



# RESOURCE MANAGEMENT GROUP



SAFEGUARDING YOUR ENVIRONMENT + KAITIAKI TUKU IHO



## Soft-Sediment Ecological Monitoring:

Opoutama and  
Pourerere Beaches  
2009/10

June 2010  
ISSN 1179 8513  
EMT 10/24  
HBRC plan No. **4215**

---

## Resource Management Group

Environmental Science

---

# Soft-Sediment Ecological Monitoring

## Opoutama and Pouterere Beaches 2009/2010

---

Prepared by:  
Anna Madarasz-Smith  
Senior Scientist – Coastal Quality



.....  
Signature:

Reviewed by:  
Adam Uytendaal  
Principal Scientist – Water Quality and Ecology



.....  
Signature:

Approved:  
**Darryl Lew**, Group Manager – Resource Management



.....  
Signature:

June 2010  
ISSN 1179 8513  
EMT 10/24  
HBRC plan No. 4215



## EXECUTIVE SUMMARY

At the interface between land and sea, coastal environments are vulnerable to threats associated with populace growth and land use intensification. Hawke's Bay Regional Council Management Plans contain policies and objectives aimed to minimise the effects of these threats where they may impact on the natural characteristics, structure and function of an ecosystem that may ultimately lead to a reduction in the life-supporting capacity of the environment. The Marine Ecology Programme provides the mechanism for assessing the effectiveness of these actions.

In 2009 Opoutama and Pouterere were sampled for infauna at sites adjacent and remote from either existing or planned development. Differences in community structure were explored using both a permutational multivariate analysis of variance, and assessment of biological summary indices.

Infaunal patterns appear consistent with medium to high energy beaches, and species present typically conform to those expected to be dominant. The structure of mid shore sites tended to be more influenced by sampling year than by site or development status, whereas the low shore sites appeared to be more influenced by site specific factors. However, the majority of the interannual variation remained unexplained (57% and 55% respectively).

The present study found that:

- The structure of mid shore sites tend to be more influenced by interannual differences than by site differences;
  - The structure of low shore sites are more influenced by site specific factors.
  - The diversity of the characterising species, and the range of sensitivities of these species to environmental stress at Opoutama Control site, indicate a healthy functioning ecosystem at this site.
  - Characterising species have changed at Opoutama between years, but functionality remains largely constant. At Pouterere characterising species were similar in 2009 to those defining sites in 2008.
  - In general infaunal patterns are consistent with medium to high energy beaches, and there is no evidence to suggest an 'unhealthy' state at any of the sampled sites.
-

## TABLE OF CONTENTS

EXECUTIVE SUMMARY .....	i
1.0 Introduction .....	1
1.1 Statutory Context .....	2
1.2 Aims and Objectives .....	2
1.3 Site Descriptions .....	3
2.0 Methodology .....	3
2.1 Site Selection .....	3
2.2 Macroinvertebrate Sampling .....	3
2.3 Data Analysis .....	4
3.0 Results .....	6
3.1 Infaunal Summary Indices .....	6
3.2 Community Characteristics – 2009 .....	8
3.3 Biological Characteristics – Between Years .....	13
4.0 Discussion .....	17
5.0 Conclusions .....	18
6.0 Recommendations .....	18
7.0 References .....	19
APPENDIX ONE: Land-use characteristics .....	20
APPENDIX TWO: Land-use characteristics – Sum of hectares .....	22
APPENDIX THREE: Infauna results .....	23
APPENDIX FOUR: Land-use characteristics – Sum of hectares .....	22

---

## 1.0 INTRODUCTION

Like many coastal environments, sandy beach ecosystems are vulnerable to the effects of both on-beach, and adjacent land-based activities. Intertidal animals living in these areas not only have to contend with these activities, but also with the harsh intertidal environment. This includes tidal inundation with subsequent changes in oxygen, temperature and salinity, and varying wave force and swash climates.

While the values associated with many other coastal environments are fairly well described, the role of sandy beach ecosystems has generally lagged (Defeo and McLachlan, 2005). In addition to protecting the terrestrial edges from the sea, sandy beaches support a vast range of meio<sup>1</sup>- and macrofauna<sup>2</sup>, support coastal fisheries, cycle nutrients, filter large volumes of seawater and provide crucial nesting and foraging habitat (Schlacher et al, 2007).

Sandy beaches form an extensive component of the Hawke's Bay coastline (48% of coastal habitats - Stevens and Robertson, 2005), and can be placed under pressure by increasing sedimentation, overharvesting, physical modification, and from the habitat reduction and alteration associated with coastal development.

The development of coastal areas for residential use is a burgeoning trend in many parts of New Zealand, and in the Hawke's Bay Region, with over 350km of coastline, this trend is currently being realised (e.g. Waipatiki, Opoutama, Mahia, Mahanga).

The physical modification typical of coastal development can affect the structure and function of marine communities, specifically in areas where erosion mitigation devices may be constructed, altering the natural exposure regime. Additionally, species typical of high salinity environments can be sensitive to the large volumes of freshwater generated by increased impervious surfaces, and stormwater diversion and the accompanying contaminants often found in stormwater such as trace metals, and PAH's.

Vehicular use on intertidal platforms, harvesting, trampling and crushing, threatens intertidal communities (Henriques et al, 1990; Stephenson, 1999). These effects can be exacerbated by the increase in the local population associated with coastal development.

Given the importance of coastal ecosystems, the services they provide, and the real risk to the integrity of these systems from the threats they are facing, monitoring of the long-term health and state is required to ensure that these vital ecosystems are being sustained in a way that will retain these key functions.

### 1.1 Statutory Context

Hawke's Bay Regional Council is responsible for achieving the sustainable management of the coastal environment, and achieves this through the framework set in the Regional Coastal (Environment) Plan. A key component of ensuring effective management of Hawke's Bay's coastal resources is comprehensive monitoring of coastal ecosystems to provide feedback on progress in achieving management goals.

Hawke's Bay Regional Council has recently developed the Coastal Monitoring Strategy for Hawke's Bay: 2006-2011 (Madarasz, 2006). Under this strategy, the Marine Ecology Monitoring Project provides the framework for monitoring and reporting on Hawke's Bay's sandy beaches to determine whether current management is effecting change (improvement, decline) in these ecosystems.

### 1.2 Aims and objectives

In line with Council's responsibilities under the RMA, monitoring of selected soft-shore ecosystems is required in order to:

---

<sup>1</sup> Those organisms less than 0.5mm in size.

<sup>2</sup> Those organisms retained on a 0.5mm mesh.

- Provide baseline information relating to soft-shore beach biodiversity;
- Assess benthic community state and health in terms of species richness and relative abundance;
- Detect trends in communities and compositions;
- Monitor Council's progress towards achieving the objectives set for specific Significant Conservation Areas; and
- Monitor the effectiveness of Council's policies relating to the maintenance of ecosystem integrity of these ecosystems.

Current planning pressures in Hawke's Bay include the development of many of the regions coastal margins, and as such, the following monitoring programme has been designed to provide information on the types and numbers of species present at beaches where development pressure is being realised.

Initially the programme was designed to allow for an assessment of the beaches before development commences, and with sites in both planned developed and planned non-developed sections of the beach to strengthen the power to detect potential changes. However, the low and variable abundance and diversity of fauna reported has meant that the programme is unlikely to offer the opportunity to assess changes over time in a statistically robust fashion. Instead, the programme has been adapted to simply provide a baseline assessment or inventory on the typical species composition of a variety of Hawke's Bay beaches, while maintaining a BACI (before-after-control-impact) based design to allow for "development"/"control" analysis if permitting.

### **1.3 Site Description**

#### *1.1.1 Opoutama*

Opoutama Beach is located along the south facing shoreline of the tombolo connecting Mahia to the mainland, and extends from the small freshwater stream (Waipiata Stream) located at the western extremity of the beach to Mahia Beach at the eastern limit (Tonkin and Taylor, 2004). The beach is comprised of fine to medium sands with surrounding coastal habitats including dune systems, grassland and plantation forestry. At the western end of the beach lies an unoccupied subdivision development which is sited on land previously known as the Blue Bay camping ground.

Opoutama is wave dominated with a SSW facing aspect exposing the beach to periodic large swells from the south. The position on the southern face of the tombolo protects the site from swells generated in the north and east. The beach profile is gently sloping at the western end (Madarasz-Smith, 2007), but becomes progressively steeper moving east with eroding sand dunes, sand banks, cusps, welded bars and gutters evident.

Opoutama is classed as a low-tide terrace/intermediate beach type.

#### *1.1.2 Pourerere*

Pourerere Beach, in southern Hawke's Bay, is characterised by a broad intertidal area and long narrow dune system and bank. The land surrounding the beach is backed by low hills and bounded by Paoanui and Tuingara Points to the north and south respectively. The beach is approximately 3.6km long, and is intersected by a rock platform which separates the two areas of residential development. The northern development is focused adjacent to the stream on the road entrance to Pourerere and is largely situated on the landward side of the coastal road. The coastal road leads to the southern settlement, comprising a caravan park and residential lots.

The beach is described as an exposed, perched beach (Tonkin and Taylor, 2004) due to the presence of a naturally occurring mudstone reef system which acts as a submerged sill. The wide beach is made up of firm, fine to medium sands, and the dune/bank elevation is moderate to low with a crest elevation of around 1.5m.

Pourerere is classed as a transverse bar/rip, intermediate dissipative beach type.

## 2.0 METHODOLOGY

The Marine Ecology Monitoring Programme contributes to Council's understanding of regional coastal biodiversity, and may also provide information on the impacts that future use of coastal margins may have on the surrounding ecology (see section 1.2).

Current planning pressures in Hawke's Bay include the development of many of the regions coastal margins, and as such, the following monitoring programme has been designed to provide information on the types and numbers of species present at beaches where development pressure is being realised. The programme has been implemented to allow for an assessment of the beaches before development commences, with sites in both planned developed and planned non-developed sections of the beach surveyed to strengthen the power of the assessment and allow for the detection of potential changes.

