GWAII HAANAS INTERTIDAL FIELD SURVEY

RESULTS OF CLUSTER ANALYSIS OF 1992 FIELD DATA

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ARCHIPELAGO MARINE RESEARCH LTD.

2ND FLOOR, 525 HEAD STREET
VICTORIA, B.C. V9A 5S1
TEL: (250) 383-4535 FAX: (250) 383-0103
email: amr@archipelago.ca

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Prepared by: Savanna Hayes and Mary Morris
Archipelago Marine Research Ltd.
Suite 200 – 525 Head Street
Victoria, BC V9A 5S2

Prepared for: Norm Sloan
Parks Canada, Gwaii Haanas
Box 37
Queen Charlotte, B.C. V0T 1S0

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Front Cover: Detail from mid-intertidal of Station 7, on west side of Annette Island, near Rose Harbour.

1.0 INTRODUCTION

1.1 BACKGROUND

Gwaii Haanas, a national park reserve, occupies approximately 1470 square km of upland with 1600 km of shoreline in the southernmost islands of the Haida Gwaii archipelago. As part of the initial phase of inventory in 1991 and 1992, a biophysical inventory of the coastal resources within the park was conducted by Coastal and Ocean Resources (Harper *et al.*, 1993 and 1994). An aerial video survey of the shoreline was completed during summer low tides, followed by coastal biophysical mapping. A field survey was then carried out in summer of 1992 to:

a) verify the qualitative habitat and community descriptions used for mapping
b) collect across-shore profile data on both morphology and community zonation levels and
c) prepare an initial species list of intertidal biota (Harper *et al.*, 1994).

Habitat types were identified by Harper *et al.* (1994) using professional interpretation of observations in the intertidal, based on the key species observed, the physical geomorphology of shore sites and an index of overall wave exposure. This shorezone biophysical mapping system was pioneered in Gwaii Haanas and has since been modified and adapted to map and classify different ecological regions throughout the rest of the British Columbia coast.

1.2 OBJECTIVES

In the following report, we re-visit the ground station data set and, by using statistical cluster analysis for non-parametric data, improve the confidence of the habitat type descriptions developed in by Harper *et al*. (1994). The shorestation data were not originally collected for the purpose of statistical analyses and are generally 'qualitative' observed data, not measured 'quantitative' data. However, we have applied non-parametric cluster analysis methods appropriate to comparing these type of data.

During the field verification program, in the summer of 1992, species observations (both macroflora and macrofauna) were recorded at 107 sites throughout Gwaii Haanas. Those data were originally transcribed into *dbase* files without data quality checks, nor were any analyses made. In 2001, a preliminary cluster analysis was run on the recovered data. In review of those preliminary results, we noted several data transcription errors per station -- in errors or omissions made either in transcribing field data or in data entry. Confidence in the results of the cluster analysis was reduced. A need to improve the quality of the old data set was identified.

The objectives for this project were:

- to review and correct the original shore station biophysical field dataset, by comparing original field data sheets and the 1992 *dbase* files to compile the data in a new ACCESS database format, including a master species list with a standard list of species names and acronyms.
- to run a cluster analysis of station/species data, using both the presence/absence data and relative abundance data for species observed at each station; as well as conducting a cluster analysis of the species data.
- to refine the definitions of 'habitat types' and 'bio-bands' (data dictionary tables used in aerial video mapping) and describe the various habitat types determined with photos and specific examples.

In a concurrent project we are reviewing the 1991 aerial imagery and adding interpretations of the bio-bands to the original data, which will make the Gwaii Haanas dataset compatible with other coastal bio-mapping projects in BC.

2.0 METHODS

2.1 DATABASE REVIEW

A review of the data transcription was carried out by comparing all entries on the original field data sheets against the current database. Species names entered for each station as well as species names on the master species list were verified and revised as necessary. Incidental intertidal fish species included in the original database were deleted prior to the completion of the cluster analysis. A few species had duplicate entries in the master species list and these were standardised into corrected names. For example, *Fucus* was entered as '*Fucus gardneri*', '*Fucus distichus*' and '*Fucus sp*'. These variations are describing the same species in Gwaii Haanas and have been standardised in the dataset for cluster analysis as '*Fucus sp*'. Substrate descriptions for the stations, wave fetch estimates and the latitude and longitude for each station were also added to the database.

2.2 CLUSTER ANALYSES

Cluster analyses are often employed to group communities based on their degree of similarity. Definitions of the cluster analyses used in this survey are defined in the text box below.

Definitions of Cluster Analyses Applied to the Gwaii Haanas Shore Station Dataset

Jaccard's similarity measure: This test compares the presence or absence of species within a station to every other species - station data comparison. Matches are "absent in both stations" (0 - 0) or "present in both stations "(1 - 1) and non-matches are species occurs in one station but not the other (0 - 1 or 1 - 0) Results of the interaction matrix are shown in a dendrogram, matching clusters of stations that are similar based on the presence or absence of a species.

Bray-Curtis similarity measure: This test compares the relative abundance of each species present within a station based on an qualitative abundance level of 1, 2 or 3. Results are shown in a dendrogram, with species' matches based on the relative abundance codes (e.g., few present at both stations:1-1 match, species common at both stations 2-2, or species abundant at both stations 3-3).

Bootstrap method: The bootstrap method has been employed to test non-parametric data and is based on re-sampling the data set (testing the relative abundance clusters against one another) when the population is not normally distributed (Nemec and Brinkhurst, 1998).

Nemec and Brinkhurst (1998) discuss the ability to distinguish between 'true' or 'artificial' differences in the underlying communities using cluster analyses. True differences are those that are statistically significant and artificial differences reflect the random variability within the community. It is expected that the variability between linkages in random clusters is higher than the variability in true clusters.

Cluster analyses were performed on the dataset from the species lists by shore station. A summary of the analyses performed is shown in Table 1. Based on the results from the first runs of the station clustering analyses, the relative abundance results showed clearer clusters of stations in the output.

Table 1. Summary of the Station Cluster and the Species Cluster Analyses.

	Station Dataset Analysis	Species Dataset Analysis
First Run of Cluster Analyses	• presence/absence cluster analysis (Jaccard's) • relative abundance cluster analysis (Bray-Curtis)	• presence/absence cluster analysis (Jaccard's)
Revisions to Dataset Input	• removed blank stations • removed ubiquitous species	• revised to include only species which occurred at least 5 times in the dataset
Second Run of the Cluster Analyses	• relative abundance cluster analysis (Bray-Curtis)	• presence/absence cluster analysis (Jaccard's)
Test significance of Cluster Analysis	• Bootstrap analysis of the clusters identified in the second run of the relative abundance clustering	• no further analysis of species clusters
Refine Clusters	• based on result of the bootstrap test, two pairs of clusters are combined, resulting in final set of 7 clusters of the station dataset.	• two general species clusters identified, corresponding approximately to the two most different clusters of stations.

The input dataset was refined prior to the second run of these analyses to further improve the cluster output. A number of species were ubiquitous throughout the stations and occurred at nearly every site. These were: *Littorina sitkana*, *Littorina scutulata*, *Verrucaria* and *Balanus glandula*. These species were removed from the second run of the analysis to improve the clustering. Also, two stations which were completely bare beaches and had no biota recorded were removed from the dataset for the second run. These stations were GH-92-77 and GH-92-26B. A total of 103 stations and 437 species were included in the second run of the relative abundance analyses.

The significance of the clusters identified in the second run of the relative abundance station data was tested using the '*bootstrap method*' (Nemec and Brinkhurst, 1998). In a bootstrap analysis, clusters are compared and a similarity index is determined for each pair of clusters compared. We used the null hypotheses that clusters were from the same community and we chose a low P-value (probability value) of 0.01 to test the null hypotheses and reduce the overall error in accepting the alternate hypotheses. That is, only clusters that were significantly different from all the other clusters were used to describe our final habitat types.

For the final station clusters, we determined which species were associated with stations in each cluster. We considered species that occurred in all of the stations in the group as *indicator* species for that cluster and also compiled a list of other associated species that occurred in at least three-quarters of the stations in the cluster.

To test which species co-occurred, we also ran a cluster analysis on the species dataset (Table 1). The analysis was based on the Jaccard's analysis for presence/absence data - the same analysis used for the station comparisons in the first run of the analyses. We subsequently simplified the species analysis output in the second run, by removing uncommon species (species occurred less than 5 times) in the dataset.

3.0 RESULTS

3.1 STATION CLUSTER ANALYSIS

Initially, nine clusters of stations were identified from the Bray-Curtis relative abundance cluster analysis and the presence/absence Jaccard's analysis. The summary of the relative abundance cluster appears below, as Table 4 and the summary table for the presence/absence station cluster is attached in Appendix A. Clear patterns between the geomorphology and the bio-exposure of the stations can be seen in the cluster summary.

Because the relative abundance analysis results showed clearer clustering of groups of stations, we used those results to refine and test the significance of the cluster results. The bootstrap test produced a dendrogram and details of the probability and the power of each comparison (called *linkages*) between clusters. The Bootstrap output is in Appendix B and summary of the linkages of the nine Bray-Curtis clusters are listed in Table 2. For each link between the nine clusters, a statistical probability is derived. The linkages with P-values of <0.01 show clusters that are from significantly different communities/habitat types (Table 2).

Table 2. Results of the Bootstrap cluster analysis showing the linkages between clusters identified in the Bray-Curtis cluster analysis.

Linkage*	Clusters linked	Probability	Power
1	3 and 5	0.0440	1.0000
2	1 and 2	0.0000	1.0000
3	1 and 3	0.0060	0.9900
4	6 and 7	0.0300	1.0000
5	1 and 4	0.0000	1.0000
10	1 and 6	0.0000	1.0000
21	1 and 8	0.8840	0.0440
24	1 and 9	0.5100	0.0000

* refers to figure in Appendix B.

Bray-Curtis relative abundance clusters that were more similar to each other were 3 and 5 which were both classified as Semi-exposed or Semi-protected and clusters 6 and 7 which were both Semi-protected or Protected exposures. The probability values for those two linkages were 0.044 and 0.030, respectively (Table 2). These two pairs of clusters were combined, based on acceptance of the null hypotheses that they are from similar communities.

Six of the linkages tested between clusters had a very high power level, equal to or greater than 0.9900 (Table 2). The higher the power level the less variability there is associated with the range of data, meaning there is greater statistical power.

Linkages 21 (between clusters 1 and 8) and 24 (between clusters 1 and 9) had a very low power including a non-significant P-value. These two clusters were different from Clusters 1 through 7, but show high variability within themselves. Therefor, the statistical significance of separateness of Clusters 8 and 9 could not be assessed due to their high internal variability.

Table 3. The Number of Clusters and Stations in the Bray Curtis Clusters and in the Bootstrap Test.

Bray Curtis Cluster Number	Number of Stations in Cluster	Revised Clusters after Bootstrap	Number of Stations in Cluster
1	12	1	12
2	8	2	8
3	14	3 and 5	18
4	5	4	5
5	4	-	-
6	15	6 and 7	19
7	4	-	-
8	15	8	15
9	8	9	8
totals:			
9 clusters	85* stations	7 clusters	85* stations

* Note that 103 stations are in the cluster analyses.

Clusters had different numbers of stations, ranging in size from 5 stations to 19 (Table 3). Of the 103 stations in the cluster analysis, only 85 were included in the significant clusters determined by the relative abundance cluster analysis. There are 18 stations that are associated with neighbouring clusters but were not included in any clusters in either the Relative Abundance cluster or in the subsequent Bootstrap test.

3.2 SPECIES CLUSTER ANALYSIS

The species cluster (Jaccard's presence/absence) analysis was simplified in the second run of the analyses by including only species that occurred at least 5 times in the dataset. In the resulting dendrogram, two major clusters were identified. Generally higher exposure indicator species clustered together and lower exposure indicator species grouped together. Some of the higher exposure species grouped together were *Mytilus californianus*, *Nereocystis luetkeana*, *Hedophyllum sessile, Phyllospadix scouleri,* and *Laminaria setchelli*. Some of the lower exposure species grouped together were *Halosaccion glandiforme, Ulva spp., Hemigrapsus nudus, Hemigrapsus oregonensis, Leathesia dira, Macrocystis integrefolia,* and *Laminaria groenlandica.* There was no clear definition of species assemblages in relation to habitat types as seen in the Bray-Curtis analyses of station data.

