus	6	4	9	13		22	1
Isactinia sps	9	25	3	1	18	5	2
Isocladus armatus				1	3		
Isocradactis magna	1	1		1		1	1
Isopods			1		1		
Jania micrarthroidia	2	1			36		
Lepsiella scobina	33	18	8	14	4	22	3
Lithothamnion spp		63	4	10		1	12
Littorina spp	59	56	23	18	40	93	17

Appendix 8. List of Frequency of Occurrence of all species at each location. Aram - Aramoana, Black - BlackHead, Kairak - Kairakau, Mang - Mangakuri, Paoan - Paoanui, Pour - Pourere, Whan - Whangaehu.

	Aram	Black	Kairak	Mang	Paoan	Pour	Whan
Mitella spinosa		3	1			2	
Melagraphia aethiops	120	78	64	55	24	73	14
Microzonia velutina		2	3	1			
Mytilus edulis aoteanus							1
Nerita atramentosa milanotragus		2	3				
Notomithrax ursus	2	4		0	1	4	
Notheia anomala		18	6	5		22	
Onchidella nigricans		9		3	4	4	4
orange anemone			1				
Oulactis muscosa		26				9	4
Ozius truncatus		1	12				
Patelloidia corticata	1			0			1
Patierella regularis	6		3	3		5	
Petrolithes elongatus		3	25	18	1	7	2
Phlyctenactis tuberculosa						1	
Plagusia chabrus		2	1				
Plocamium costatum		2		0	13		
Pomatoceros cariniferris	1	3	11	15		3	1
Porphyra colombina		1	2				8
Pterocladia spp		1	3		2		
Sargassum sinclairii	1	3	4	2	4	2	
Scutus breviculus	1	1				4	
Scytothamnus australis	16	12	15	42	13	17	2
Siphonaria zelandica		3	2			6	1
Spirobis sp	33	6	11	31	2	22	1
Splachnidium rugosum				1	2	3	
Sypharochiton sps	56	55	38	57	15	30	9
Thais orbita		1	1				
top shells					1		

Appendix 8. List of Frequency of Occurrence of all species at each location. Aram - Aramoana, Black - BlackHead, Kairak - Kairakau, Mang - Mangakuri, Paoan - Paoanui, Pour - Pourere, Whan - Whangaehu.

	Aram	Black	Kairak	Mang	Paoan	Pour	Whan
Tunicates			1				
Turbo smaragdus	109	115	67	60	50	89	15
Ulva lactuca	7	34	1		2	6	5
Xenostrobus pulex		2		2	3	1	1
Xymene plebeius						2	
Yellow Lichen			2	10	1	2	
Zeacumantus subcarinatus	58	24	8	7	43	67	
Zonaria angusta	6	14	6	4	3		2
Zostera muelleri	22	16	33	9	18	39	