### 2.1 Site selection

Beaches were selected to provide information on resource issues encountered by Hawke's Bay soft-sediment ecosystems. Prior to site determination in the current project, an inventory was undertaken of beach and reef systems within Hawke's Bay. This inventory is summarised in 'Hawke's Bay Region: Coastal beach/reef inventory' (Madarasz-Smith, 2007).

Sites were selected based on:

- Beach type being suitable for monitoring over time;
- Contributing to regional knowledge of soft-sediment communities;
- Development potential likely to be realised in the short to medium term; and/or
- Other pressures identified that would contribute towards plan effectiveness monitoring.

The current survey details the second year of monitoring of Opoutama and Pourerere Beaches.

At each beach two sites were identified with similar gradient, sediment composition and aspect, but differed in relation to whether their landward boundary had existing or proposed residential or holiday home development.

At each site three transects spaced 50m apart were laid from the toe of the dune face to the Mean Low Water Spring mark (MLWS). At each transect three replicate core samples were taken at the approximate point of the mid and low tide level (see figure 1 and 2).

Sampling was undertaken on 3<sup>rd</sup> December 2009 (Pourerere) and 29<sup>th</sup> January 2010 (Opoutama).

### 2.2 Macroinvertebrate sampling

Benthic infauna are commonly used as bio-indicators as they are relatively sedentary and so cannot avoid adverse conditions and are only exposed to the environment under study, they have relatively long generation times, therefore integrating environmental conditions over time, and they respond predictably to stress and are relatively easy and cost-effective to monitor.

At each station an infaunal core was collected using a circular PVC 130mm (internal diameter) core (total area 0.013m<sup>2</sup>). Samples were collected by pushing the core into the sediment to a depth of 150mm and digging down the outside of the core, placing a hand over the bottom and extracting the core and intact sample. Samples were ejected from the core into a 0.5mm mesh sieve and sediment gently washed through, leaving infauna on the screen. Samples were then washed into sample jars with 95% Ethanol and fixed in the same. After transporting samples back to the lab a few drops of Rose Bengal solution was added to each sample, and left for several hours to allow samples to uptake the stain. Samples were then poured into shallow trays and all biological material carefully picked out. The material was then examined under a dissecting microscope, and all biology enumerated and identified to the lowest possible taxonomic grouping.



Figure 1: Opoutama Beach Monitoring sites (A-C adjacent to planned subdivision, D-F outside planned subdivision).



Figure 2: Pourerere Beach Monitoring sites (A-C adjacent to planned subdivision, D-F outside planned subdivision).

### 2.3 Data analysis

Differences in community structure were explored using a permutational multivariate analysis of variance (PERMANOVA) (Anderson, 2005). This test was considered appropriate, as comparison of statistical approaches has identified it as a powerful tool for testing the significance of taxonomic compositional changes (Walters and Coen, 2006).

The model was based on permutation of raw data for the fixed factor 'site' (Opoutama 'Dev', Opoutama 'Control', Pourerere 'Dev', Pourerere 'Control'). Data were fourth root transformed before analysis, as this type of transformation scales down the effect of highly abundant species thus increasing the equitability of the dataset (variance standardisation). Multivariate analyses

were based on a Bray-Curtis distance matrix. Spatial variations in species composition of the full dataset were visually assessed using principle coordinate analysis (PCO) (Anderson, 2003), a type of metric multidimensional scaling technique.

Low and mid shore samples were analysed separately to reduce the level of variability around the mean.

Benthic infaunal data were compared primarily between sites within beaches, but also between beaches and between years where appropriate. Differences in abundance, diversity indices, richness and evenness (collectively known as biological summary indices) were explored by single or two factor ANOVA (fixed factors: site, tide level) (StatSoft, 2004) with post hoc analysis of individual terms by Tukeys HSD test. Where required, data were transformed  $\ln(x+1)$  to satisfy the assumptions of ANOVA.

Data were also contrasted using non-metric multidimensional scaling (Kruskal and Wish, 1978) with ordination based on the Bray-Curtis distance matrix in PRIMER v5 (Clarke and Gorley, 2001), and major taxa contributing to the similarities of each site identified using analysis of similarities, or SIMPER (Clarke and Gorley, 2001; Clarke and Warwick, 1994).

### 3.0 RESULTS

#### 3.1 Infaunal Summary Indices

##### 3.1.1 Present survey

The number of species (S) at Opoutama mid shore sites ranged between 0 – 3 and 0- 6 per core, with an average number of 0.9 and 3.1 per core (development and control sites respectively). The low shore sites show a similar pattern with a range of between 0 – 3 and 0 - 6 species per core, with an average of 1.3 and 4.6 species per core (development and control respectively) (figure 3.1A). Pouterere sites also showed low taxa numbers at all sites, with between 0 – 2 and 1 – 4 per core ( $\bar{x}$  = 0.77 and 2.11) for development and control sites respectively in the mid shore, and between 0 – 2, and 1 – 4 per core ( $\bar{x}$  = 0.66 and 1.56) in the low shore.

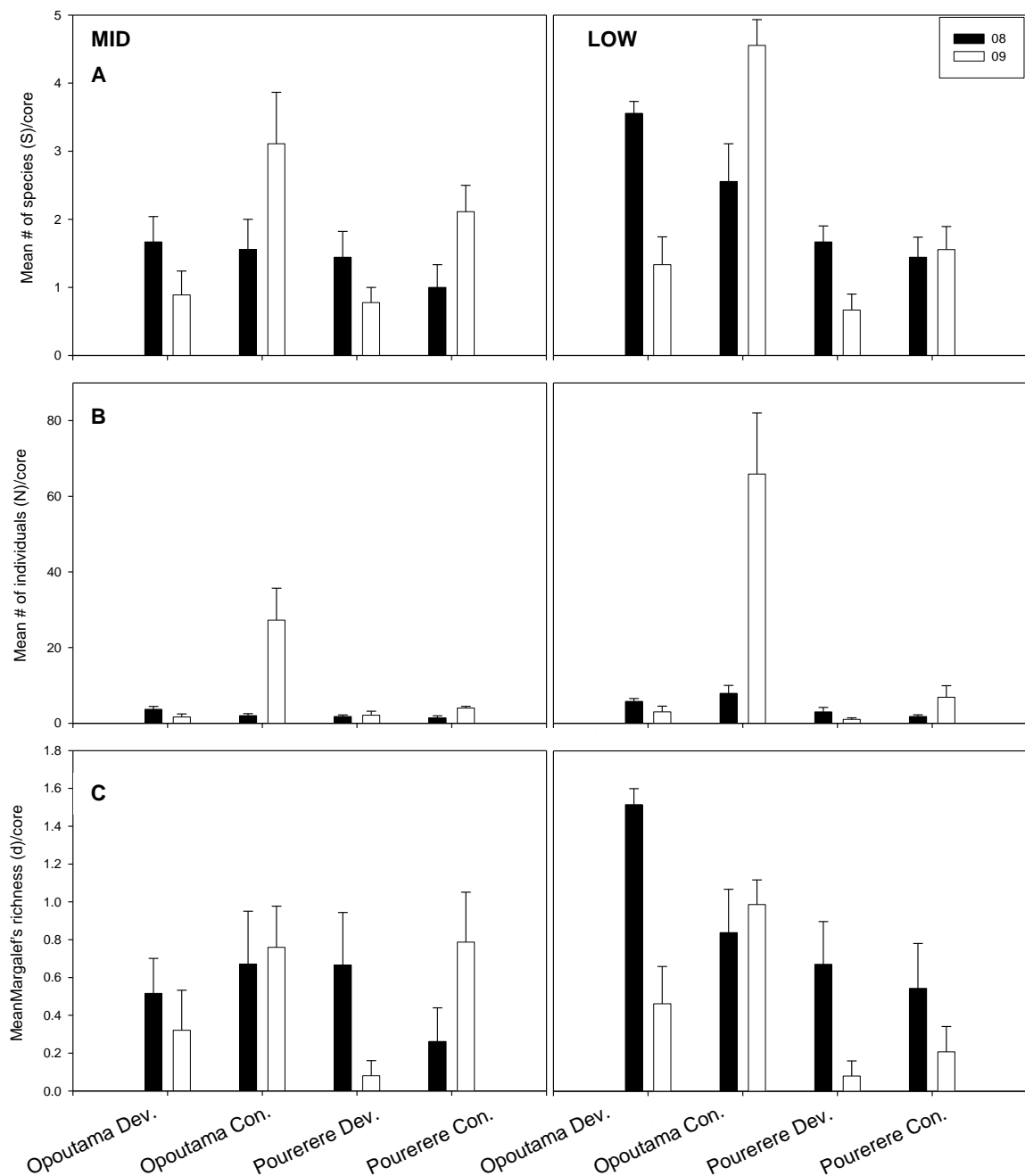


Figure 3.1 Infaunal taxa richness (A); abundance (B), and Margalef's richness (C) of beach development and control sites for mid (left) and low (right) tidal levels. Black indicates results from 2008, white, 2009.