Table 4. Summary of the Bray-Curtis Relative Abundance Cluster Analysis. Cluster Group is a summary of the Cluster ID. Cluster numbers followed by decimal numbers are the stations that were adjacent to, but outside of the 9 clusters determined in the Bray Curtis analysis. (* Definitions of Bio-exposure in Appendix D, Table D - 3. Exposure 'XX' means current-dominated sites).

cluster group	Station Number	location	Cluster ID	coastal class name	definition of general substrate	exposure from biota *
1	GH-92-55	Wells Cove, south of Gowgaia Bay, west coast Moresby Is.	A2B2C1D2E2F2G2H2I2J2	Rock Ramp, wide	bedrock	VE
1	GH-92-21	Ninstints Pt., Louscoone Inlet	A2B2C1D2E2F2G2H2I2J2	Rock Ramp, narrow	bedrock	E
1	GH-92-10	Rock point just south of Lyman Point, east coast of Kunghit Is	A2B2C1D2E2F2G2H2I2J2	Rock Cliff	bedrock	E
1	GH-92-29	West shore Woodruff Bay, Kunghit Is.	A2B2C1D2E2F2G2H2I2J2	Rock Ramp, narrow	bedrock	E
1	GH-92-50	East end, East Copper Is.	A2B2C1D2E2F2G2H2I2J2	Rock Platform, wide	bedrock	E
1	GH-92-01	East shore High Is, entrance to Heater Hbr, NE Kunghit Is.	A2B2C1D2E2F2G2H2I2J2	Rock Ramp, wide	bedrock	E
1	GH-92-25	North tip Gordon Is, off west side Kunghit Is.	A2B2C1D2E2F2G2H2I2J2	Rock Ramp, wide	bedrock	E
1	GH-92-23	South side Bowles Pt, Kunghit Is	A2B2C1D2E2F2G2H2I2J2	Rock Ramp, wide	bedrock	E
1	GH-92-72	North of Gowgaia Bay	A2B2C1D2E2F2G2H2I2J2	Rock Ramp, narrow	bedrock	VE
1	GH-92-11	South of Lyman Pt., East shore Kunghit Is	A2B2C1D2E2F2G2H2I2J2	Cliff with gravel beach	mixed bedrock and sediment	E
1	GH-92-30	Cape St. James	A2B2C1D2E2F2G2H2I2J2	Rock Ramp, narrow	bedrock	E
1	GH-92-67	Kloo Rock	A2B2C1D2E2F2G2H2I2J2	Rock Ramp, wide	bedrock	E

Cluster 1 summary: 12 stations, all from bedrock ramp sites and from Exposed or Very Exposed Bio-exposure category.

2	GH-92-66	Kloo Rock, South shore	A2B2C1D2E2F2G2H2I2J1K3L3M2	Rock Ramp, narrow	bedrock	E
2	GH-92-42	Benjamin Pt. Lagoon	A2B2C1D2E2F2G2H2I2J1K3L3M2	Ramp w gravel/sand beach, wide	mixed bedrock and sediment	SE
2	GH-92-84	SW Bischoff Is	A2B2C1D2E2F2G2H2I2J1K3L3M2	Rock Ramp, narrow	bedrock	SE
2	GH-92-78	Lyell Is, Stansung It	A2B2C1D2E2F2G2H2I2J1K3L3M2	Rock Ramp, narrow	bedrock	SE
2	GH-92-41	Benjamin Pt.	A2B2C1D2E2F2G2H2I2J1K3L3M2	Platform with gravel beach, wide	mixed bedrock and sediment	SE
2	GH-92-08	Trevan Rock, Houston Stewart Channel	A2B2C1D2E2F2G2H2I2J1K3L3M2	Channel	current dominated	XX
2	GH-92-87	East Tar Is	A2B2C1D2E2F2G2H2I2J1K3L3M2	Rock Platform, wide	bedrock	SE
2	GH-92-101	Tanu village reef	A2B2C1D2E2F2G2H2I2J1K3L3M2	Ramp w gravel/sand beach, wide	mixed bedrock and sediment	SE

Cluster 2 summary: 8 stations, from bedrock and mixed sediment sites, nearly all from the Semi-exposed or Current-dominated Bio-exposure category.

Table 4. continued. Summary of the Bray-Curtis Relative Abundance Cluster Analysis. (* Definitions of Bio-exposure in Appendix D, Table D - 3).

cluster group	Station Number	location	Cluster ID	coastal class name	definition of general substrate	exposure from biota *
3	GH-92-63	Outside of Matheison Inlet	A2B2C1D2E2F2G2H2I2J1K3L3M1	Ramp w gravel/sand beach, wide	mixed bedrock and sediment	SE
3	GH-92-07	West side Annette Is., Houston Stewart Channel	A2B2C1D2E2F2G2H2I2J1K3L3M1	Channel	current dominated	XX
3	GH-92-81	Dodge Pt. Lyell Is	A2B2C1D2E2F2G2H2I2J1K3L3M1	Gravel flat, wide	sediment dominated	SE
3	GH-92-26	NW tip Gordon Is	A2B2C1D2E2F2G2H2I2J1K3L3M1	Ramp with gravel beach, wide	mixed bedrock and sediment	SE
3	GH-92-13	Southern shore of Luxana Bay, Kunghit Is	A2B2C1D2E2F2G2H2I2J1K3L3M1	Platform with gravel beach, wide	mixed bedrock and sediment	SE
3	GH-92-49	East Copper Is.	A2B2C1D2E2F2G2H2I2J1K3L3M1	Rock Ramp, narrow	bedrock	SE
3	GH-92-03	South shore Heater Hbr, NE Kunghit Is.	A2B2C1D2E2F2G2H2I2J1K3L3M1	Platform with gravel beach	mixed bedrock and sediment	SE
3	GH-92-57	Wells Cove, north entrance	A2B2 C1D2E2F2G2H2I2J1K3L3M1	Rock Ramp, wide	bedrock	SE
3	GH-92-35	West of Ross Is. in Rose Inlet	A2B2C1D2E2F2G2H2I2J1K3L3M1	Rock Ramp, narrow	bedrock	SE
3	GH-92-65	Juan Perez Sound, NW Werner Pt between Werner I and Marco I	A2B2C1D2E2F2G2H2I2J1K3L3M1	Rock Cliff	bedrock	SE
3	GH-92-43	Hancock Pt., Carpenter Bay	A2B2C1D2E2F2G2H2I2J1K3L3M1	Rock Ramp, wide	bedrock	SE
3	GH-92-19	NE shore Louscoone Inlet	A2B2C1D2E2F2G2H2I2J1K3L3M1	Rock Ramp, narrow	bedrock	SE
3	GH-92-83	Dodge Pt, Lyell Is	A2B2C1D2E2F2G2H2I2J1K3L3M1	Rock Platform, narrow	bedrock	SE
3	GH-92-05	Ross Is., Houston Stewart Channel	A2B2C1D2E2F2G2H2I2J1K3L3M1	Rock Ramp, narrow	bedrock	SE
5	GH-92-33	East facing boulder beach on inner lagoon at Ninstints Is	A2B2C1D2E2F2G2H2I2J1K1	Gravel beach, narrow	sediment dominated	SP
5	GH-92-94	S side Cape Freeman	A2B2C1D2E2F2G2H2I2J1K1	Gravel flat, wide	sediment dominated	SE
5	GH-92-75	Kwoon Cove (west coast)	A2B2C1D2E2F2G2H2I2J1K2	Ramp with gravel/sand beach	mixed bedrock and sediment	SE
5	GH-92-95	Anvil Cove flats	A2B2C1D2E2F2G2H2I2J1K1	Sand & gravel flat or fan	sediment dominated	SP
5.1	GH-92-69A	Murchison Is, near lagoon outflow	A2B2C1D2E2F2G2H2I1	Channel	current dominated	XX
5.1	GH-92-69B	Murchison Is, in lagoon outflow stream	A2B2C1D2E2F2G2H2I1	Channel	current dominated	XX
5.2	GH-92-32A	North side of islets north of Ninstints Is	A2B2C1D2E2F2G2H1	Gravel flat, wide	sediment dominated	SE
5.2	GH-92-32	Lagoon to the north of main island of Ninstints	A2B2C1D2E2F2G2H1	Gravel flat, wide	sediment dominated	SE
5.2	GH-92-27	Cape St. James	A2B2C1D2E2F2G2H1	Gravel flat, wide	sediment dominated	SE
5.3	GH-92-56	Southwest Huxley Is.	A2B2C1D2E2F2G1	Sand beach	sand and mud	SE
5.3	GH-92-82	Stansung Is, Lyell Is	A2B2C1D2E2F2G1	Rock Ramp, narrow	bedrock	SP
5.3	GH-92-100	Islet, north central Tanu Is	A2B2C1D2E2F2G1	Rock Platform, narrow	bedrock	SP

Cluster 3 and 5 summary: 18 stations in combined cluster, most from bedrock dominated or bedrock with sediment sites, nearly all from Semi-exposed Bio-exposure category. Eight stations associated with, but clustered outside of Cluster 5. These non-clustered sites tended to be sediment dominated or current affected sites -- both attributes affect the mixture of species that are observed at these transitional sites.

Table 4. continued. Summary of the Bray-Curtis Relative Abundance Cluster Analysis. (* Definitions of Bio-exposure in Appendix D, Table D - 3).

cluster group	Station Number	location	Cluster ID	coastal class name	definition of general substrate	exposure from biota *
4	GH-92-64	West side Marco Island	A2B2C1D2E2F2G2H2I2J1K3L1	Rock Platform, narrow	bedrock	SP
4	GH-92-68	Murchison/Faraday Channel	A2B2C1D2E2F2G2H2I2J1K3L1	Channel	current dominated	XX
4	GH-92-89	Kostan Pt, North side	A2B2C1D2E2F2G2H2I2J1K3L1	Ramp with gravel beach	mixed bedrock and sediment	SP
4	GH-92-96	NE end of Centre Is	A2B2C1D2E2F2G2H2I2J1K3L1	Rock Ramp, narrow	bedrock	SP
4	GH-92-45	Swan Is, northeast	A2B2C1D2E2F2G2H2I2J1K3L1	Rock Ramp, narrow	bedrock	SP
4.1	GH-92-18	West shore Louscoone Inlet	A2B2C1D2E2F2G2H2I2J1K3L2	Rock Ramp, narrow	bedrock	SE

Cluster 4 summary: 5 sites, mostly from bedrock sites and from Semi-protected wave exposure category.

6	GH-92-36	Rose Inlet, near Pincher Rocks	A2B2C1D2E2F1G2H2I1J2	Rock Ramp, narrow	bedrock	SP
6	GH-92-46	Swan Is., west	A2B2C1D2E2F1G2H2I1J2	Ramp with gravel beach, wide	mixed bedrock and sediment	P
6	GH-92-90	Point at Lyell Bay	A2B2C1D2E2F1G2H2I1J2	Cliff with gravel beach	mixed bedrock and sediment	P
6	GH-92-38	Dolomite Pt, at entrance to Dolomite Narrows	A2B2C1D2E2F1G2H2I1J2	Rock Ramp, narrow	bedrock	P
6	GH-92-16A	West shore Louscoone Inlet	A2B2C1D2E2F1G2H2I1J2	Ramp with gravel beach, wide	mixed bedrock and sediment	P
6	GH-92-97	NE side Kat Is	A2B2C1D2E2F1G2H2I1J2	Rock Ramp, narrow	bedrock	SP
6	GH-92-71	SW tip Hotspring Is	A2B2C1D2E2F1G2H2I1J2	Platform with gravel beach, wide	mixed bedrock and sediment	SP
6	GH-92-61	Matheson Inlet, west shore	A2B2C1D2E2F1G2H2I1J2	Gravel flat, wide	sediment dominated	P
6	GH-92-70	Hotspring Is, East side	A2B2C1D2E2F1G2H2I1J2	Sand & gravel flat or fan	sediment dominated	SP
6	GH-92-88	Windy Bay Creek	A2B2C1D2E2F1G2H2I1J2	Estuary	estuary	SP
6	GH-92-60	Goski Bay islet, tombolo (in Gowgaia Bay)	A2B2C1D2E2F1G2H2I1J2	Sand & gravel flat or fan	sediment dominated	P
6	GH-92-86	South-facing bay, Bischoff Is	A2B2C1D2E2F1G2H2I1J2	Gravel beach, narrow	sediment dominated	P
6	GH-92-80	Stansung Is, Lyell Is	A2B2C1D2E2F1G2H2I1J2	Gravel flat, wide	sediment dominated	SP
6	GH-92-99	North central Tanu Is	A2B2C1D2E2F1G2H2I1J2	Gravel flat, wide	sediment dominated	P
6	GH-92-44	West side Hancock Pt, Carpenter Bay	A2B2C1D2E2F1G2H2I1J2	Platform with gravel/sand beach, wide	mixed bedrock and sediment	P
6.1	GH-92-02	Heater Hbr, north shore;NE Kunghit Is.	A2B2C1D2E2F1G2H2I2	Gravel flat, wide	sediment dominated	SP
6.1	GH-92-12	Luxana Bay, NE shore, Kunghit Is	A2B2C1D2E2F1G2H2I2	Platform with gravel beach, wide	mixed bedrock and sediment	SP
7	GH-92-06	East side Ross Is., Houston Stewart Channel	A2B2C1D2E2F1G2H2I1J1	Ramp with gravel/sand beach	mixed bedrock and sediment	SP
7	GH-92-34	North end Ninstints Is, with a small enclosed lagoon	A2B2C1D2E2F1G2H2I1J1	Sand & gravel flat or fan	sediment dominated	P
7	GH-92-20	West side Louscoone Inlet, in a small lagoon	A2B2C1D2E2F1G2H2I1J1	Gravel flat, wide	sediment dominated	P
7	GH-92-58	Islet near entrance to Wells Cove	A2B2C1D2E2F1G2H2I1J1	Rock Ramp, narrow	bedrock	SP
7.5	GH-92-52	Dolomite Narrows	A2B2C1D2E2F1G2H1	Channel	current dominated	XX
7.5	GH-92-51	Dolomite Narrows	A2B2C1D2E2F1G2H1	Channel	current dominated	XX
7.5	GH-92-48	Entrance to Slim Inlet, at tombolo	A2B2C1D2E2F1G2H1	Ramp w gravel/sand beach, wide	mixed bedrock and sediment	P

Table 4. continued. Summary of the Bray-Curtis Relative Abundance Cluster Analysis. (* Definitions of Bio-exposure in Appendix D, Table D - 3).