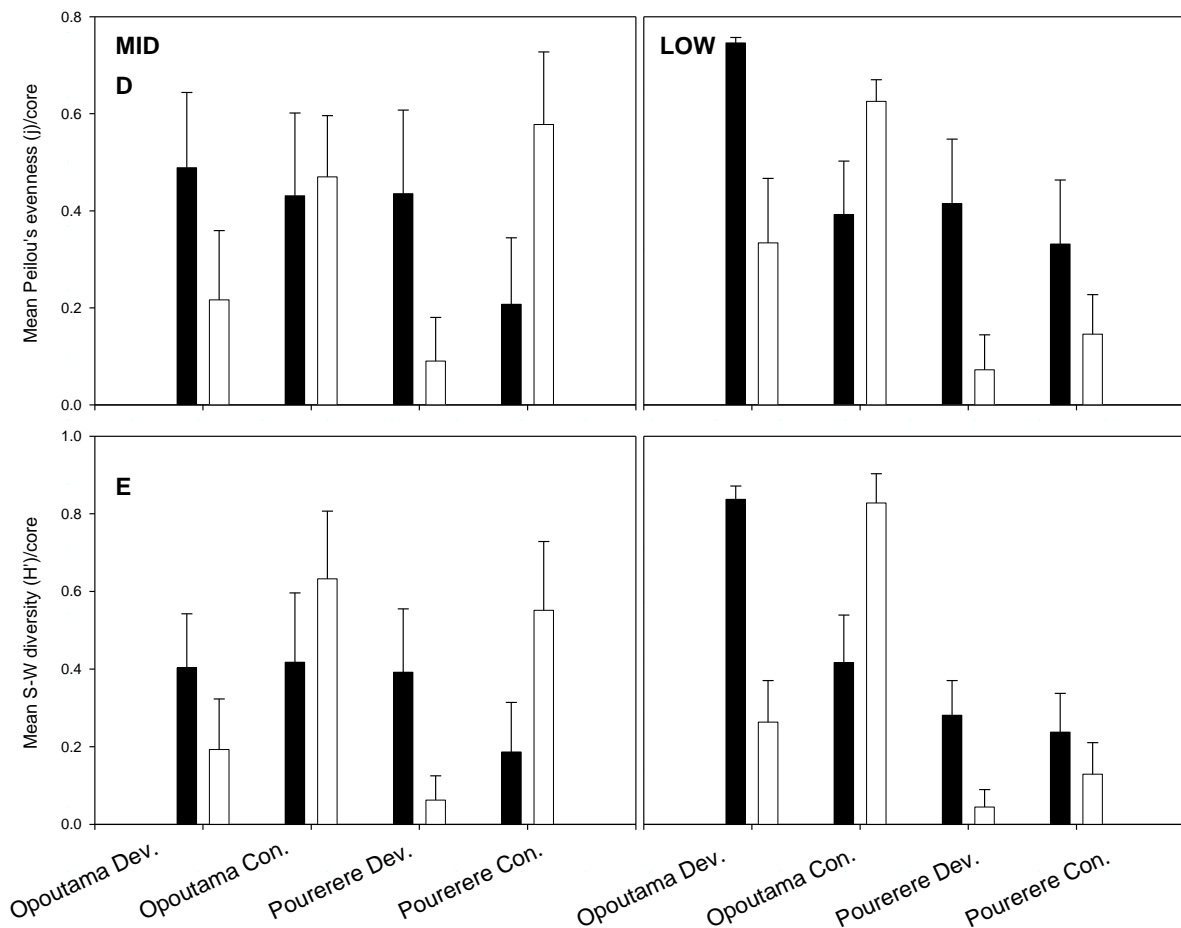


Figure 3.1 cont.: Infaunal evenness (D), and species diversity (E) of beach development and control sites for mid (left) and low (right) tidal levels. Black indicates results from 2008, white, 2009.

Abundance (N) was generally low at Opoutama Development and both Pourerere sites, but significantly higher at the Opoutama Control site which ranged between 0 – 67 individuals ( $\bar{x}$  = 27) at the mid tidal level, and between 5 – 139 ( $\bar{x}$  = 66) individuals at the low tide site (figure 3.1B).

Margalef's richness (d) is a measure of diversity based on the number of species and taking into account the number of individuals. No significant difference was observed in the richness of species in the mid intertidal area between sites (figure 3.1C); however Opoutama Control again showed significantly higher richness in the low intertidal areas compared to all other low shore sites.

Pielou's evenness (J') measures the similarity in abundances of different species in a group or community, i.e. it represents how evenly abundance is spread between species. Those communities with values nearer to 1 indicate even abundances among species, while values closer to 0 indicate dominance of particular taxa.

There was no significant difference in the evenness (J') of communities at all sites in the mid shore area with relatively low to average levels of evenness. In the low intertidal area the Opoutama Control site showed significantly higher evenness of abundance between species compared to the other sites. Pourerere sites showed uneven distribution of abundance between species (figure 3.1D).

The Shannon-Weiner diversity index (H') measures the likelihood that the next individual encountered in a sample will be of the same species as the previous individual. A diversity index of 0 would indicate only one individual, higher numbers indicate more taxa, each with a few individuals.

Diversity ( $H'$ ) was highest at both of the control sites in the mid shore, and was significantly lower at Pourerere Development compared to all other sites (figure 3.1E). In the low intertidal area, diversity was significantly higher at Opoutama Control site than at any other site.

In 2009 the Opoutama Control site (low shore) had a significantly higher number of species, abundance, and S-W- diversity index than all other sites, and significantly higher richness and evenness than the Pourerere sites (figures 3.1). This would suggest that in 2009 Opoutama Control site (low shore) has the healthiest infaunal community compared to the other study sites.

### 3.1.2 Sites between years

No significant difference in the number of taxa, individuals, richness or diversity was observed in the mid tide areas of the Opoutama Development site between the 2008 and 2009 surveys (figures 3.1). However, evenness was significantly higher in 2009 than in 2008 (figure 3.1D). Conversely, the low intertidal area at this site reported significantly higher diversity indices in 2008 compared with 2009, (figures 3.1) with the exception of abundance (figure 3.1B). This supports the significant interaction term observed in the PERMANOVA below (table 3.2) which indicates that differences between years are not consistent at each site.

The mid intertidal Opoutama Control site showed significantly higher levels of abundance in 2009 (figure 3.1B), and correspondingly lower levels of evenness in 2009 compared to 2008 (figure 3.1D), while the low intertidal sites showed significantly higher taxa, abundance and diversity in 2009 compared to 2008 (figures 3.1A,B,E).

No significant differences were observed between the infaunal summary indices at Pourerere Development site in the mid intertidal area, however in the low intertidal area taxa numbers, richness, evenness and diversity were significantly lower in 2009 compared to 2008 (figures 3.1A,B,E).

Conversely, at Pourerere Control site significantly higher numbers of taxa and abundance were observed in 2009 compared to 2008 at the mid intertidal area (figures 3.1A,B), while no significant differences were observed in the summary indices in the low intertidal area. Again, this supports the significant interaction term observed in the PERMANOVA below (table 3.2), which indicates that differences between years are not consistent at each site.

## 3.2 Community Characteristics – 2009

### 3.2.1 Infauna (Mid shore)

Grouping by location (colour) was apparent in the analysis of between site differences in community composition (figure 3.2). Within site groupings based on development status (shapes) were more observable within Pourerere (green) than within Opoutama (pink).

Mid shore sites at Opoutama 'Control' were strongly correlated with the presence of Oligochaetes, Syllids and nemertean worms, and *Microphoxus* amphipods (figure 3.3). The SIMPER analysis confirms these observations with the Opoutama sites characterised by Oligochaetes, *Microphoxus* spp., Syllid and Nemotodes (table 3.1). In comparison, fauna at Opoutama 'Dev' sites were low in abundance and diversity. However this difference in species correlations did not correspond to a statistically significant difference between the development status within Opoutama (pair-wise *a posteriori* comparisons appendix 4).

The mid shore community at Pourerere 'Control' was largely characterised by the presence of the bivalve tuatua, *Paphies subtriangulata*, and the occasional occurrence of the polychaete *Agalophamus macroura*. Pourerere 'Dev' sites had the lowest abundance and diversity of macrofauna. The SIMPER analysis highlighted tuatua and *Microphoxus* amphipods as being characterising species of the mid shore at Pourerere (table 3.1).

Table 3.1: List of infaunal species that contribute most to the similarity among **mid shore** sites at Opoutama (OPO) and Pourerere Beaches (POU). Top 90% of contributing species.

Site	Species	Av. Abundance	Av. Sim	Sim/SD	Contrib %	Cum %
OPO (av. sim. = 25%)	Oligochaeta	11.23	16.2	0.8	65.22	65.22
	<i>Microphoxus sp.</i>	0.69	2.96	0.41	11.92	77.14
	Syllid	0.62	2.1	0.46	8.46	85.6
	Nemotode	1.23	1.5	0.35	6.03	91.63
POU (av. Sim. 32%)	<i>Paphies</i>					
	<i>subtriangulata</i>	1.73	20.36	0.76	63.38	63.38
	<i>Microphoxus sp.</i>	1.33	8.95	0.46	27.85	91.23

In general the PERMANOVA confirmed the spatial patterns observed in the mid shore fauna, showing differences only between Pourerere 'Control' and all others sites and no significant differences between any other sites, Opoutama 'Dev', Opoutama 'Con' and Pourerere 'Dev' (pair-wise *a posteriori* comparisons appendix 4).

For the mid-shore sites, a PERMANOVA (based on permutation of raw data for the fixed factor 'Site' (Opoutama and Pourerere) and 'Development Status (Opoutama 'Dev', Opoutama 'Con', Pourerere 'Dev', Pourerere 'Con)'), detected a significant difference between sites, impact levels and a significant interaction term (table 3.2). A pair-wise *a posteriori* test revealed significant differences in the development status levels only at Pourerere and not at Opoutama. This is likely to be due to the fact that while Opoutama has no existing development in place (and therefore no existing pressure on the intertidal community), Pourerere has existing houses and baches adjacent to the sites deemed 'Dev'.

The significant interaction term (site\*dev. status) suggests that differences between development status at each site are not consistent.

Table 3.2: PERMANOVA results examining the effect of site and development status on beach mid shore infauna. All data were square-root transformed, and analysis was based on Bray-Curtis dissimilarities. P (perm) indicates the permutational p-value, P(MC) indicates the Monte Carlo p-value.

Source	df	SS	MS	F-value	P(perm)	P (MC)
Site	1	20378	20378	7.24	0.0001	0.0001
Dev. Status	1	14822	14822	5.27	0.0004	0.0002
Site x Dev. Status	1	12634	12634	4.49	0.0013	0.0014
Residual	32	90069	2815			
Total	35	137902				

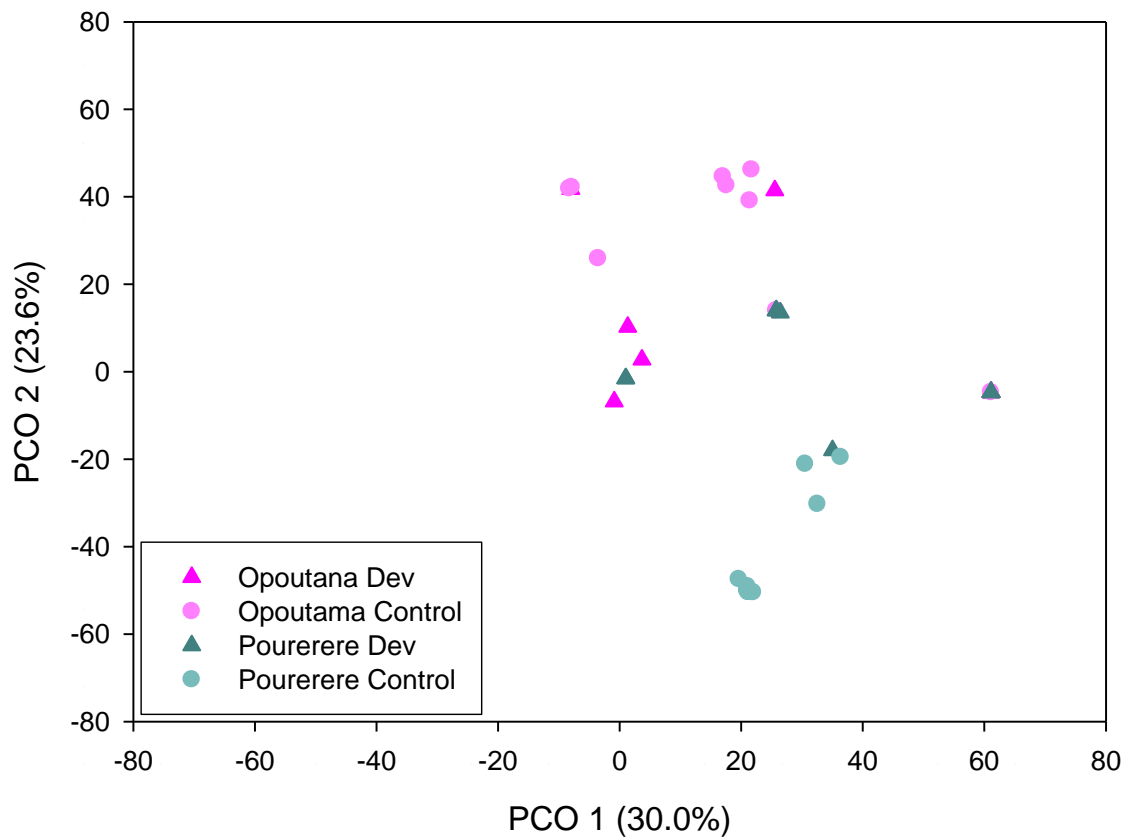


Figure 3.2 Principal Coordinates Analysis (PCO) (or metric MDS) of mid shore benthic infauna. Data were fourth-root transformed prior to analysis, and groupings based on Bray-Curtis dissimilarities. Percentage values indicate the percentage of variation among samples explained by each axis.

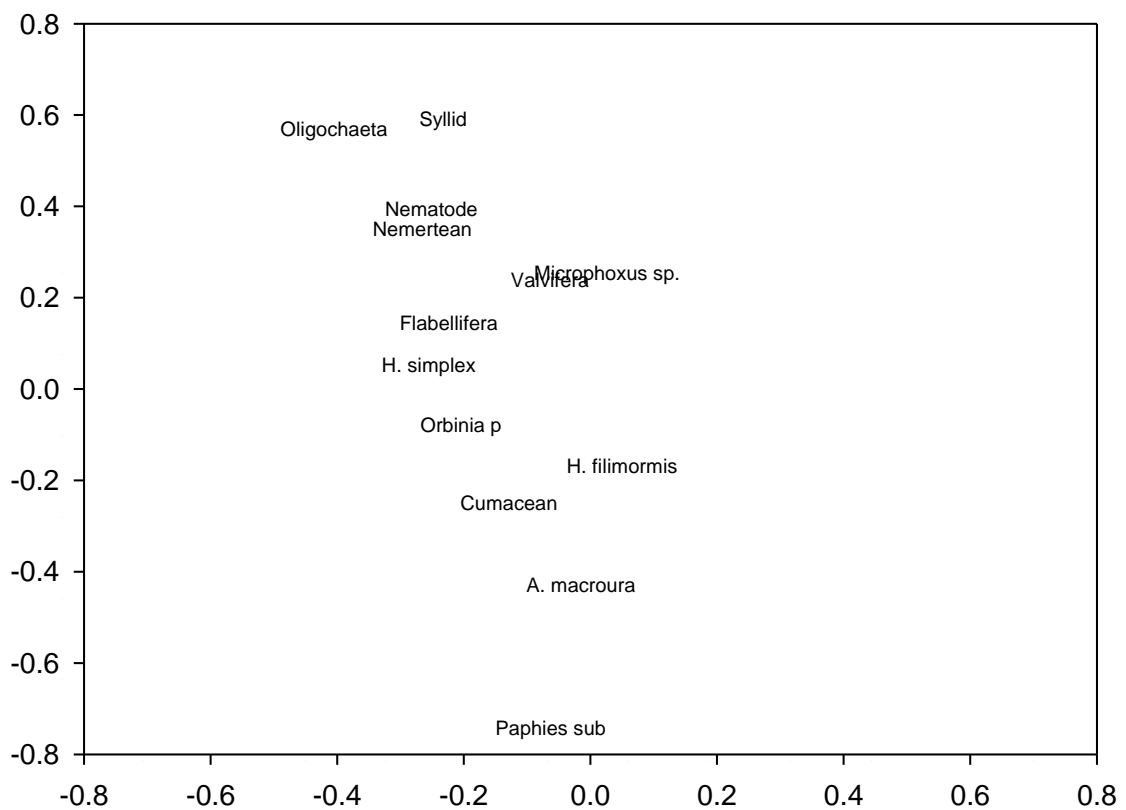


Figure 3.3 Correlations between mid shore infaunal species abundances and PCO axes for 2009.

### 3.2.2 Infauna (Low shore)

Principal coordinates analysis for low-shore samples exhibited less obvious groupings compared to the mid shore area (figure 3.4). Community structure at Pourerere 'Dev' were characterised by the presence of the orbinid polychaete *Orbinia papillosa* (see figures 3.4 and 3.5). The SIMPER analysis showed this to be a dominant characterising species, contributing to 60% of the within site similarity (table 3.3). Opoutama 'Control' sites showed higher diversity than other sites with a mixture of nemertean worms, nematodes, Oligochaetes, Syllids and the amphipod *Microphoxus sp.* These observations are supported by the SIMPER analysis (table 3.3).

Interestingly, while in the mid-shore fauna Pourerere 'Control' site stood outside the other 3 sites, for the low- shore Opoutama 'Control' site showed more dissimilarity compared to the other 3 sites. In general the low shore fauna showed more dissimilarity between sites than the mid shore fauna.

For the low shore sites, a PERMANOVA (based on permutation of raw data for the fixed factor 'Site' (Opoutama and Pourerere) and 'Development Status (Opoutama 'Dev', Opoutama 'Con', Pourerere 'Dev', Pourerere 'Con'), detected a significant difference between sites, impact levels and a significant interaction term (table 3.4). Unlike for the mid shore, a pair-wise *a posteriori* test revealed significant differences in the development status levels at both Pourerere and Opoutama. The significant interaction term (site\*dev. status) suggests that differences between development status at each site are not consistent.

Table 3.3: List of infaunal species that contribute most to the similarity among **low shore** sites at Opoutama (OPO) and Pourerere Beaches (POU). Top 90% of contributing species.

Site	Species	Av. Abundance	Av. Sim	Sim/SD	Contrib %	Cum %
OPO (av. sim. = 29%)	Oligochaeta	9.73	8.59	0.8	29.59	29.59
	Nematode	4.33	6.2	0.75	21.37	50.97
	<i>Microphoxus sp.</i>	5.13	5.19	0.55	17.87	68.84
	Syllid	15.13	4.75	0.54	16.38	85.22
	Cumacean	0.87	2.99	0.29	10.31	95.53
POU (av. sim. 16%)	<i>Orbinia paillosa</i>	0.62	9.63	0.37	60.21	60.21
	<i>Microphoxus sp.</i>	0.54	3.02	0.26	18.88	79.1
	Cumacean	3.54	2.15	0.2	13.43	92.52

Table 3.4: PERMANOVA results examining the effect of site and development status on beach low shore infauna. All data were fourth-root transformed, and analysis was based on Bray-Curtis dissimilarities. P (perm) indicates the permutational p-value, P(MC) indicates the Monte Carlo p-value.