Cluster 6 and 7 summary: 19 sites, mostly from mixed substrate or from sediment dominated sites, and from Semi-protected and Protected wave exposure categories. Five sites were associated with, but clustered outside of Cluster 6 and 7. Several of these non-clustered sites were from current-dominated sites which might have been the reason for a mixture of species being recorded.

cluster group	Station Number	location	Cluster ID	coastal class name	definition of general substrate	exposure from biota *
8	GH-92-91	Lyell Bay, east side	A2B2C1D2E2F1G1	Sand & gravel flat or fan	sediment dominated	P
8	GH-92-85	Bischoff Is lagoon (Fly's Bay)	A2B2C1D2E2F1G1	Sand & gravel beach, narrow	sediment dominated	P
8	GH-92-04	Head of Heater Hbr, north shore; NE Kunghit Is.	A2B2C1D2E2F1G1	Estuary	estuary	P
8	GH-92-37	Estuary at head of Rose Inlet	A2B2C1D2E2F1G1	Estuary	estuary	P
8	GH-92-92	Echo Harbour, meadow and estuary	A2B2C1D2E2F1G1	Estuary	estuary	P
8	GH-92-39	Head of Island Bay	A2B2C1D2E2F1G1	Estuary	estuary	P
8	GH-92-93	Anna Inlet estuary	A2B2C1D2E2F1G1	Estuary	estuary	P
8	GH-92-62	Head of Matheison Inlet	A2B2C1D2E2F1G1	Estuary	estuary	P
8	GH-92-47	Slim Inlet, head	A2B2C1D2E2F1G1	Estuary	estuary	P
8	GH-92-16B	West shore Louscoone Inlet	A2B2C1D2E2F1G1	Sand & gravel flat or fan	sediment dominated	P
8	GH-92-98	NW of Burnaby Narrows	A2B2C1D2E2F1G1	Sand & gravel flat or fan	sediment dominated	SP
8	GH-92-40	Offshore islet near the head of Island Bay	A2B2C1D2E2F1G1	Platform with gravel beach, wide	mixed bedrock and sediment	P
8	GH-92-59	Goski Bay, delta	A2B2C1D2E2F1G1	Sand & gravel flat or fan	sediment dominated	P
8	GH-92-22	Estuary at the head of Louscoone Inlet	A2B2C1D2E2F1G1	Sand & gravel flat or fan	sediment dominated	P
8	GH-92-53	Dolomite Narrows	A2B2C1D2E2F1G1	Sand & gravel flat or fan	sediment dominated	P
8.1	GH-92-73	Puffin Cove (boulder cobble beach)	A2B2C1D2E1	Gravel flat, wide	sediment dominated	SE
8.2	GH-92-15	Treat Bay, east shore Kunghit Is	A2B2C1D1	Ramp with gravel beach, wide	mixed bedrock and sediment	SE

Cluster 8 summary: 15 sites, nearly all from sediment-dominated or estuary sites, and from Protected wave exposure categories. Two sites associated with Cluster 8 were from higher wave exposures and likely shared species characteristic of both wave exposure categories and represented transitional sites.

9	GH-92-54	Southern entrance to Dolomite Narrows	A2B2C2D2	Sand & gravel flat or fan	sediment dominated	P
9	GH-92-74	Puffin Cove, west coast (inside, across lagoon)	A2B2C2D2	Sand & gravel flat or fan	sediment dominated	P
9	GH-92-24	Sand pocket beach in small bay on South shore Bowles Pt, Kunghit Is	A2B2C2D1	Sand flat	sand and mud	E
9	GH-92-14	Head of Luxana Bay, Kunghit Is	A2B2C2D2	Sand flat	sand and mud	SP
9	GH-92-28	Gilbert Bay, Kunghit Is	A2B2C2D1	Sand beach	sand and mud	E
9	GH-92-31	Woodruff Bay, Kunghit Is.	A2B2C2D1	Sand beach	sand and mud	SE
9	GH-92-76	Kwoon Cove	A2B2C2D1	Sand beach	sand and mud	E
9	GH-92-17	Mid way along east shore Louscoone Inlet	A2B2C2D1	Sand & gravel flat or fan	sediment dominated	SP
9.1	GH-92-09	Raspberry Cove, Houston Stewart Channel	A2B1	Gravel flat, wide	sediment dominated	SE
9.2	GH-92-79	Dodge Pt, Lyell Is	A1	Sand & gravel flat or fan	sediment dominated	SE

Cluster 9 summary: 8 sites, all fine sediment dominated and although from a mixture of bio-exposure categories, all represent sites with few species recorded.

4.0 DISCUSSION

4.1 SUMMARY OF THE CHARACTERISTICS OF THE RELATIVE ABUNDANCE CLUSTERS OF STATIONS.

For each cluster identified in the Bootstrap analysis (Table 3 and 4), we have compiled a summary of the cluster's typical geomorphology, bio-exposure and indicator species. Species names in bold occurred in all stations in the cluster. Other species listed for each cluster occurred in at least 75% of the stations in the cluster.

4.1.1 Cluster 1 The *Lessoniopsis* Cluster.

Table 5. Summary of Relative Abundance Cluster.

Description:

The twelve stations identified in this cluster (Table 4) are all from sites open to long wave fetches found on the west side of Moresby Island or to the full open shore on Hecate Strait. Species found at higher wave exposure sites are distinctly different from species found at lower wave energy sites and this cluster was shown to be significantly different from other clusters because of the clear differences in the species assemblages.

Sites are all from non-mobile bedrock sites and the wave exposure categories for all the sites in the cluster are either Exposed or Very Exposed. Sites of these wave exposures tend to also have a few species that are found in lower (semi-exposed) wave exposures as the presence of 'micro-habitat' features such as surge channels and off-shore reefs break the full force of the highest exposures and allow species tolerant of slightly lower wave exposures to be established. The cluster is named for a stalked woody brown kelp that is an indicator species of the highest wave exposure sites: *Lessoniopsis littoralis.* Other common Exposed site species typical in this cluster are: *Mytilus californianus*, *Pollicipes polymerus*, and *Laminaria setchellii*. Common indicator species from the Semi-exposed habitats included: *Phyllospadix scouleri*, *Strongylocentrotus franciscanus*, and *Hedophyllum sessile*.

Example photos in Figure 1, 2, and 3.

Cluster number:	1
Number of Stations in the Cluster:	12 (12% of Gwaii Haanas stations)
Cluster name:	*Lessoniopsis*
Typical station geomorphology:	bedrock ramp
Typical Bio-exposure category:	Exposed or Very Exposed

Typical species found at Cluster 1 stations (species names in bold were found at all the stations in the cluster):

KATHTU	***Katharina tunicata***
LESSLI	***Lessoniopsis littoralis***
LITHOT	***Lithothamnion***
MYTICA	***Mytilus californianus***
ANTHXA	*Anthopleura xanthogrammica*
CORAVA	*Corallina vancouverensis*
ENDOMU	*Endocladia muricata*
HEDOSE	*Hedophyllum sessile*
LAMISE	*Laminaria setchellii*
LOTTPE	*Lottia pelta*
NERELU	*Nereocystis leutkeana*
POLLPO	*Pollicipes polymerus*
PORPSP	*Porphyra sp*
SEMICA	*Semibalanus cariosus*

Example Photos from Cluster 1

Figure 1. Station 10 at Lyman Point shows two major bio-bands in an exposed site. At the waterline is a dense band of *Lessoniopsis littoralis* (the 'chocolate brown' CHB band) and the band above is a typical California mussel (MUS) band showing the mixture of *Pollicipes polymerus* and *Mytilus californianus*.

Figure 2. At Station 29, on the west shore of Woodruff Bay, another example of the typical bio-bands from Exposed sites was seen. The lush chocolate brown band (CHB) was dominated by *Lessoniopsis littoralis* and *Hedophyllum sessile*. The upper band is California mussel (MUS), a mixture of *Mytilus californianus, Semibalanus carious* and *Pollicipes polymerus*.

Figure 3. The lower intertidal of Station 29 shows the lush foliose coralline red algae understory for the *Lessoniopsis littoralis*, both indicators of a typical Exposed site. Other species seen here are *Laminaria setchelli, Hedophyllum sessile* and *Phyllospadix scouleri*.

4.1.2 Cluster 2 The California Mussel/*Alaria* group.

Table 6. Summary of Relative Abundance Cluster 2.

Description:

Cluster 2 is a group of high Semi-exposed stations. Species diversity at sites is high and most of the sites are bedrock dominated substrate. Species observed at these stations includes some of the indicator species from Exposed sites (*Pollicipes* and *Laminaria setchelli*) as well as lower exposure species. Common species are *Mytilus californianus, Alaria spp, Fucus spp,* and *Nereocystis luetkeana*. Sites with boulders present add to habitat diversity and, as is typical at higher exposure sites, habitat diversity increases species diversity, with the under boulder and surge channels making suitable microhabitat for species of a range of wave exposures.

Example photos in Figure 4 and 5.

Cluster number:	2
Number of Stations in the Cluster:	8 (8% of Gwaii Haanas stations)
Cluster name:	California mussel/*Alaria*
Typical station geomorphology:	bedrock
Typical Bio-exposure category:	high Semi-exposed

Typical species found at Cluster 2 stations (species names in bold were found at all the stations in the cluster):

ALARSP	***Alaria sp***
ANTHEL	***Anthopleura elegantissima***
ANTHXA	***Anthopleura xanthogrammica***
FUCUSP	***Fucus sp***
LITHOT	***Lithothamnion sp***
MYTICA	***Mytilus californianus***
NERELU	***Nereocystis luetkeana***
CODIFR	*Codium fragile*
CODISE	*Codium settchelli*
EGREME	*Egregia menziesii*
ENDOMU	*Endocladia muricata*
HALOGL	*Halosaccion glandiformis*
HEDOSE	*Hedophyllum sessile*
KATHTU	*Katharina tunicata*
LAMISE	*Laminaria setchellii*
LEATDI	*Leathesia difformis*
LOTTDI	*Lottia digitalis*
MASTPA	*Mastocarpus papillatus*
MICRBO	*Microcladia borealis*
ONCHBO	*Onchidella borealis*
PHYLSC	*Phyllospadix scouleri*
PISAOC	*Pisaster ochraceous*
POLLPO	*Pollicipes polymerus*
SEMICA	*Semibalanus cariosus*
STROFR	*Strongylocentrotus franciscanus*
ULVASP	*Ulva sp*

Example Photos from Cluster 2

Figure 4. Station 84, on the southwest corner of Bischoff Islands, showed distinct bio-bands and associated indicator species typical of Semi-exposed sites. The upper band is a *Fucus* (FUC) band with *Halosaccion glandiforme* and patches of *Ulva.* The middle band is filamentous red algae mixed with *Hedophyllum sessile* (the chocolate brown CHB band). The lower bright green band is *Phyllospadix scoulerii* -- the surfgrass (SUR) band.

Figure 5. Station 41 at Benjamin Point shows a lush chocolate brown (CHB) band dominated by *Hedophyllum sessile*. A bed of *Nereocystis leutkeana* (NER band) is seen just offshore.

4.1.3 Cluster 3 and 5 The *Halosaccion*/surfgrass group.

Table 7. Summary of Relative Abundance Cluster 3 and 5.