Source	df	SS	MS	F-value	P(perm)	P (MC)
Site	1	16140	16140	5.57	0.0001	0.0002
Dev. Status	1	20332	20332	7.02	0.0001	0.0001
Site x Dev. Status	1	12895	12895	4.45	0.0005	0.0011
Residual	32	92676	2896			
Total	35	142042				

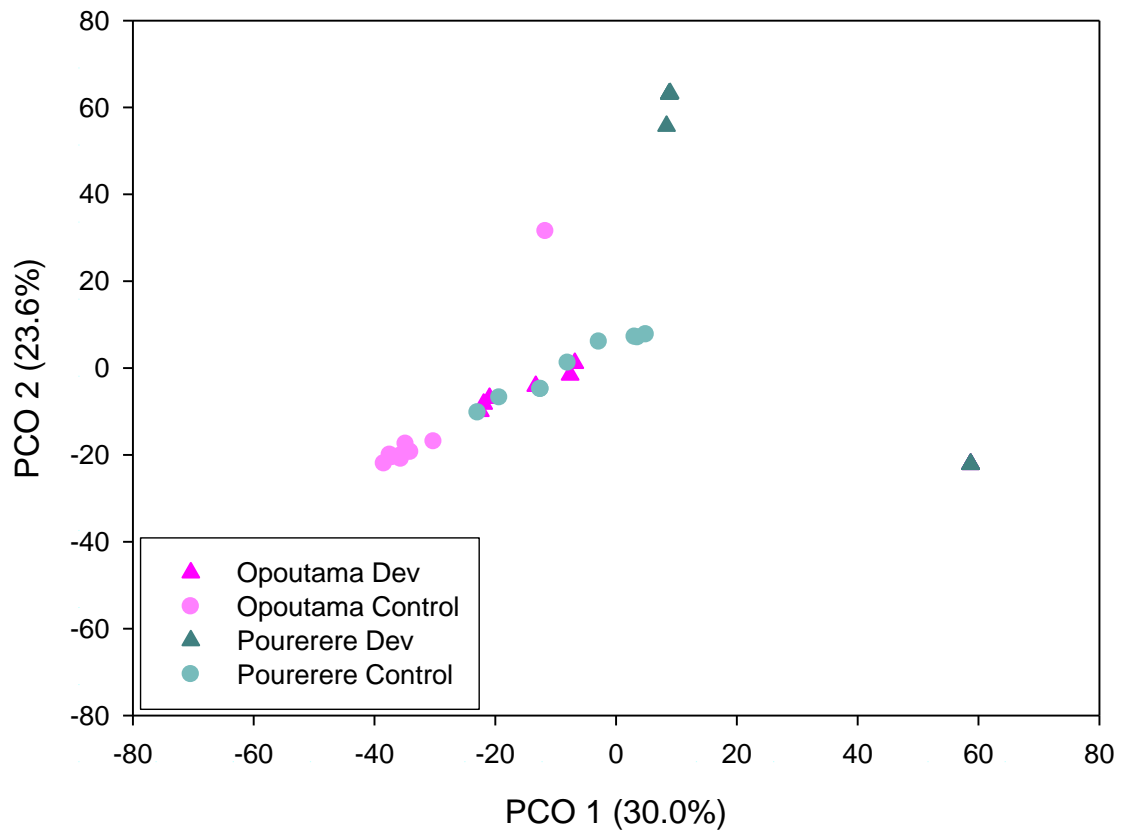


Figure 3.4 Principal Coordinates Analysis (PCO) (or metric MDS) of low shore benthic infauna. Data were fourth-root transformed prior to analysis, and groupings based on Bray-Curtis dissimilarities. Percentage values indicate the percentage of variation among samples explained by each axis.

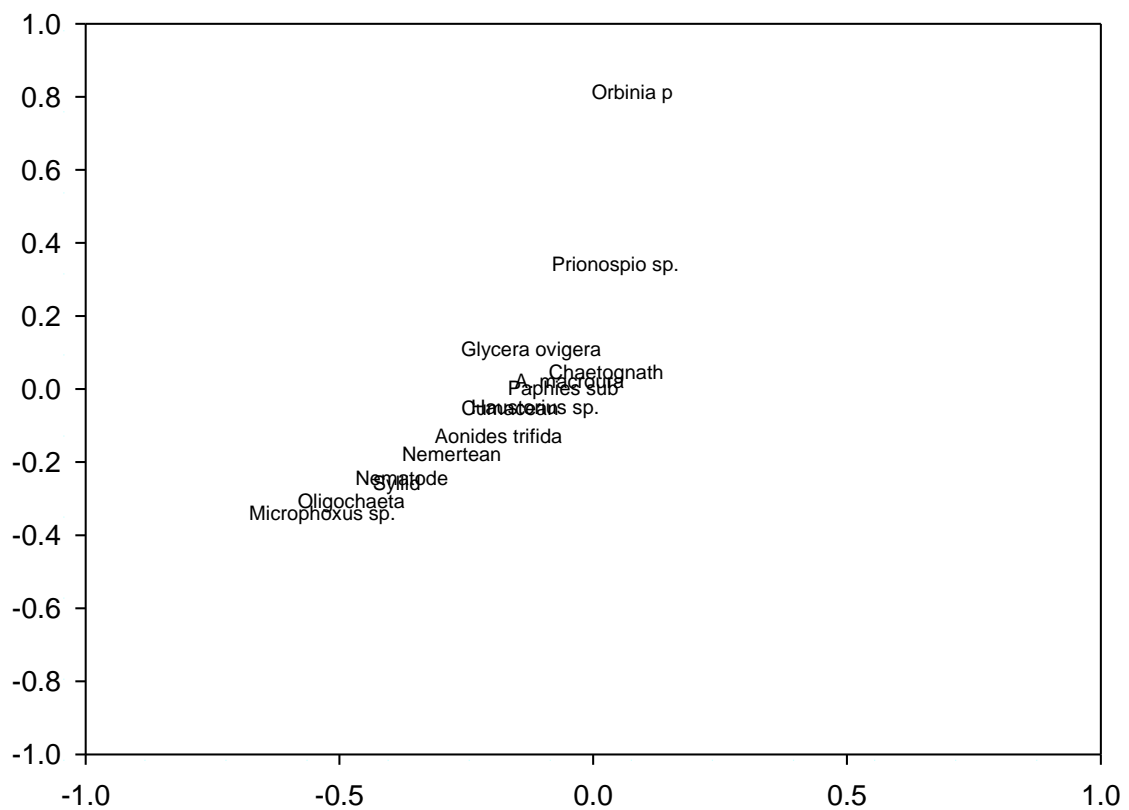


Figure 3.5 Correlations between low shore infaunal species abundances and PCO axes for 2009.

### 3.3 Biological Characteristics – Between Years

#### 3.3.1 Infauna (Mid shore)

A PERMANOVA (based on permutation of raw data for the fixed factor ‘Site’ (Opoutama ‘Dev’, Opoutama ‘Con’, Pourerere ‘Dev’, Pourerere ‘Con’), and ‘Year’ (2008 and 2009) detected a significant difference within the sites Opoutama Control, Opoutama Development and Pourerere Control between years, but not between years at site Pourerere Development (table 3.5).

The PCO confirms these differences, showing more discernable grouping by year (dark purple) than by site (shape) (figure 3.6). The PCO indicates that while the two factors analysed for, year and site, account for just over 43% of the variability, 57% remains unaccounted for. Combined with the grouping by year, this would suggest that climatic conditions have a considerable influence in similarities between sites within years.

In 2009, mid tidal infauna tended to be characterised by the tuatua (*Paphies subtriangulata*), oligochaete worms, *Microphoxus* amphipods and syllids, while in 2008 infauna tended to be strongly characterised by the presence of the polychaete worm *Glycera ovigera*, small numbers of *Perna canaliculus* spat and *Haustorius* amphipods.

Given the generation time of many species associated with these communities, the observed annual variation is likely to be due to vagaries in recruitment periods for different species, rather than any significant shift in community state.

Table 3.5: PERMANOVA results examining the effect of site and year on beach mid shore infauna. All data were fourth-root transformed, and analysis was based on Bray-Curtis dissimilarities. P (perm) indicates the permutational p-value, P(MC) indicates the Monte Carlo p-value.

Source	df	SS	MS	F-value	P(perm)	P (MC)
Site	3	41500	13833	4.59	0.0001	0.0001
Year	1	24678	24678	8.20	0.0001	0.0001
Site x Year	3	38861	12954	4.30	0.0001	0.0001
Residual	64	192707	3011			
Total	71	297747				

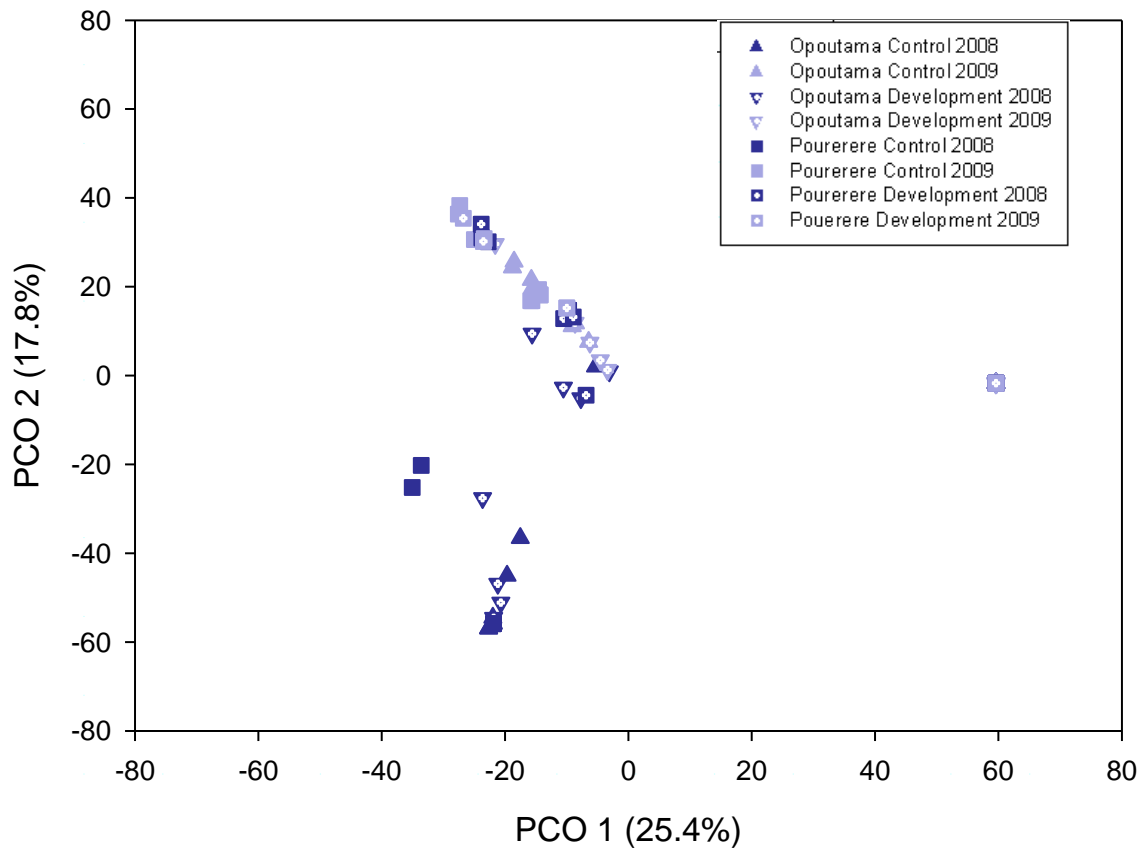


Figure 3.6 Principal Coordinates Analysis (PCO) (or metric MDS) of mid shore benthic infauna. Data were fourth-root transformed prior to analysis, and groupings based on Bray-Curtis dissimilarities. Percentage values indicate the percentage of variation among samples explained by each axis.

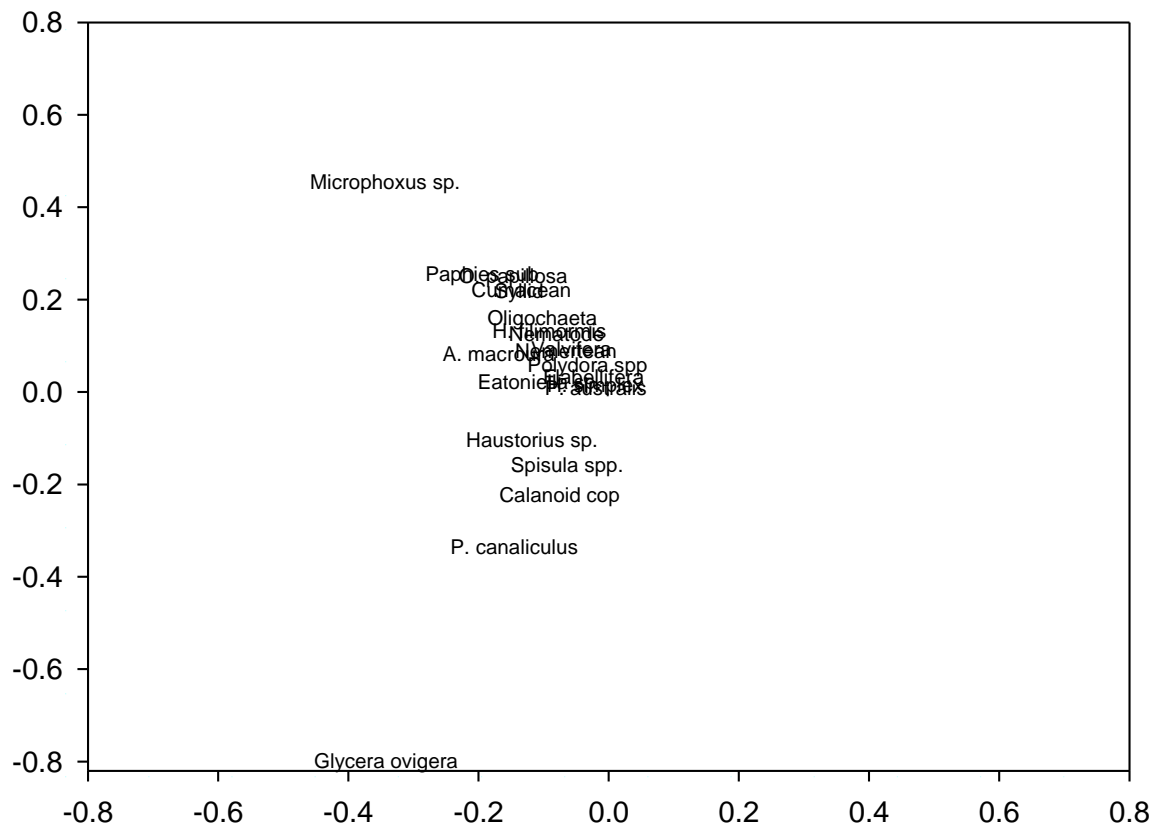


Figure 3.7 Correlations between mid shore infaunal species abundances and PCO axes.

### 3.3.1 Infauna (Low shore)

Unlike the results observed for the mid shore infaunal community, the PCO for the low shore community showed more grouping according to site (shape), with less observable groupings according to year (colour) (figure 3.8). Within these groupings, the PERMANOVA detected significant differences between years at Opoutama Development and Control, but no significant differences between years at either of the Pourerere sites (table 3.6). This indicates that the Opoutama sites are more variable between years than the sites at Pourerere.

The Pourerere Development sites were strongly characterised in both years by the polychaete worm *Orbinia papillosa*, and to a lesser degree by *Microphoxus* amphipods (figure 3.9). At Pourerere Control sites, the polychaete worm *Aglaophamus macroura*, cumacea and *Microphoxus* amphipods were dominant infauna, while the Opoutama sites were more variable between years (see PERMANOVA results). Opoutama Control tended to be characterised by Oedicerotid amphipods and small numbers of Tuatua in 2008, and by quite a different community structure in 2009 with Oligochaetes, Syllids, *Microphoxus* amphipods, nemertea and nematodes making up most of the biomass.

Likewise, Opoutama Development sites were more variable between years with Tuatua, the glycerid polychaete *Glycera ovigera*, and amphipods being the dominant infauna in 2008, while in 2009 abundance levels were generally low and the infauna was primarily made up of low numbers of cumacea, nematodes, and amphipods.

As with the mid shore, the PCO indicates that the two factors analysed for, year and site, account for almost 45% of the variability, 55% remains unaccounted for. However, unlike the mid shore, the grouping by site rather than by year for the low shore area indicate that site specific factors may play a more significant role in structuring these infaunal communities.

Table 3.6: PERMANOVA results examining the effect of site and year on beach low shore infauna. All data were fourth-root transformed, and analysis was based on Bray-Curtis dissimilarities. P (perm) indicates the permutational p-value, P(MC) indicates the Monte Carlo p-value.

Source	df	SS	MS	F-value	P(perm)	P (MC)
Site	3	58924	19641	6.77	0.0001	0.0001
Year	1	18009	18009	6.21	0.0001	0.0001
Site x Year	3	37849	12616	4.35	0.0001	0.0001
Residual	64	185677	2901			
Total	71	300459				



## 4.0 DISCUSSION

At the interface between land and sea, coastal environments are vulnerable to threats associated with populace growth and land use intensification. Hawke's Bay Regional Council Management Plans contain policies and objectives aimed to minimise the effects of these threats where they may impact on the natural characteristics, structure and function of ecosystems. The Marine Ecology Programme provides the mechanism for assessing the effectiveness of these plans to protect the life-supporting capacity of the environment.

In 2009, the low intertidal area of the Opoutama Control site showed significantly higher scores among the infaunal summary indices compared to other study sites, indicating that this site had the healthiest infaunal community. The characterising species at this site as observed in the PCO correlation and SIMPER analyses were oligochaetes, nematode worms, amphipods (*Microphoxus sp.*), syllids and cumacea. These species represent a range of tolerances to environmental stress with individuals present from groups ranging from species indifferent to enrichment (e.g. syllids), to first-order opportunistic species (e.g. oligochaetes). The presence also of the species *Magelona papillicornis* (polychaete worm) at Opoutama Control site in both the mid and low shore site, a species which is known as very sensitive to organic enrichment (Borja et. al., 2000), supports the assessment of health at this site.

In general, both the diversity of the characterising species, and the range of sensitivities of these species to environmental stress, indicate a healthy functioning ecosystem at this site.

In addition to between site differences in infaunal summary indices, analysis of macroinvertebrate communities revealed significant differences within the development status level in the mid shore at Pourerere but not at Opoutama. The Pourerere site is the only site in the current survey with existing beachfront development in place; however the significant difference is likely to have been caused by the low abundance of both individuals and taxa, and an almost total dominance of the amphipod *Microphoxus sp.*, and is unlikely to represent an 'impacted' community.

Conversely, the low intertidal sites revealed significant differences between development status, however when coupled with the significant differences observed between all sites at the low intertidal level, it is likely that these differences reflect spatial variation among communities rather than any indication of development state.

In 2009, mid shore infauna tended to be characterised by the tuatua (*Paphies subtriangulata*), oligochaete worms, *Microphoxus* amphipods and syllids, while in 2008 infauna tended to be strongly characterised by the presence of the polychaete worm *Glycera ovigera*, small numbers of *Perna canaliculus* spat and *Haustorius* amphipods.

Given the generation time of many species associated with these communities, the observed annual variation is likely to be due to vagaries in recruitment periods for different species, rather than any significant shift in community state. This is supported by the PCO only being able to explain less than 50% of the variation seen within the communities.

In the low shore, community structure appears to be more dominated by site specific factors, as infaunal communities tended to group according to site rather than year. This is in contrast to the mid shore counterparts, which strongly grouped according to year. This may be explained by interannual climatic conditions playing a more significant role in the mid shore where differences in wave, tidal height and storm frequency can have more considerable effect.

Despite the low number of individuals captured in the present survey, each beach contained fauna consistent with its morphodynamic state. Opoutama is largely characterised by amphipod, polychaete, nematode and oligochaete species, and while the characterising species appear to have changed between years (see also Smith, 2009), their functionality remains constant. Conversely, Pourerere characterising species have remained consistent between years.

Interestingly, the glycerid polychaete *Glycera ovigera* was a dominant feature of the infauna in 2008 at both Opoutama (accounting for 76% of similarity) and Pourerere (accounting for 35% of similarity), but was present in only small numbers in 2009 (two in the Opoutama low shore). This

species is both predatory and detritivorous, and it is likely that its abundance in 2008 was due to vagaries in the recruitment of either itself or its main prey species, or climatic conditions that created abundant feeding sources.

## 5.0 CONCLUSIONS

Infaunal patterns appear consistent with medium to high energy beaches, and species present typically conform to those expected to be dominant (for example, *Microphoxus* and haustorid amphipod crustacean, rapidly-burrowing molluscs such as tuatua and polychaetes (Defeo and McLachlan, 2005)).