Description:

In this combined cluster, stations are all low Semi-exposed or high Semi-protected. The substrate at most sites is bedrock and several sites are a mix of bedrock and sediment. The sediment-dominated sites were nearly all in Cluster 5.

Only a few species occurred at every site in this cluster, and these tended to be species ubiquitous throughout our survey: encrusting coralline *Lithothamnion*, *Mastocarpus*, and *Littorina*. Both *Halosaccion* and surfgrass (*Phyllospadix*) occurred at 17 of the 18 stations in the cluster. Other common species were a mixture of Semi-exposed indicators (e.g., *Egregia*) and Semi-protected sites; and many species common in this cluster are invertebrates.

Eight stations are "associated" but outside of Cluster 5 (see Table 4). These non-clustered sites tended to be sediment-dominated or current affected and share some of the species found in these cluster, but not enough to be included in the main cluster.

Example photos in Figure 6, 7, 8, and 9.

Cluster number:	3 and 5
Number of Stations in the Cluster:	18 (19% of Gwaii Haanas stations)
Cluster name:	*Halosaccion*/surfgrass
Typical station geomorphology:	bedrock or mixture of bedrock and sediment
Typical Bio-exposure category:	low Semi-exposed

Typical species found at Cluster 3 and 5 stations (species names in bold were found at least 17 of the stations in the cluster):

HALOGL	***Halosaccion glandiforme***
LITHOT	***Lithothamnion/Lithophyllum***
LOTTPE	***Lottia pelta***
MASTPA	***Mastocarpus papillatus***
PHYLSC	***Phyllospadix scouleri***
ANTHEL	*Anthopleura elegantissima*
ANTHXA	*Anthopleura xanthogrammica*
CHTHDA	*Chthamalus dalli*
CODIFR	*Codium fragile*
EGREME	*Egregia menziesii*
FUCUSP	*Fucus spp*
GLOIFU	*Gloiopeltis furcata*
LOTTDI	*Lottia digitalis*
MYTICA	*Mytilus californianus*
PETROC	*Petrocelis*
PETRCI	*Petrolisthes cinctipes*
PHASAG	*Phascolosoma agassizi*
PISAOC	*Pisaster ochraceous*
PORPSP	*Porphyra spp*
SEMICA	*Semibalanus cariosus*
SERPVE	*Serpula vermicularis*
SPIRSP	*Spirorbis spp*
TECTSC	*Tectura scutum*
ULVASP	*Ulva/Ulvaria sp*

Example Photos from Clusters 3 and 5

Figure 6. Station 19, on the east shore of Louscoone Inlet, is a typical Semi-exposed site, and showed a thick lower intertidal band of *Phyllospadix scouleri* (the surfgrass SUR band). Patches of filamentous reds and *Egregia menziesii* are visible just above the waterline.

Figure 7. Station 75, at Kwoon Cove, was at a Semi-exposed boulder beach near a bare sand beach. The boulders in the lower intertidal were covered b a chocolate brown band (CHB) with a patchy surfgrass band (SUR). The upper intertidal boulders were mostly bare of epibiota.

Figure 8. The wide platform at Station 26 on the northwest corner of the Gordon Islands was one of the richest stations surveyed. The station is an excellent example of the diversity of species found on rock platforms in Semi-exposed wave exposures. The lower intertidal had a wide surfgrass band (SUR). Encrusting coralline reds formed the understory of the surfgrass and there was rich encrusting invertebrates.

Figure 9. Station 26 in the Gordon Islands shows a good example of the red urchin band (*Strongylocentrotus franciscanus* -- URC band) seen at the waterline. Often abundant urchin concentrations over-graze the algae and form 'urchin barrens' of bleached encrusted coralline algae, as is seen in this photo.

4.1.4 Cluster 4 The *Astrea*/sea star group

Table 8. Summary of Relative Abundance Cluster 4.

Description:

Only five stations were included in Cluster 4. These stations are high Semi-protected, and include one current-dominated site from Muchison/Faraday Channel. Substrate at the sites are bedrock dominated. More invertebrates than algal species are on the indicator species list. Also, several of these invertebrates are sea stars.

Example photos in Figure 10 and 11.

Cluster number:	4
Number of Stations in the Cluster:	5 (5% of Gwaii Haanas stations)
Cluster name:	*Astrea*/sea star
Typical station geomorphology:	bedrock
Typical Bio-exposure category:	high Semi-protected

Typical species found at Cluster 4 stations (species names in bold were found at least 17 of the stations in the cluster):

ASTRGI	***Astrea gibberosa***
FUCUSP	***Fucus sp***
HALOGL	***Halosaccion glandiforme***
HEMINU	***Hemigrapsus nudus***
KATHTU	***Katharina tunicata***
LITHOT	***Lithothamnion sp***
MYTICA	***Mytilus californianus***
SEMICA	***Semibalanus cariosus***
SERPVE	***Serpula vermicularis***
SPIRSP	***Spirorbis sp***
ASTEMI	*Asteria miniata*
DERMIM	*Dermasteria imbricata*
EVASTR	*Evasterias troschellii*
HEMIOR	*Hemigrapsus oregonensis*
LAMIGR	*Laminaria groenlandica*
LOTTPE	*Lottia pelta*
MACRIN	*Macrocystis integrefolia*
PAGUHI	*Pagurus hirutiusculus*
PETRER	*Pertrolisthes eriomerus*
PISAOC	*Pisaster ochraceous*
TECTSC	*Tectura scutum*

Example Photos from Cluster 4

Figure 10. Near Station 89, on the north side of Kostan Point, three distinct bio-bands show across the intertidal. The upper band is the golden yellow *Fucus* (FUC band), the middle is the bright green *Ulva* (ULV), and the lower bio-band is the mixed filamentous RED band. Scattered large *Laminaria* sp are interspersed at the waterline.

Figure 11. Station 68, located on an islet between Murchison Island and Faraday Island, is affected by currents. This photograph shows lush algal cover on the rocky platform, including diversity of blade and filamentous reds, *Egregia*, and bullate *Hedophyllum* -- a mixture of indicator species from both Semi-protected and Semi-exposed sites as is typical in current-affected areas.

4.1.5 Cluster 6 and 7 *Fucus*/barnacle group

Table 9. Summary of Relative Abundance Cluster 6 and 7.

Description:

The combined cluster 6 and 7 sites are all Semi-protected or Protected wave exposures. Most are sediment-dominated. Most of the sites also seemed to low species diversity and species indicator lists (the most commonly occurring species) include several ubiquitous species that occurred throughout the whole study. Ubiquitous species were common in all clusters of stations and were not considered as diagnostic for any cluster. The common species are those from the upper intertidal: *Fucus, B. glandula,* and *Littorina spp*. The lower intertidal areas of these sites did not appear to have species in common.

Five stations were associated with Cluster 6 and 7 but were not included in the joint cluster (see Table 4). Two of those associated stations were from Dolomite Narrows channel.

Example photos in Figure 12, 13, and 14.

Cluster number:	6 and 7
Number of Stations in the Cluster:	19 (18% of Gwaii Haanas stations)
Cluster name:	*Fucus*/ barnacle
Typical station geomorphology:	sediment-dominated or mixture of bedrock and sediment
Typical Bio-exposure category:	low Semi-protected and Protected

Typical species found at Cluster 6 and 7 stations (species names in bold were found at least 17 of the stations in the cluster and include three commonly occurring species which are not counted as indicator species in other clusters):

BALAGL	***Balanus glandula****
FUCUSP	***Fucus sp***
HEMINU	***Hemigrapsus nudus***
LEATDI	***Leathesia difformis***
LITTSC	***Littorina scutulata****
LITTSI	***Littorina sitkana****
MASTPA	***Mastocarpus papillatus***
HEMIOR	*Hemigrapsus oregonensis*
LITHOT	*Lithothamnion/Lithophyllum*
LOTTPE	*Lottia pelta*
SPIRSP	*Spirorbis sp*
ULVASP	*Ulva_Ulvaria spp*

* these species were nearly ubiquitous, occurring in nearly every station in the survey and were not considered as useful indicator species for clusters of stations. These ubiquitous species also occurred in most of the other clusters but were not included on other clusters' species lists.

Example Photos from Clusters 6 and 7

Figure 12. Station 86, a south facing beach on the Bischoff Islands, shows a Semi-protected to Protected site. The upper beach is dominated with *Balanus glandula* (the BAR band) and the lower beach has a sparse filamentous red band (RED). The biota at the site is not diverse which is typical of this cluster of stations.

Figure 13. Station 16A, on the west shore of Louscoone Inlet, is dominated in the upper and mid intertidal by a FUC (*Fucus*) band. Some filamentous greens (ULV) are seen at the waterline along with some offshore kelps.

Figure 14. Station 6, on Ross Island in the Houston Stewart Channel shows a lush lower intertidal covered in *Laminaria* spp. and *Alaria marginata* (SBR band). A few filamentous reds and *Ulva* spp. blades can be seen throughout the SBR band. The upper intertidal is mainly *Fucus* spp.

4.1.6 Cluster 8 Zostera estuary group

Table 10. Summary of Relative Abundance Cluster Group 8: the cluster.

Description:

Most of the stations in Cluster 8 are from estuaries or are sand and gravel flats near estuaries. Wave exposures are Protected.

The biota found at these sites tends to be low species diversity. *Mytilus edulis* is the only indicator species that occurred at all stations however all but one station had *Zostera marina*, and many sites had various species of bivalves.

Example photos in Figure 15, 16, 17 and 18.

Cluster number:	8
Number of Stations in the Cluster:	15 (15% of Gwaii Haanas stations)
Cluster name:	*Zostera*/Estuary
Typical station geomorphology:	sediment-dominated, estuary or sand & gravel flats
Typical Bio-exposure category:	Protected

Typical species found at Cluster 8 stations (species names in bold were found at least 11 of the stations in the cluster):

MYTITR	***Mytilus trossulus***
EVASTR	*Evasterias troschelii*
FUCUSP	*Fucus sp*
HEMIOR	*Hemigrapsus oregonensis*
LOTTPE	*Lottia pelta*
SAXIGI	*Saxidomus giganteus*
ZOSTMA	*Zostera marina*

4.1.7 Cluster 9 Bare sediment beaches

Table 11. Summary of Relative Abundance Cluster 9.

Description:

Cluster 9 stations are all sand or sand and gravel beaches and show very few species observed. Stations also tend to have few species in common. The most common indicator species were dune grass (*Elymus*) and beach hopper (Gammarid amphipods). Sites of various wave exposures clustered together due to the similarity of having very few species observed rather than having the same species observed at the beach sites.

Example photos in Figure 19, 20 and 21.

Cluster number:	9
Number of Stations in the Cluster:	8 (8% of Gwaii Haanas stations)
Cluster name:	Bare sediment beaches
Typical station geomorphology:	sand or sand & gravel beaches
Typical Bio-exposure category:	various, from Protected to Exposed

Typical species found at Cluster 9 stations (Only three species were recorded in at least 5 stations in the cluster, and no species occurred more frequently in this cluster).

GRASSP	*Grass spp*
GAMMSP	*Gammeridae spp*
ELYMMO	*Elymus mollis*
ZOSTMA	*Zostera marina*
TALISP	*Talitridae spp*
RUMESA	*Rumex salicifolius*

Example Photos from Cluster 8

Figure 15. Station 39, located at the estuary at the head of Island Bay, shows a wide band of *Mytilus trossulus* (BMU). Patches of golden *Fucus* are scattered across the BMU band. A SAL band (*Salicornia virginica* and other salt tolerant grasses) is seen in the distance in the upper intertidal. Both the SAL and the BMU bands are typical of Gwaii Haanas estuaries.

Figure 16. Detail of the *Salicornia* (SAL) band in the estuary at Station 39, at the head of Island Bay. The SAL band is an indicator of estuary sites.

Figure 17. Station 93, the Anna Inlet estuary, is dominated by a FUC (*Fucus*) band. In the background are salt tolerant grasses, commonly found in estuaries. The bare lower intertidal is indicative of a low wave exposure.

Figure 18. Station 59, on the delta in Goski Bay shows sparse cover of biota in the intertidal zone. Patchy *Fucus* and acorn barnacles makes up most of the species at this site. The lower intertidal has mudflat with a thin-bladed morph of *Zostera* present.

Example Photos from Cluster 9

Figure 19. The steep, bare sand beach at Kwoon Cove, is a good example of the stations in Cluster 9. Few species, other than rove beetles and amphipods were observed on the beach.

Figure 20. Woodruff Bay, at Station 31, is a bare beach facing open Hecate Strait. The gradient of the beach is less steep than at Kwoon Cove. Crawling clams (*Tellina nuculoides*) were observed on the lower intertidal beach.