The type and abundance of species present is generally driven in beach communities by the waves, tide and substratum. Specifically, species richness, abundance and biomass are more related to the physical variables, particularly sand particle size, beach face slope and spring tide range (McLachlan and Dorvlo, 2005). Therefore low species richness etc does not necessarily indicate impact or health. Typically, beaches with the smallest particle size, steepest slopes and smallest tides generally contain the lowest richness, abundance and biomass. This can reduce the potential use of these indicators to compare 'health' between sites, however provided changes in beach slope, grain size etc do not occur (i.e. due to seawall or other coastal protection devices), they can still provide useful information on change over time within a site.

The present study found that:

- The structure of mid shore sites tend to be more influenced by interannual differences than by site differences;
- The structure of low shore sites are more influenced by site specific factors.
- The diversity of the characterising species, and the range of sensitivities of these species to environmental stress at Opoutama Control site, indicate a healthy functioning ecosystem at this site.
- Characterising species have changed at Opoutama between years, but functionality remains largely constant. At Pourerere characterising species were similar in 2009 to those defining sites in 2008.
- In general infaunal patterns are consistent with medium to high energy beaches, and there is no evidence to suggest an 'unhealthy' state at any of the sampled sites.

## 6.0 RECOMMENDATIONS

Based on the results of the current monitoring, the following recommendations are suggested:

- Expand the monitoring programme to determine whether objectives for Significant Conservation Areas (SCA's) are being met;
- Continue to conduct monitoring in-line with the Coastal Monitoring Strategy (2006) with the next monitoring scheduled for December 2010;
- Conduct beach profile annually and sediment texture analysis (8 class) 5 –yearly;
- Given the current interest in the Opoutama site with regard to potential wastewater disposal, it is recommended that sampling continue at this site to gain a more in-depth understanding of processes driving infaunal community structure. Therefore, it is recommended that the sites for the 2010 survey include:
  - Opoutama;
  - Pourerere;
  - Pukehina Beach

## Acknowledgements

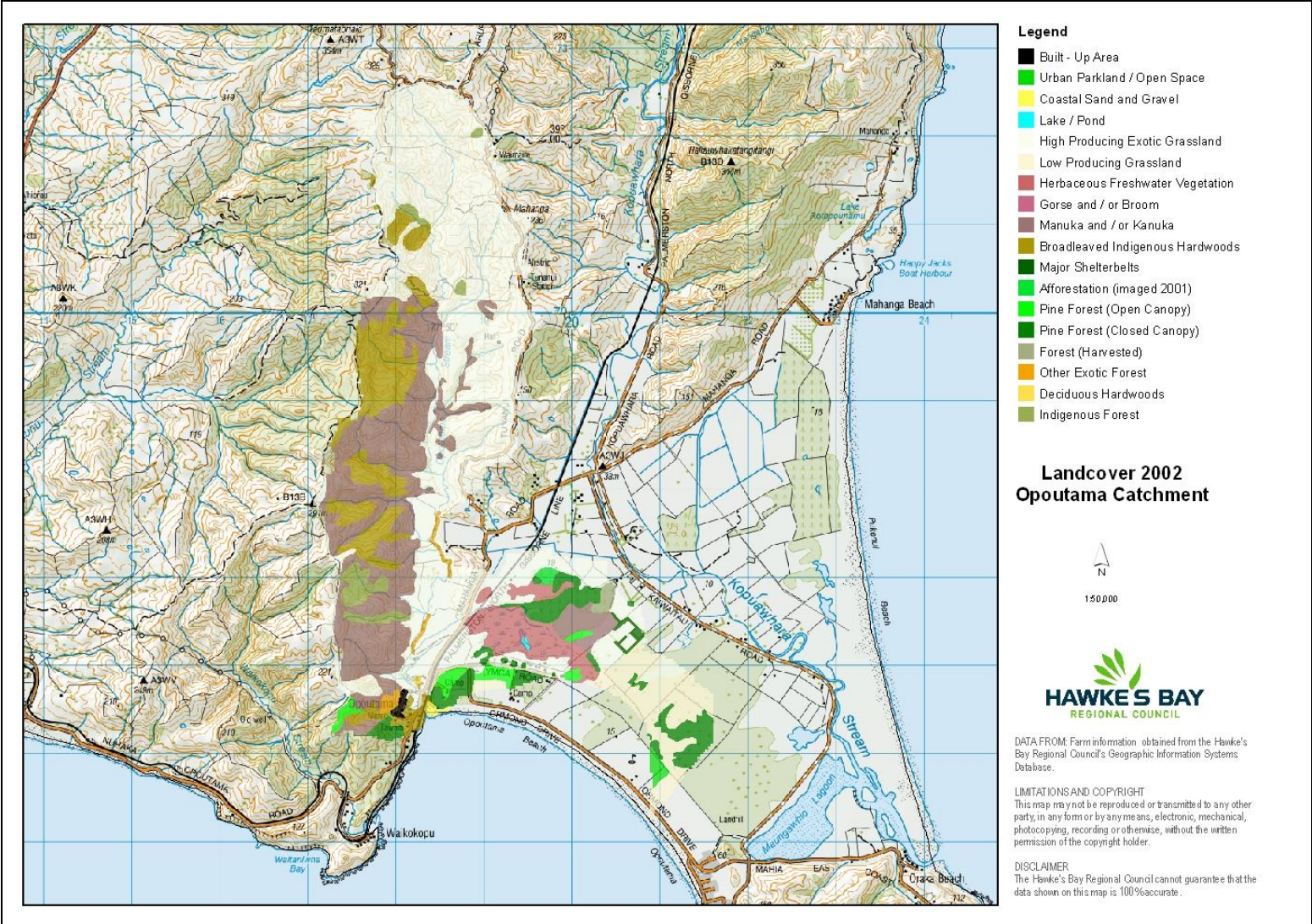
The author would like to thank Shade Smith (EAM), Fiona Cameron, Sarah Alexander, Richard Harrison and Michelle Armer for assistance with fieldwork.

## 7.0 REFERENCES

- Anderson, M.J. (2003). PCO: a FORTRAN computer programme for principle coordinate analysis. Department of Statistics, University of Auckland, New Zealand.
- Anderson, M.J. (2005). PERMANOVA: a FORTRAN computer programme for permutational multivariate analysis of variance. Department of Statistics, University of Auckland, New Zealand.
- Borja, A., Franco, J., Perez, V. (2000). A marine biotic index to establish the ecological quality of soft-bottom benthos within European Estuarine and Coastal Environments. *Marine Pollution Bulletin* 40: 1100-1114.
- Defeo, O. and McLachlan, A. (2005). Patterns, processes and regulatory mechanisms in sandy beach macrofauna: a multi-scale analysis. *Marine Ecology Progress Series* 295: 1-20.
- Henriques, P.R., Binmore, H., Grant, N.E., Anderson, S.H., and Duffy, C.A.J. (1990). Coastal Resource Inventory First Order Survey Hawke's Bay Conservancy. DoC ISBN 6-478-01236-5, ISBN 0-478-01242-X.
- Madarasz, A.L. (2006). Coastal Monitoring Strategy for Hawke's Bay: 2006-2011. EMI 06/07, HBRC Plan Number 3850.
- Madarasz-Smith, A.L. (2007). Hawke's Bay Region: Coastal Beach/Reef Inventory. EMI 07/14, HBRC Plan Number 3930.
- McLachlan, A. and Dorvlo, A. (2005). Global patterns in sandy beach macrobenthic communities. *Journal of Coastal Research* 21: 674-687.
- Schlacher, T.A., Dugan, J., Schoeman, D.S., Lastra, M., Jones, A., Scapini, F., McLachlan, A. and Defeo, O. (2007). Sandy beaches at the brink. *Diversity and Distributions*, 1-5.
- Smith, S. (2009). Soft sediment ecological monitoring: Opoutama, Waimarama and Pourerere Beaches. Hawke's Bay Regional Council EMT 09/23, HBRC Plan Number 4146.
- Stephenson, G. (1999). Vehicle impacts on the biota of sandy beaches and coastal dunes: a review from a New Zealand perspective. *Science for Conservation* 121. Department of Conservation, Wellington, ISSN 1173-2946, ISBN 0-478-21847-8.
- Stevens, L. and Robertson, B. (2005). Broad scale habitat mapping of the coastline of the Hawke's Bay region. Report prepared for Hawke's Bay Regional Council EMT 05/02, HBRC Plan Number 3745. Cawthron Report 1034.
- Tonkin and Taylor, 2004. Hawke's Bay Regional Coastal Hazard Assessment Report: Volume 2 20514, Hawke's Bay Regional Council.
- Walters, K. and Coen, L.D. (2006). A comparison of statistical approaches to analyzing community convergence between natural and constructed oyster reefs. *Journal of Experimental Marine Biology and Ecology* 330: 81-95.