Figure 21. Species observed at station 54, at the south entrance to Dolomite Narrows, included *Zostera* in the lower intertidal and dune grasses and herbs in the upper intertidal log line. This beach is an example of a bare beach of lower wave exposure.

4.2 COMPARISON OF HABITAT TYPES WITH STATION CLUSTER RESULTS

The habitat types developed in 1992 included of a total of 9 habitat types (see Appendix D, Table D - 1), with a number of indicator species for each Habitat Type. These Habitat Type descriptions correspond to the categories recorded in the bio-mapping from aerial video -- the Bio-exposure field (EXP_BIO) and the Habitat Observed (HAB_OBS) field. Initially, the Habitat Types were compiled from expert knowledge and literature and were not based on field data. Each Habitat Type code is defined by a species assemblage at certain substrate type and wave exposure category. (Harper *et al.*, 1994). The substrate type, including substrate description and morphology at the site, and wave exposure estimate at the site are described for each shore station and use the same summary codes as those used for each shore unit mapped from the aerial imagery. Codes used in Table D - 1 are the BC standard for 'Coastal Class' (defined in Appendix D, Table D - 2) and the wave exposure category (defined in Appendix D, Table D - 3).

Initially a total of 9 clusters were identified from the Bray-Curtis relative abundance cluster analysis. After the bootstrap significance test, two pairs of clusters were combined and a total of 7 groups of stations were described (Table 3). Each of the clusters identified in the significance clustering can be matched up and compared with the Habitat Types described by Harper *et al.* (1994) and the similarities and differences between the original Habitat Types and the new cluster results are discussed for each exposure category.

The Harper *et al.* table had two high exposure categories (Very Exposed and Exposed) while only one high Exposed cluster of stations was identified. (see Table 12). The Harper *et al.* Very Exposed category was originally defined to describe the species assemblages observed on the southwest coast of Moresby Island. Few of these sites were sampled in the field survey due to the extremely rugged terrain. Very Exposed communities were observed to have lush foliose coralline red algae species (such as *Bosiella, Calliarthron* and *Corallina*) and a fewer species overall than the Exposed sites. The large brown kelps were mostly small *Alaria nana* and lush *Lessoniopsis littoralis.* All of these species also occur in the Exposed categories as well, making distinguishing between these Habitat Types difficult based solely on the species observed. The species assemblage that clustered in the Exposed sites was clearly unique to that habitat type and diagnostic of a distinct and separate set of stations.

Table 12. Comparing the species assemblages from 'Exposed' Habitat Types determined by Harper *et al.* (1994) with new Relative Abundance Station Clusters.

	Indicator Species listed in Harper *et al.* (1994) (see Table D - 1)		Indicator Species determined from Relative Abundance Cluster 1 (Table 5)
Exposure (EXP_BIO)	**VE**	**E**	**E**
Community Codes	**1**	**equivalent to 2**	**2**
upper intertidal	*Verrucaria*	*Verrucaria*	
			*Littorina sitkana**
			*Littorina scutulata**
	Balanus glandula	*Balanus glandula*	*Balanus glandula**
middle intertidal			*Lottia pelta*
			Porphyra spp
	[Semibalanus carriosus]	*Semibalanus cariosus*	*Semibalanus carriosus*
	Mytilus californianus	***Mytilus californianus***	*Mytilus californianus*
	Pollicipes polymerus	*Pollicipes polymerus*	***Pollicipes polymerus***
			Katharina tunicata
lower intertidal			*Anthopleura xanthogrammica*
			Endocladia muricata
	[Laminaria setchelli]	*Laminaria setchellii*	*Laminaria setchelli*
	[Alaria 'nana' morph*]*	*Alaria 'nana'* morph	
			Hedophyllum sessile
	Lessoniopsis littoralis	***Lessoniopsis littoralis***	***Lessoniopsis littoralis***
	lush foliose coralline reds: *Bossiella/ Calliarthron/ Corallina*	*foliose coralline reds*	
			Corallina vancouverensis
	Lithothamnion sp	***Lithothamnion sp***	*Lithothamnion sp*
subtidal	*Nereocystis luetkeana*	*Nereocystis leutkeana*	*Nereocystis luetkeana*

* These ubiquitous species were common in most clusters but have not been included in indicator species lists in Table 5.

The Semi-exposed habitat type was separated into two clusters in the Relative Abundance cluster analysis, while it was considered one Habitat Type in the Harper *et al.* work (Table 13). The cluster analyses separated Semi-exposed indicator species into 'high semi-exposed' and 'low semi-exposed' groups of stations.

The High Semi-exposed sites contained a lower diversity of species compared to the Lower Semi-exposed sites and this was observed from the upper intertidal down through to the subtidal zone. In comparison to the Harper *et al.* Semi-exposed habitat type, some species commonly observed in lower exposures were not found in the High Semi-exposed cluster such as *Enteromorpha spp., Laminaria groenlandica, Macrocystis integrefolia and Agarum.* In the Low Semi-exposed cluster *Agarum.* and *Enteromorpha spp.* do not appear nor do they in any of the other clusters. The Low Semi-exposed cluster includes many invertebrate species and overall contains the highest number of species compared to other clusters. It is lacking some higher exposure indicator species included in the Harper *et al.* Semi-exposed species list such as *Hedophyllum sessile, Laminaria setchelli, Alaria spp.,* and *Nereocystis integrefolia*.

Table 13. Comparing the species assemblages from 'Semi-exposed' Habitat Types determined by Harper *et al.* (1994) with new Relative Abundance Station Clusters.

	Indicator Species listed in Harper *et al.* (1994) (see Table D - 1)	Indicator Species determined from Relative Abundance Clusters (Table 6 and Table 7)	
Cluster No.	**--**	**2**	**3 and 5**
Exposure (EXP_BIO)	**SE**	**High SE**	**Low SE**
Community Codes	**3**	**equivalent to 3**	**equivalent to 3**
upper intertidal	*Verrucaria*		*Verrucaria**
		*Littorina sitkana**	*Littorina sitkana**
		*Littorina scutulata**	*Littorina scutulata**
	Balanus glandula	*Balanus glandula**	*Balanus glandula**
			Chthalamus dalli
	Fucus distichus	***Fucus sp.***	***Fucus sp.***
middle intertidal			***Lottia pelta***
		Lottia digitalis	***Lottia digitalis***
			Tectura scutum
	Anthopleura elegantissima	***Anthopleura elegantissima***	*Anthopleura elegantissima*
		Anthopleura xanthogrammica	*Anthopleura xanthogrammica*
			Porphyra spp
	Semibalanus cariosus	*Semibalanus cariosus*	***Semibalanus cariosus***
	Enteromorpha sp.		
		Mastocarpus papillatus	***Mastocarpus papillatus***
			Petrocelis
	Mytilus californianus	***Mytilus californianus***	*Mytilus californianus*
		Pollicipes polymerus	
		Ulva sp.	*Ulva sp.*
			Gloiopeltis furcata
		Leathesia defformis	
		Katharina tunicata	
	Halosaccion glandiforme	*Halosaccion glandiforme*	*Halosaccion glandiforme*
lower intertidal		*Endocladia muricata*	
		Microcladia borealis	
	Laminaria setchelli	*Laminaria setchellii*	
	Laminaria groenlandica diverse mixed red algae Alaria 'marginata'*morph*		
		Alaria sp	
	Egregia menziesii	*Egregia menziesii*	*Egregia menziesii*
	Hedophyllum sessile	*Hedophyllum sessile*	
	Phyllospadix scouleri	*Phyllospadix scouleri*	***Phyllospadix scouleri***
	Codium fragile	*Codium fragile*	*Codium fragile*
		Codium setchellii	
		Onchidella borealis	
			Serpula vermicularis
			Phascolsoma agassize
			Spirorbis sp.
		Pisaster ochreaceous	*Pisaster ochreaceous*
	Lithothamnion sp.	***Lithothamnion sp.***	***Lithothamnion sp.***
subtidal	*Nereocystis luetkeana*	***Nereocystis leutkeana***	
	Macrocystis integrefolia		
	Agarum sp.		
	Strongylocentrotus franciscanus	*Strongylocentrotus franciscanus*	

* These ubiquitous species were common in most clusters but have not been included in indicator species lists in Table 6 and 7.

The Semi-protected habitat types in the original Harper *et al.* table (Table 14) were based on two different geomorphological habitats (mobile sediment and immobile bedrock) but both substrate types were described with the same species list. The new cluster analysis also identified two Semi-protected clusters, one comprised of mainly bedrock/gravel, the other was a lower Semi-protected with a sand gravel type substrate; however, each cluster contained a different species assemblage. The major difference in the species composition of the two clusters was the increase of invertebrates on the bedrock type substrate. It appears that both the original Semi-protected habitat type and the newly identified clusters contain species from a wide array of exposure levels varying from *Mytilus californianus* to *Zostera marina.*

Table 14. Comparing the species assemblages from 'Semi-protected Habitat Types determined by Harper *et al.* (1994) with new Relative Abundance Station Clusters.

	Indicator Species determined from Relative Abundance Clusters (Table 8 and Table 9)		Indicator Species listed in Harper *et al.* (1994) (see Table D - 1)	
Cluster No.	**4**	**6 and 7**	**--**	**--**
Exposure (EXP_BIO)	**SP**	**SP/P**	**SP**	**SP**
Community Codes	**equivalent to 4**	**equivalent to 6/7**	**4**	**6**
upper intertidal			*Verrucaria*	*Verrucaria*
	*Littorina sitkana**	*Littorina sitkana**		
	*Littorina scutulata**	*Littorina scutulata**		
	*Balanus glandula**	*Balanus glandula**	*Balanus glandula*	*Balanus glandula*
	Fucus sp.	***Fucus sp.***	*Fucus distichus*	*Fucus distichus*
	Lottia pelta	*Lottia pelta*		
			Mytilus trossulus	*Mytilus trossulus*
	Tectura scutum			
			Halosaccion glandiforme	*Halosaccion glandiforme*
	Semibalanus cariosus		*Semibalanus cariosus*	*Semibalanus cariosus*
		Mastocarpus papillatus		
middle intertidal				
			Anthopleura elegantissima	*Anthopleura elegantissima*
	Mytilus californianus			
			Enteromorpha sp.	*Enteromorpha sp.*
		Ulva/ Ulvaria sp.	***Ulva/ Ulvaria sp.***	***Ulva/ Ulvaria sp.***
		Leathesia difformis		
	Astrea gibberosa			
	Pagurus hirutiusculus			
	Hemigrapsus nudus	***Hemigrapsus nudus***		
	Hemigrapsus oregonensis	***Hemigrapsus oregonensis***		
	Petrolisthes eriomerus			
	Katharina tunicata			
	Halisaccion glandiformis			
			Codium fragile	*Codium fragile*
lower intertidal	*Laminaria groenlandica*		*Laminaria groenlandica* ***Laminaria saccharina*** *Alaria 'marginata'* morph	*Laminaria groenlandica* ***Laminaria saccharina*** *Alaria 'marginata'* morph
	Serpula vermicularis			
	Spirorbis sp.	***Spirorbis sp.***		
	Evasterias troschellii			
	Dermasterias imbricata			
	Asteria miniata			
	Pisaster ochreaceous			
	Lithothamnion sp.	***Lithothamnion sp.***	*Lithothamnion sp.*	*Lithothamnionsp*
subtidal			*Agarum sp.*	*Agarum sp.*
			Nereocystis luetkeana	*Nereocystis luetkeana*
	Macrocystis integrefolia		*Macrocystis integrifolia*	*Macrocystis integrifolia*
			Strongylocentrotus franciscanus	***Strongylocentrotus franciscanus***
			Zostera marina	***Zostera marina***

* These ubiquitous species were common in most clusters but have not been included in indicator species lists in Table 8 and 9.

The Harper *et al.* table contained two different habitat types for Protected exposures (Table 15). These were separated by the geomorphological features bedrock/gravel, and sand and gravel.

The species list for the stations in the Protected cluster (Cluster 8) was slightly different that the Harper *et al* list for the Protected Habitat Types. The Cluster 8 Protected sites on mainly bedrock/gravel tended to have a higher species diversity and more algal species than the sand and gravel sites. The new cluster of Protected stations was most comparable to the Harper *et al* Habitat Type 7 (Table 15), including the species: *Zostera marina*, *Mytilus edulis* and *Fucus.*

Table 15. Comparing the species assemblages from 'Protected Habitat Types determined by Harper *et al*. (1994) with new Relative Abundance Station Clusters.

	Indicator Species determined from Relative Abundance Cluster 8 (Table 10)	**Protected Exposure Indicator Species listed in Harper *et al.* (1994) (see Table D - 1)**		**Estuarine Indicator Species listed in Harper *et al.* (1994) (see Table D - 1)**
Exposure (EXP_BIO)	**P**	**VP/P**	**VP/P**	**SP/VP/P**
Community Codes	**equivalent to 8**	**5**	**7**	**8**
upper		*Verrucaria*	*Verrucaria*	**grasses & rushes**
	*Littorina scutulata**			
	*Balanus glandula**			
		Enteromorpha sp.	*Enteromorpha sp.*	***Salicornia virginica***
		Balanus glandula	*Balanus glandula*	*Balanus glandula*
	Lottia pelta			
	Fucus spp	*Fucus distichus*	*Fucus distichus*	*Fucus distichus*
middle	*Mytilus trossulus*	*Mytilus trossulus*	*Mytilus trossulus*	*Mytilus trossulus*
		Ulva/ Ulvaria sp.	***Ulva/Ulvaria sp.***	*Ulva/ Ulvaria sp.*
	Hemigrapsus oregonensis			
		Halosaccion glandiforme	*Halosaccion glandiforme*	
lower	*Saxidomus giganteus*			
		Laminaria saccharina	***Laminaria saccharina***	
	Evasterias troschelii			
subtidal		*Macrocystis integrifolia*		
		Agarum sp.	*Agarum sp.*	
	Zostera marina	***Zostera marina***	***Zostera marina***	***Zostera marina***

* These ubiquitous species were common in most clusters but have not been included in indicator species lists in Table 10.

Two other habitat types were defined on the Harper *et al.* table: the bare Exposed or Semi-exposed beaches and a current dominated habitat type. In the cluster analysis only the bare beach habitat type (Table 16) was identified, and it included wave exposures from Protected to Exposed. The original Harper *et al.* table shows no visible macrobiota present whereas the newly identified cluster does contain a few species such as salt tolerant grasses, *Zostera marina* and amphipods.

Table 16. Comparing the species assemblages from Bare Beaches Habitat Types determined by Harper *et al.* (1994) with new Relative Abundance Station Clusters.

	Indicator Species determined from Relative Abundance Clusters (Table 11)	Indicator Species listed in Harper *et al.* (1994) (see Table D - 1)
Cluster No.	**9**	**--**
Exposure (EXP_BIO)	**E-P (bare beaches)**	**SE/E**
Community Codes	**9**	**9**
upper	***Elymus mollis***	
	Grass spp	
	Rumex salicifolius	
middle		no visible intertidal macrobiota due to sediment mobility
lower	*Talitridae spp*	
	Gammeridea spp	
subtidal	*Zostera marina*	

* These ubiquitous species were common in most clusters but have not been included in indicator species lists in Table 11.

The current-dominated sites were found in several different clusters, and were not recognised by species assemblage as being different from other sites. We identified current-dominated sites as having a species assemblage anomalous (usually species of a higher exposure category) than we expected to see at the station due to the site's wave exposure alone. For example, many current-dominated sites are in Protected or Semi-protected wave exposure environments and species present there are Semi-exposed indicators.

4.3 DISCUSSION OF THE SPECIES CLUSTER ANALYSIS

The results of the Jaccard's species cluster analysis showed a general distinction between higher and lower exposure species but no clusters appeared to be defined by wave exposure. This may be because this type of species cluster can only be based on the presence/absence data. As seen in the field, species abundance changes gradually depending on several factors such as wave fetch, current, physical substrate and salinity. Microhabitats created by some of these factors can change the overall species assemblage creating a site that contains a mixture of indicator species, each relating to a different habitat type. An example of a habitat type containing indicator species from another exposure level is shown in Table 5. In this cluster the dominant indicator species indicated a 'E' (exposed) exposure level, however due to the microhabitats created by surge channels and tidepools, 'SE' (semi-exposed) indicator species were also present.

4.4 DISCUSSION OF THE BIO-BAND TABLE DESCRIPTIONS

The bio-band table, as developed for the northern Queen Charlotte project (Reimer *et al.*, 1999) is attached in Appendix C. The bio-band methodology post-dated the 1992 Gwaii Haanas field program and bio-band descriptions are not part of the Gwaii Haanas station database. Revisions and improvements to the bio-band table will be completed during the review of the aerial video tapes and will be based on the cluster analysis results for different wave exposure/ substrate combinations as described above.

6.0 BIBLIOGRAPHY

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Appendix A. Summary Table for the Presence/Absence Station Cluster. See Definitions of field names in Table 4.

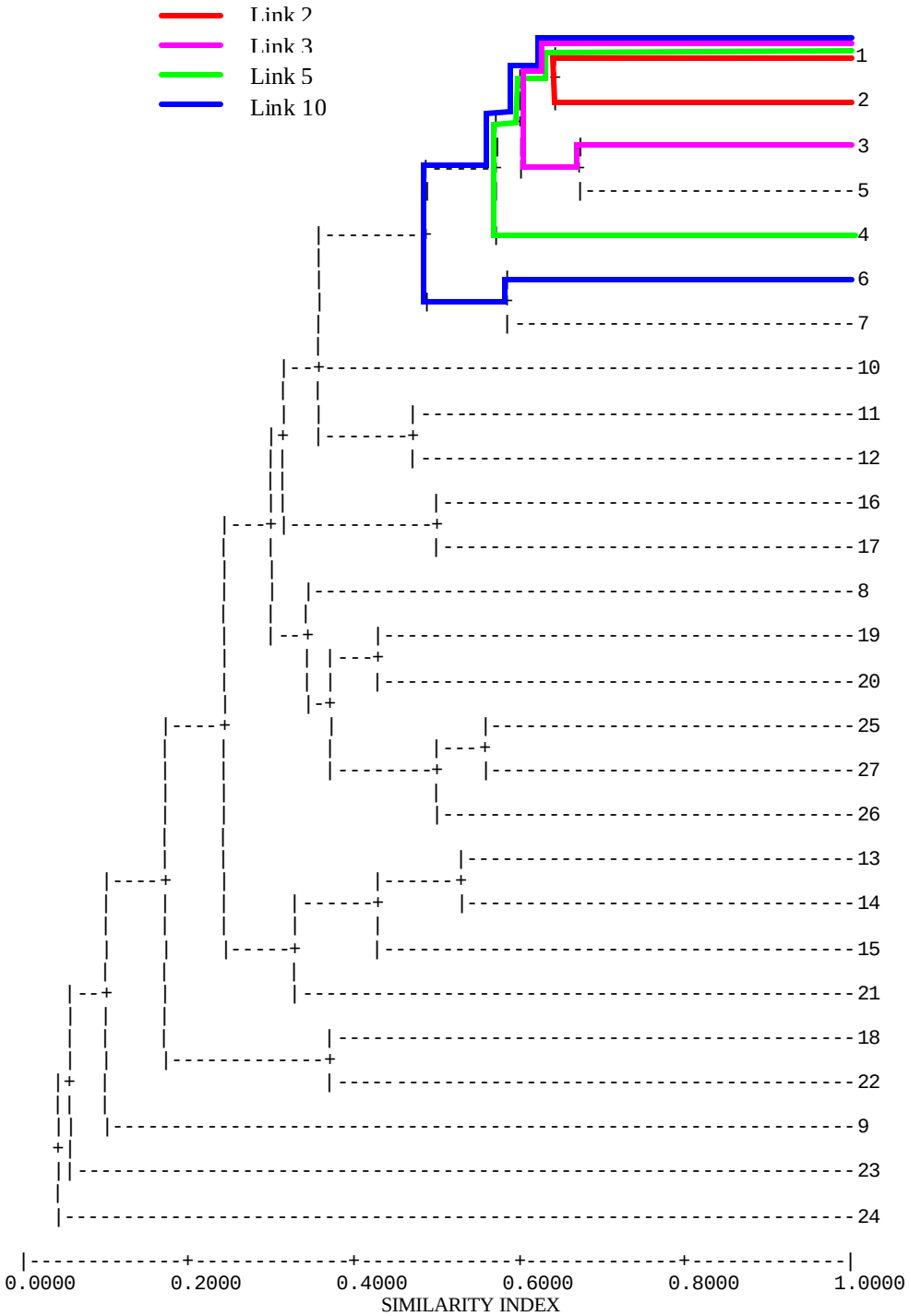
cluster group	Station Number	location	Cluster ID code	coastal class name	definition of general substrate	exposure from biota
1	GH-92-21	Ninstints Pt., Louscoone Inlet	A2B2C2D2E2F3G2H2I2J2K3L3	Rock Ramp, narrow	bedrock	E
1	GH-92-29	West shore Woodruff Bay, Kunghit Is.	A2B2C2D2E2F3G2H2I2J2K3L3	Rock Ramp, narrow	bedrock	E
1	GH-92-01	East shore High Is, entrance to Heater Hbr, NE Kunghit Is.	A2B2C2D2E2F3G2H2I2J2K3L3	Rock Ramp, wide	bedrock	E
1	GH-92-25	North tip Gordon Is, off west side Kunghit Is.	A2B2C2D2E2F3G2H2I2J2K3L3	Rock Ramp, wide	bedrock	E
1	GH-92-23	South side Bowles Pt, Kunghit Is	A2B2C2D2E2F3G2H2I2J2K3L3	Rock Ramp, wide	bedrock	E
2	GH-92-78	Lyell Is, Stansung It	A2B2C2D2E2F3G2H2I2J2K3L2	Rock Ramp, narrow	bedrock	SE
2	GH-92-41	Benjamin Pt.	A2B2C2D2E2F3G2H2I2J2K3L2	Platform with gravel beach, wide	mixed bedrock and sediment	SE
2	GH-92-30	Cape St. James	A2B2C2D2E2F3G2H2I2J2K3L2	Rock Ramp, narrow	bedrock	E
2	GH-92-84	SW Bischoff Is	A2B2C2D2E2F3G2H2I2J2K3L2	Rock Ramp, narrow	bedrock	SE
2	GH-92-66	Kloo Rock, South shore	A2B2C2D2E2F3G2H2I2J2K3L2	Rock Ramp, narrow	bedrock	E
2	GH-92-10	Rock point just south of Lyman Point, east coast of Kunghit Is	A2B2C2D2E2F3G2H2I2J2K3L2	Rock Cliff	bedrock	E
2	GH-92-87	East Tar Is	A2B2C2D2 E2F3G2H2I2J2K3L2	Rock Platform, wide	bedrock	SE
2	GH-92-50	East end, East Copper Is.	A2B2C2D2E2F3G2H2I2J2K3L2	Rock Platform, wide	bedrock	E
2	GH-92-67	Kloo Rock	A2B2C2D2E2F3G2H2I2J2K3L1	Rock Ramp, wide	bedrock	E
2	GH-92-72	North of Gowgaia Bay	A2B2C2D2E2F3G2H2I2J2K3L1	Rock Ramp, narrow	bedrock	VE
2.5	GH-92-55	Wells Cove, south of Gowgaia Bay, west coast Moresby Is.	A2B2C2D2E2F3G2H2I2J2K2	Rock Ramp, wide	bedrock	VE
2.5	GH-92-11	South of Lyman Pt., East shore Kunghit Is	A2B2C2D2E2F3G2H2I2J2K1	Cliff with gravel beach	mixed bedrock and sediment	E
2.5	GH-92-18	West shore Louscoone Inlet	A2B2C2D2E2F3G2H2I2J1	Rock Ramp, narrow	bedrock	SE
3	GH-92-68	Murchison/Faraday Channel	A2B2C2D2E2F3G2H2I1J3	Channel	current dominated	XX
3	GH-92-89	Kostan Pt, North side	A2B2C2D2E2F3G2H2I1J3	Ramp with gravel beach	mixed bedrock and sediment	SP
3	GH-92-64	West side Marco Island	A2B2C2D2E2F3G2H2I1J3	Rock Platform, narrow	bedrock	SP
3	GH-92-45	Swan Is, northeast	A2B2C2D2E2F3G2H2I1J3	Rock Ramp, narrow	bedrock	SP
3	GH-92-96	NE end of Centre Is	A2B2C2D2E2F3G2H2I1J3	Rock Ramp, narrow	bedrock	SP
3	GH-92-101	Tanu village reef	A2B2C2D2E2F3G2H2I1J3	Ramp w gravel/sand beach, wide	mixed bedrock and sediment	SE
3	GH-92-42	Benjamin Pt. Lagoon	A2B2C2D2E2F3G2H2I1J3	Ramp w gravel/sand beach, wide	mixed bedrock and sediment	SE
4	GH-92-07	West side Annette Is., Houston Stewart Channel	A2B2C2D2E2F3G2H2I1J2	Channel	current dominated	XX
4	GH-92-03	South shore Heater Hbr, NE Kunghit Is.	A2B2C2D2E2F3G2H2I1J2	Platform with gravel beach	mixed bedrock and sediment	SE
4	GH-92-57	Wells Cove, north entrance	A2B2C2D2E2F3G2H2I1J2	Rock Ramp, wide	bedrock	SE
4	GH-92-81	Dodge Pt. Lyell Is	A2B2C2D2E2F3G2H2I1J2	Gravel flat, wide	sediment dominated	SE
4	GH-92-26	NW tip Gordon Is	A2B2C2D2 E2F3G2H2I1J2	Ramp with gravel beach, wide	mixed bedrock and sediment	SE
4	GH-92-35	West of Ross Is. in Rose Inlet	A2B2C2D2E2F3G2H2I1J2	Rock Ramp, narrow	bedrock	SE
4	GH-92-83	Dodge Pt, Lyell Is	A2B2C2D2E2F3G2H2I1J2	Rock Platform, narrow	bedrock	SE
4	GH-92-13	Southern shore of Luxana Bay, Kunghit Is	A2B2C2D2E2F3G2H2I1J2	Platform with gravel beach,	mixed bedrock and	SE