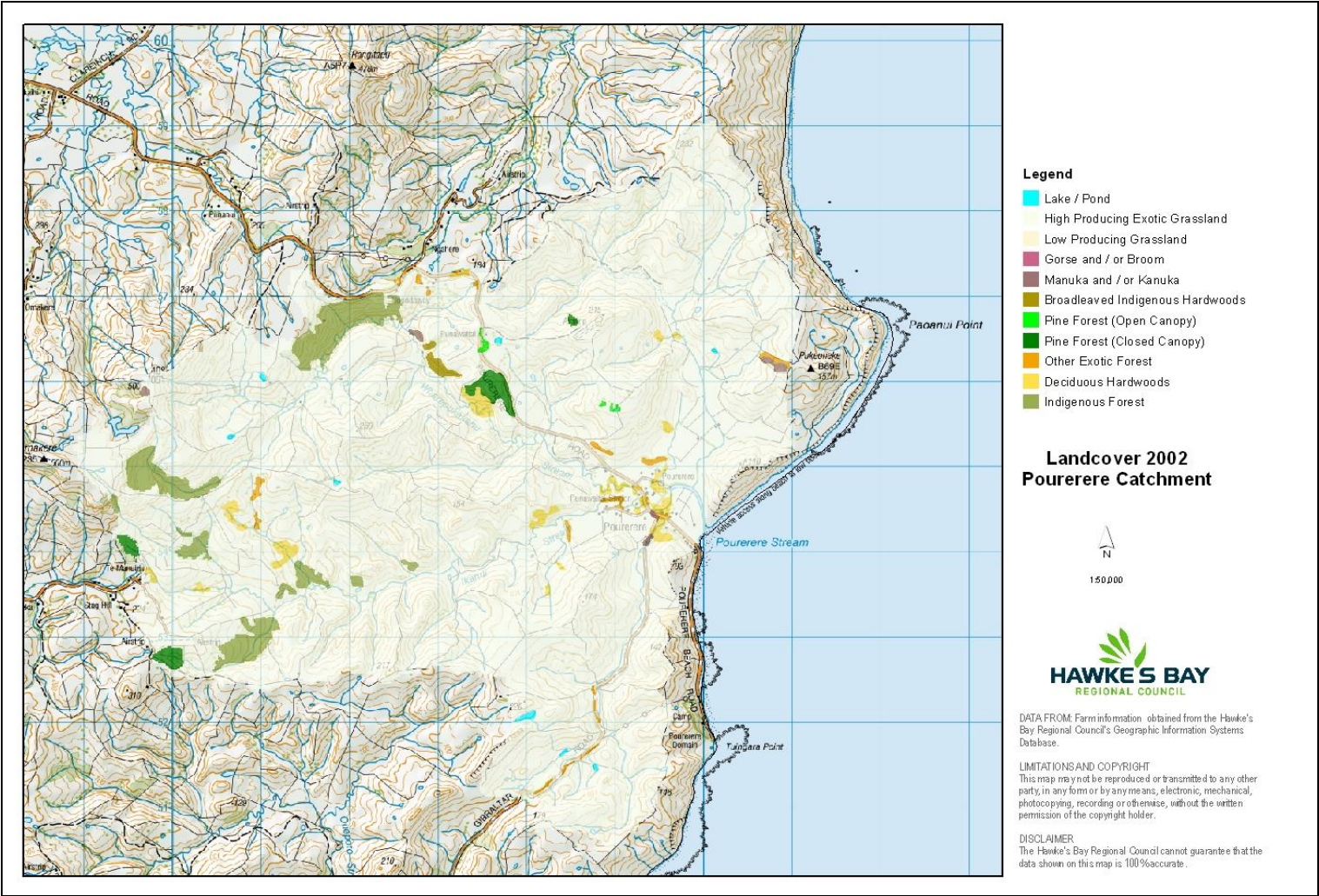
# APPENDIX ONE: LAND-USE CHARACTERISTICS

## Opoutama Beach



**APPENDIX ONE: LAND-USE CHARACTERISTICS (CONT.)**

**Pourerere Beach**



## APPENDIX TWO: LAND-USE CHARACTERISTICS – SUM OF HECTARES

LCDB2NAME	Opoutama	Pourerere	Grand Total
Afforestation (imaged, post LCDB 1)	3.5		3.5
Broadleaved Indigenous Hardwoods	150.1	5.8	155.9
Built-up Area	3.2		3.2
Coastal Sand and Gravel	2.5		2.5
Deciduous Hardwoods	1.0	45.4	46.3
Forest Harvested	5.6		5.6
Gorse and Broom	0.9	0.0	0.9
Herbaceous Freshwater Vegetation	64.7		64.7
High Producing Exotic Grassland	745.8	3479.2	4225.0
Indigenous Forest	28.8	119.4	148.2
Lake and Pond	0.7	4.5	5.2
Low Producing Grassland	90.3	3.6	93.9
Major Shelterbelts	5.2		5.2
Manuka and or Kanuka	306.2	6.8	313.0
Other Exotic Forest	10.1	16.3	26.3
Pine Forest - Closed Canopy	78.1	24.7	102.8
Pine Forest - Open Canopy	21.5	2.6	24.1
Urban Parkland/ Open Space	5.2		5.2
<b>Grand Total</b>	<b>1523.4</b>	<b>3708.3</b>	<b>5231.7</b>

### APPENDIX THREE: INFAUNA RESULTS

		MID SHORE															LOW SHORE																																								
OPOUTAMA BEACH		OPOUTAMA DEVELOPMENT									OPOUTAMA CONTROL						OPOUTAMA DEVELOPMENT									OPOUTAMA CONTROL																															
General Group	Taxa	A	A	A	B	B	B	C	C	C	D	D	D	E	E	E	F	F	F	A	A	A	B	B	B	C	C	C	D	D	D	E	E	E	F	F	F																				
Amphipoda	<i>Haustorius</i> sp.																																																								
Amphipoda	<i>Microphoxus</i> sp.			1							1			4		1		1	1	2																	5	13		14		17	15	6	5												
Bivalvia	<i>Paphies subtriangulata</i>																																																								
Chaetognatha	Chaetognath																																																								
Cumacea	Cumacean	1																		1	2	1				8												1																			
Isopoda	Flabellifera										1																																														
Isopoda	Valvifera																	1																																							
Nematoda	Nematode				1									1	6	1		7							1	5	2										2			18	2	6	3	24	2												
Nemertea	Nemertean													3	28	16																								1	26		4		48	4											
Oligochaeta	Oligochaeta			2				7			1		2	31	29	34	8	14								2												22	4	2	21	36	4	8	19	28											
Polychaeta: Capitellidae	<i>Heteromastus filiformis</i>																																																								
Polychaeta: Glyceridae	<i>Glycera ovigera</i>																									1															1																
Polychaeta: Glyceridae	<i>Hemipodus simplex</i>	1			1																																																				
Polychaeta: Magelonidae	<i>Magelona papillicornis</i>																	1																				1																			
Polychaeta: Opheliidae	<i>Agalophamus macroura</i>																																																								
Polychaeta: Orbiniidae	<i>Orbinia papillosa</i>																																									1															
Polychaeta: Spionidae	<i>Aonides triffida</i>																																						2																		
Polychaeta: Spionidae	<i>Prionospio</i> sp.																																																								
Cumacea	Syllid			1										1	2	1		1	2	1																		17			7	27	2	2	42	21											
Number of Individuals		1	1	4	2	0	0	7	0	0	1	2	0	11	67	48	34	19	17	2	4	1	0	0	1	14	5	0	49	18	5	86	65	33	28	139	60																				
Number of Taxa		1	1	3	2	0	0	1	0	0	1	2	0	5	4	5	1	6	3	2	2	1	0	0	1	3	3	0	6	3	4	5	3	5	4	5	5																				

POURERERE BEACH		MID SHORE												LOW SHORE																								
		POURERERE DEVELOPMENT						POURERERE CONTROL						POURERERE DEVELOPMENT						POURERERE CONTROL																		
General Group	Taxa	A	A	A	B	B	B	C	C	C	D	D	D	E	E	E	F	F	F	A	A	A	B	B	B	C	C	C	D	D	D	E	E	E	F	F	F	
Nemertea	Nemertean																																					
Bivalvia	<i>Paphies subtriangulata</i>								1	1	4	1	4	2	2	3	6	2																	1		1	
Polychaeta: Orbiniidae	<i>Orbinia papillosa</i>			1				1				1							1	1					3	1	2											
Polychaeta: Opheliidae	<i>Agalophamus macroura</i>															1	1		1										2							1		1
Polychaeta: Spionidae	<i>Prionospio</i> sp.																								1													
Cumacea	Cumacean												1				1																	25	13		8	
Amphipoda	<i>Microphoxus</i> sp.				1	2			1	3	2		1			1												1				1				3	2	
Polychaeta: Capitellidae	<i>Heteromastus filiformis</i>															1																						
Chaetognatha	Chaetognath																																	1				
Number of Individuals		0	0	0	1	1	2	1	1	4	3	4	4	4	2	5	4	7	3	1	1	0	0	0	0	4	1	2	2	1	2	1	1	1	26	16		12
Number of Taxa		0	0	0	1	1	1	1	1	2	2	1	4	1	1	4	2	2	2	1	1	0	0	0	0	2	1	1	1	1	1	1	1	1	2	2		4

## APPENDIX FOUR: PAIR-WISE *A POSTERIORI* COMPARISONS

### Between sites – 2009

Group	T	P_perm	P_MC	# unique values	T	P_perm	P_MC	# unique values
Tide Level	<b>Mid shore</b>				<b>Low shore</b>			
OPO D VS OPO C	1.6890	0.0342	0.0408	2572	2.5075	<b>0.0003</b>	<b>0.0010</b>	6197
OPO D VS POU D	1.2927	0.1247	0.1578	253	1.8996	0.0130	0.0207	398
OPO D VS POU C	3.0852	<b>0.0001</b>	<b>0.0001</b>	2645	1.5324	0.0211	0.0380	3304
OPO C VS POU D	1.9218	0.0089	0.0139	1450	3.7297	<b>0.0001</b>	<b>0.0001</b>	2567
OPO C VS POU C	3.8229	<b>0.0001</b>	<b>0.0001</b>	7374	2.6220	<b>0.0001</b>	<b>0.0004</b>	7344
POU D VS POU C	2.7793	<b>0.0002</b>	<b>0.0005</b>	3427	2.3111	<b>0.0001</b>	<b>0.0009</b>	970

### Between years

Group	T	P_perm	P_MC	# unique values	T	P_perm	P_MC	# unique values
Tide Level	<b>Mid shore</b>				<b>Low shore</b>			
OPO D VS OPO D	2.6733	<b>0.0002</b>	<b>0.0005</b>	2506	3.6201	<b>0.0002</b>	<b>0.0001</b>	7373
OPO C VS OPO C	1.9176	<b>0.0039</b>	<b>0.0061</b>	650	2.4822	<b>0.0001</b>	<b>0.0006</b>	6246
POU D VS POU D	3.4256	<b>0.0001</b>	<b>0.0001</b>	3034	1.0574	0.3262	0.3453	1343
POU C VS POU C	1.2281	0.2281	0.2227	998	1.6474	0.0645	0.0698	677