				wide	sediment	
4	GH-92-63	Outside of Matheison Inlet	A2B2C2D2E2F3G2H2I1J2	Ramp w gravel/sand beach, wide	mixed bedrock and sediment	SE
4	GH-92-43	Hancock Pt., Carpenter Bay	A2B2C2D2E2F3G2H2I1J2	Rock Ramp, wide	bedrock	SE
4	GH-92-65	Juan Perez Sound, NW Werner Pt between Werner I and Marco I	A2B2C2D2E2F3G2H2I1J2	Rock Cliff	bedrock	SE
4	GH-92-19	NE shore Louscoone Inlet	A2B2C2D2E2F3G2H2I1J2	Rock Ramp, narrow	bedrock	SE
4	GH-92-69A	Murchison Is, near lagoon outflow	A2B2C2D2E2F3G2H2I1J2	Channel	current dominated	XX
4	GH-92-05	Ross Is., Houston Stewart Channel	A2B2C2D2E2F3G2H2I1J2	Rock Ramp, narrow	bedrock	SE
4	GH-92-49	East Copper Is.	A2B2C2D2E2F3G2H2I1J2	Rock Ramp, narrow	bedrock	SE
4.1	GH-92-94	S side Cape Freeman	A2B2C2D2E2F3G2H2I1J1	Gravel flat, wide	sediment dominated	SE
4.1	GH-92-95	Anvil Cove flats	A2B2C2D2E2F3G2H2I1J1	Sand & gravel flat or fan	sediment dominated	SP
4.1	GH-92-08	Trevan Rock, Houston Stewart Channel	A2B2C2D2E2F3G2H1	Channel	current dominated	XX
4.2	GH-92-75	Kwoon Cove (west coast)	A2B2C2D2E2F3G1	Ramp with gravel/sand beach	mixed bedrock and sediment	SE
4.2	GH-92-71	SW tip Hotspring Is	A2B2C2D2E2F3G1	Platform with gravel beach, wide	mixed bedrock and sediment	SP
4.2	GH-92-73	Puffin Cove (boulder cobble beach)	A2B2C2D2E2F3G1	Gravel flat, wide	sediment dominated	SE
4.2	GH-92-58	Islet near entrance to Wells Cove	A2B2C2D2E2F3G1	Rock Ramp, narrow	bedrock	SP
4.3	GH-92-27	Cape St. James	A2B2C2D2E2F2	Gravel flat, wide	sediment dominated	SE
4.3	GH-92-32	Lagoon to the north of main island of Ninstints	A2B2C2D2E2F2	Gravel flat, wide	sediment dominated	SE
4.3	GH-92-32A	North side of islets north of Ninstints Is	A2B2C2D2E2F2	Gravel flat, wide	sediment dominated	SE
4.4	GH-92-69B	Murchison Is, in lagoon outflow stream	A2B2C2D2E2F1	Channel	current dominated	XX
4.4	GH-92-33	East facing boulder beach on inner lagoon at Ninstints Is	A2B2C2D2E2F1	Gravel beach, narrow	sediment dominated	SP
4.5	GH-92-82	Stansung Is, Lyell Is	A2B2C2D2E1	Rock Ramp, narrow	bedrock	SP
4.5	GH-92-100	Islet, north central Tanu Is	A2B2C2D2E1	Rock Platform, narrow	bedrock	SP
4.5	GH-92-56	Southwest Huxley Is.	A2B2C2D2E1	Sand beach	sand and mud	SE
4.6	GH-92-12	Luxana Bay, NE shore, Kunghit Is	A2B2C2D1E2F2	Platform with gravel beach, wide	mixed bedrock and sediment	SP
4.6	GH-92-06	East side Ross Is., Houston Stewart Channel	A2B2C2D1E2F2	Ramp with gravel/sand beach	mixed bedrock and sediment	SP
4.6	GH-92-02	Heater Hbr, north shore;NE Kunghit Is.	A2B2C2D1E2F2	Gravel flat, wide	sediment dominated	SP
5	GH-92-38	Dolomite Pt, at entrance to Dolomite Narrows	A2B2C2D1E2F1G3	Rock Ramp, narrow	bedrock	P
5	GH-92-44	West side Hancock Pt, Carpenter Bay	A2B2C2D1E2F1G3	Platform with gravel/sand beach, wide	mixed bedrock and sediment	P
5	GH-92-60	Goski Bay islet, tombolo (in Gowgaia Bay)	A2B2C2D1E2F1G3	Sand & gravel flat or fan	sediment dominated	P
5	GH-92-86	South-facing bay, Bischoff Is	A2B2C2D1E2F1G3	Gravel beach, narrow	sediment dominated	P
5	GH-92-16A	West shore Louscoone Inlet	A2B2C2D1E2F1G3	Ramp with gravel beach, wide	mixed bedrock and sediment	P
5	GH-92-34	North end Ninstints Is, with a small enclosed lagoon	A2B2C2D1E2F1G3	Sand & gravel flat or fan	sediment dominated	P
5	GH-92-20	West side Louscoone Inlet, in a small lagoon	A2B2C2D1E2F1G3	Gravel flat, wide	sediment dominated	P
5	GH-92-70	Hotspring Is, East side	A2B2C2D1E2F1G3	Sand & gravel flat or fan	sediment dominated	SP
5	GH-92-97	NE side Kat Is	A2B2C2D1E2F1G3	Rock Ramp, narrow	bedrock	SP

5	GH-92-80	Stansung Is, Lyell Is	A2B2C2D1E2F1G3	Gravel flat, wide	sediment dominated	SP
5	GH-92-90	Point at Lyell Bay	A2B2C2D1E2F1G3	Cliff with gravel beach	mixed bedrock and sediment	P
5	GH-92-99	North central Tanu Is	A2B2C2D1E2F1G3	Gravel flat, wide	sediment dominated	P
5	GH-92-46	Swan Is., west	A2B2C2D1E2F1G3	Ramp with gravel beach, wide	mixed bedrock and sediment	P
5.1	GH-92-36	Rose Inlet, near Pincher Rocks	A2B2C2D1E2F1G2	Rock Ramp, narrow	bedrock	SP
6	GH-92-48	Entrance to Slim Inlet, at tombolo	A2B2C2D1E2F1G1	Ramp w gravel/sand beach, wide	mixed bedrock and sediment	P
6	GH-92-53	Dolomite Narrows	A2B2C2D1E2F1G1	Sand & gravel flat or fan	sediment dominated	P
6	GH-92-61	Matheson Inlet, west shore	A2B2C2D1E2F1G1	Gravel flat, wide	sediment dominated	P
6	GH-92-52	Dolomite Narrows	A2B2C2D1E2F1G1	Channel	current dominated	XX
6	GH-92-51	Dolomite Narrows	A2B2C2D1E2F1G1	Channel	current dominated	XX
7	GH-92-37	Estuary at head of Rose Inlet	A2B2C2D1E1	Estuary	estuary	P
7	GH-92-40	Offshore islet near the head of Island Bay	A2B2C2D1E1	Platform with gravel beach, wide	mixed bedrock and sediment	P
7	GH-92-93	Anna Inlet estuary	A2B2C2D1E1	Estuary	estuary	P
7	GH-92-04	Head of Heater Hbr, north shore; NE Kunghit Is.	A2B2C2D1E1	Estuary	estuary	P
7	GH-92-62	Head of Matheison Inlet	A2B2C2D1E1	Estuary	estuary	P
7	GH-92-88	Windy Bay Creek	A2B2C2D1E1	Estuary	estuary	SP
7	GH-92-16B	West shore Louscoone Inlet	A2B2C2D1E1	Sand & gravel flat or fan	sediment dominated	P
7	GH-92-85	Bischoff Is lagoon (Fly's Bay)	A2B2C2D1E1	Sand & gravel beach, narrow	sediment dominated	P
7	GH-92-59	Goski Bay, delta	A2B2C2D1E1	Sand & gravel flat or fan	sediment dominated	P
7	GH-92-47	Slim Inlet, head	A2B2C2D1E1	Estuary	estuary	P
7	GH-92-92	Echo Harbour, meadow and estuary	A2B2C2D1E1	Estuary	estuary	P
7	GH-92-22	Estuary at the head of Louscoone Inlet	A2B2C2D1E1	Sand & gravel flat or fan	sediment dominated	P
7	GH-92-98	NW of Burnaby Narrows	A2B2C2D1E1	Sand & gravel flat or fan	sediment dominated	SP
7	GH-92-91	Lyell Bay, east side	A2B2C2D1E1	Sand & gravel flat or fan	sediment dominated	P
7	GH-92-39	Head of Island Bay	A2B2C2D1E1	Estuary	estuary	P
7.1	GH-92-15	Treat Bay, east shore Kunghit Is	A2B2C1	Ramp with gravel beach, wide	mixed bedrock and sediment	SE
8	GH-92-14	Head of Luxana Bay, Kunghit Is	A2B1C2	Sand flat	sand and mud	SP
8	GH-92-74	Puffin Cove, west coast (inside, across lagoon)	A2B1C2	Sand & gravel flat or fan	sediment dominated	P
8	GH-92-54	Southern entrance to Dolomite Narrows	A2B1C2	Sand & gravel flat or fan	sediment dominated	P
8	GH-92-09	Raspberry Cove, Houston Stewart Channel	A2B1C2	Gravel flat, wide	sediment dominated	SE
9	GH-92-24	Sand pocket beach in small bay on South shore Bowles Pt, Kunghit Is	A2B1C1	Sand flat	sand and mud	E
9	GH-92-28	Gilbert Bay, Kunghit Is	A2B1C1	Sand beach	sand and mud	E
9	GH-92-76	Kwoon Cove	A2B1C1	Sand beach	sand and mud	E
9	GH-92-31	Woodruff Bay, Kunghit Is.	A2B1C1	Sand beach	sand and mud	SE
9	GH-92-17	Mid way along east shore Louscoone Inlet	A2B1C1	Sand & gravel flat or fan	sediment dominated	SP
9	GH-92-79	Dodge Pt, Lyell Is	A1	Sand & gravel flat or fan	sediment dominated	SE

Appendix B. Results of the Bootstrap Analysis.

Results of the Bootstrap analysis, using clusters identified from the Bray-Curtis Relative Abundance Station cluster analysis. The significantly different clusters in Linkages 2, 3, 5 and 10 are highlighted. Cluster numbers listed on the right correspond to the Bray-Curtis clusters summarised in Table 4.



Appendix C. Revisions to the Bio-band Definitions

Bio-band definitions were compiled for mapping completed on Haida Gwaii, for coastline north of Gwaii Haanas (see Table C - 2, from Reimer *et al.*, 1999). These definitions will be used during the completion of the bio-band observations for the Gwaii Haanas mapping. Minor revisions have been made to the exposure category indicated by bio-bands (Table C - 1).

Table C-1. Bio-band exposure categories that were altered based results of the bootstrap cluster analysis

Band name	original exposure category	new exposure category
HAL6	SP, P	SE, SP
SBR6	SP, P	SP
MAC	SE, SP, P	SE, SP

Descriptions for the Bio-bands in Table C - 2 have been retained. Common species that are included in the bio-band table are based on expert knowledge and provide a more comprehensive overview of each band.

The bio-band table (Table C-1) is arranged from the supra-tidal, across the intertidal to the nearshore subtidal. The methodology and definitions used here are developed and applied in British Columbia in Searing and Frith (1995) and Harper *et al.* (1996) and others.

The across-shore intervals are called 'zones' and are defined as:

Zone A - Supratidal
Zone B - Intertidal
Zone C - Nearshore Subtidal

During the interpretation of aerial video imagery, bio-bands observed in each along-shore unit are recorded in the across-shore zone and component where they were seen. Where there is no entry in the band data field (i.e., the field is left blank), the bio-band was not observed in that unit. The occurrence of observed bio-bands are coded as either: 'P' for patchy, and irregular through the unit or, as 'C' for continuous through the unit and an estimate of over 50% cover in the unit. For the VER band only, (*Verrucaria* splash zone band in the supratidal), the observed banding is recorded by width as:

N - narrow < 1m
M - medium width 1 - 5 m
W - wide, > 5m

Usually the VER band is most visible on bedrock shorelines.

The presence or absence of indicator species and indicator species assemblages as bio-bands, together with the unit's substrate and wave exposure, are used to determine the 'bio-exposure' (EXP_BIO field) code. Substrate mobility in a shore unit is determined by the amount of bedrock and the size of coarse substrate, together with the wave exposure at the shoreline.

Several of the lower intertidal bio-bands have been noted as having different species compositions in different coastal BC geographic areas. These bio-bands are: SBR (soft-brown),

CHB (chocolate browns), HAL (Halosaccion or bleached reds) and RED (dark red). So far, six different bio-band tables have been compiled, with slightly different species assemblages identified for these four bio-bands. In the Queen Charlotte study area, we have identified band descriptions specific to the islands with the number 6. (See Table C-1).

Table C - 2. Bio-band definitions developed for the northern Queen Charlotte Islands.

Zone	Colour Band Name	Code Name	Colour	Description	Exposure Category
A	'Verrucaria'	**VER**	black or bare rock	splash zone: may be marked by black encrusting lichen & blue-green algae. Best observed on bedrock & sometimes visible on low energy boulder/cobble shorelines	width can be an index of wave exposure
A	grasses & *Salicornia*	**SAL**	light/bright green	*Salicornia*, marsh grasses, dune grasses and other salt-tolerant herbaceous plants	SP, P, estuary
B upper	upper barnacle	**BAR**	grey-white	continuous band of *B. glandula* &/or *S. cariosus* in upper intertidal, also can include bare rock (sometimes recorded in the field as BRE) Extensive bare zones only occur in association with VER on high energy bedrock shorelines	E,SE,SP, P
B upper	'Fucus'	**FUC**	golden brown	dominated by *Fucus*, includes *B. glandula*.	SE, SP, P
B mid	mussel-barnacle	**MUS**	grey-blue	dominated by *Semibalanus cariosus* and *Mytilus californianus* with scattered *Pollicipes* at higher SE & in E	E, SE
B mid	'Ulva'	**ULV**	bright green	*Ulva/'Ulvaria'* blade greens and *Enteromorpha*-type filamentous greens. May appear as thick patches or as green haze of small plants	SP, P, estuary
B lower	'Halosaccion'	**HAL6**	golden yellow	named for golden-yellow colour of *Halosaccion* which may not be present or dominate the band. Band may occur as an assemblage of bleached reds in the lower intertidal. Typical spp in QC area are: *Gastroclonium* & *Odonthalia* and other bleached blade and filamentous reds.	SE, SP
B lower	mixed filamentous & blade reds	**RED6**	dark red-brown	algal-rich band of lower intertidal, complex of filamentous and blade red algae, including *Microcladia-Odonthalia – Polysiphonia* and others	SE, SP, currents
B lower	soft browns	**SBR6**	brown	large bladed *Laminaria spp.* - the unstalked blade browns, which are seen in the lower intertidal and nearshore subtidal. Includes *L. groenlandica*, *L.saccharina*, *Agarum*	SP
B lower	chocolate browns	**CHB6**	dark brown	shiny, leathery dark brown browns, including *Hedophyllum, Egregia, Alaria, L. setchelli.* Often exposed in the lower intertidal during the lowest low tides.	E, SE,
B lower	surfgrass	**SUR**	emerald green	continuous cover of *Phyllo spadix*, attaches to coarse sediment or bedrock substrates	SE
C upper	'Zostera'	**ZOS**	dark green	eelgrass, (*Zostera marina*) fine sediment, may extend slightly upslope into intertidal. Often encrusted with epiphytic blade red.	P, SP, estuary
C upper	urchin barrens	**URC**	underwater, coralline white	shows as rocky substrate, bare of macroalgae. Often has pink-white colour of encrusting coralline red algae. May or may not see urchins.	SE, SP, current
C upper	'Nereocystis'	**NER**	dark brown, shiny	bull kelp beds, floating blades and fronds in nearshore	E, SE, SP, current
C upper	'Macrocystis'	**MAC**	brown	leafy, soft 'giant kelp' beds, usually an indicator of fully-marine waters	SE, SP

Appendix D.

Table D - 1. The original Gwaii Haanas indicator species and Habitat Types (HAB_OBS) Definitions. Each Habitat Type code is defined by a species assemblage at certain substrate type (coastal class) and wave exposure (EXP_BIO) category. (updated from Harper *et al.*, 1994).

	IMMOBILE SUBSTRATES									
MAJOR SUBSTRATE	BEDROCK	BEDROCK	BEDROCK/BOULDER	BEDROCK/GRAVEL	BEDROCK/GRAVEL	SAND & GRAVEL	SAND & GRAVEL	ESTUARY or SAND/MUD	SEDIMENT	BEDROCK OR SEDIMENT
COASTAL CLASSES	**1-20**	**1-20**	**1-23, 32, 33**	**1-23, 33**	**1-23, 33**	**24, 25, 26, 32**	**24, 25, 26, 32**	**27, 28, 29, 30, 31**	**21-30**	**34**
EXPOSURE (EXP_BIO)	**VE**	**E**	**SE**	**SP**	**VP, P**	**SP**	**VP, P**	**VP, P, SP**	**SE, E**	**VP, P, SP**
COMMUNITY CODE (HAB_OBS)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
upper	*Verrucaria* *Balanus glandula*	*Verrucaria* *Balanus glandula*	*Verrucaria* *Enteromorpha* *Balanus glandula* *Fucus distichus*	*Verrucaria* *Enteromorpha* *Balanus glandula* *Fucus distichus*	*Verrucaria* *Enteromorpha* *Balanus glandula* *Fucus distichus*	*Verrucaria* *Enteromorpha* *Balanus glandula* *Fucus distichus*	*Verrucaria* *Enteromorpha* *Balanus glandula* *Fucus distichus*	**grasses & rushes** ***Salicornia virginica*** *Balanus glandula* *Fucus distichus*		tidal current dominated; may be a protected wave exposure but shows an assemblage of indicator species from higher wave exposures. Assemblage observed is 'anomalous' for the wave energy of the site.
middle	***Pollicipes polymerus*** *Mytilus californianus* *[Semibalanus carriosus]*	***Pollicipes polymerus*** *Mytilus californianus* *Semibalanus carriosus*	*Mytilus californianus* *Semibalanus carriosus*	*Mytilus trossulus* *Semibalanus carriosus* ***Ulva/ Ulvaria spp.***	*Mytilus trossulus* ***Ulva/ Ulvaria spp.***	*Mytilus trossulus* *Semibalanus carriosus* ***Ulva/ Ulvaria spp.***	*Mytilus trossulus* ***Ulva/Ulvaria spp.***	*Mytilus trossulus* *Ulva/ Ulvaria*	no visible intertidal macrobiota due to sediment mobility	
mid/low	 *[Alaria 'nana'* morph*]*	*Anthopleura elegantissima* *Alaria 'nana'* morph	*Halosaccion glandiforme* *Anthopleura elegantissima* ***Hedophyllum sessile*** *Codium fragile* ***Phyllospadix scouleri*** ***Egregia menziesii***	*Halosaccion glandiforme* *Anthopleura elegantissima* *Codium fragile*	*Halosaccion glandiforme*	*Halosaccion glandiforme* *Anthopleura elegantissima* *Codium fragile*	*Halosaccion glandiforme*			
lower	***Lessoniopsis littoralis*** *[Laminaria setchelli]* **lush foliose coralline reds:** *Bossiella/ Calliarthron/ Corallina* *Lithothamnion*	***Lessoniopsis littoralis*** *Laminaria setchelli* **foliose coralline reds** *Lithothamnion*	*Laminaria setchelli* *Laminaria groenlandica* diverse mixed red algae *Alaria 'marginata'* morph *Lithothamnion*	*Laminaria groenlandica* ***Laminaria saccharina*** *Alaria 'marginata'* morph *Lithothamnion*	***Laminaria saccharina***	*Laminaria groenlandica* ***Laminaria saccharina*** *Alaria 'marginata'* morph *Lithothamnion*	***Laminaria saccharina***			
subtidal	*Nereocystis luetkeana*	*Nereocystis luetkeana*	*Nereocystis luetkeana* ***Macrocystis integrifolia*** *Agarum spp.* ***Strongylocentrotus franciscanus***	*Nereocystis luetkeana* *Macrocystis integrifolia* *Agarum spp.* ***Strongylocentrotus franciscanus*** ***Zostera marina***	*Macrocystis integrifolia* *Agarum spp.* ***Zostera marina***	*Nereocystis luetkeana* *Macrocystis integrifolia* *Agarum spp.* ***Strongylocentrotus franciscanus*** ***Zostera marina***	*Macrocystis integrifolia* *Agarum spp.* ***Zostera marina***	***Zostera marina***		

Table D - 2. BC Coastal Class Definitions.

SUBSTRATE	SEDIMENT	WIDTH	SLOPE	COASTAL CLASS	NO.
ROCK	N/A	WIDE (>30m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Rock Ramp, wide	1
			FLAT (<5°)	Rock Platform, wide	2
		NARROW (<30m)	STEEP (>20°)	Rock Cliff	3
			INCLINED (5-20°)	Rock Ramp, narrow	4
			FLAT(<5°)	Rock Platform, narrow	5
ROCK & SEDIMENT	GRAVEL	WIDE (>30m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Ramp with gravel beach, wide	6
			FLAT (<5°)	Platform with gravel beach, wide	7
		NARROW (<30m)	STEEP (>20°)	Cliff with gravel beach	8
			INCLINED (5-20°)	Ramp with gravel beach	9
			FLAT (<5°)	Platform with gravel beach	10
	SAND & GRAVEL	WIDE (>30m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Ramp w gravel & sand beach, wide	11
			FLAT (<5°)	Platform with G&S beach, wide	12
		NARROW (<30m)	STEEP (>20°)	Cliff with gravel/sand beach	13
			INCLINED (5-20°)	Ramp with gravel/sand beach	14
			FLAT (<5°)	Platform with gravel/sand beach	15
	SAND	WIDE (>30m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Ramp with sand beach, wide	16
			FLAT (<5°)	Platform with sand beach, wide	17
		NARROW (<30m)	STEEP (>20°)	Cliff with sand beach	18
			INCLINED (5-20°)	Ramp with sand beach, narrow	19
			FLAT (<5°)	Platform with sand beach, narrow	20
SEDIMENT	GRAVEL	WIDE (>30m)	FLAT (<5°)	Gravel flat, wide	21
		NARROW (<30m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Gravel beach, narrow	22
			FLAT (<5°)	Gravel flat or fan	23
	SAND & GRAVEL	WIDE (>30m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	n/a	
			FLAT (<5°)	Sand & gravel flat or fan	24
		NARROW (<30m)	STEEP >20°)	n/a	
			INCLINED (5-20°)	Sand & gravel beach, narrow	25
			FLAT (<5°)	Sand & gravel flat or fan	26
	SAND/MUD	WIDE (>30m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Sand beach	27
			FLAT (<5°)	Sand flat	28
			FLAT (<5°)	Mudflat	29
		NARROW (<30m)	STEEP (>20°)	n/a	
			INCLINED (5-20°)	Sand beach	30
			FLAT (<5°)	n/a	n/a
	ORGANICS/FINES	n/a	n/a	Estuaries	31
ANTHRO-POGENIC	MAN-MADE	n/a	n/a	Man-made, permeable	32
			n/a	Man-made, impermeable	33
CURRENT				Channel	34
LAGOON				Lagoon	35

Table D - 3. Wave Exposure Category definitions (from Harper *et al.*, 1994).

wave exposure abbreviation	name	fetch distance	description
VE	Very Exposed	>1,000 km	continuous ocean swells, wave height seldom <1m and generally >2m, spray zone commonly +10m above high tide line
E	Exposed	500 - 1000km	continuous ocean swells, spray zone +5m above high tide line
SE	Semi-exposed	50 - 500km	ocean swells attenuated by either seaward land masses or islands, spray zone 1 to 5m above high tide line
SP	Semi-protected	10 - 50km	sheltered from ocean swells but may be subject to waves generated over limited fteches, spary zone present but less than 1m above high tide line
P	Protected	1 - 10km	complete shelter from ocean swells and minimal affect of local waves, no spray zone
VP	Very Protected	<1km	very sheltered lagoon or inlet, minimal local waves, no spray zone