coastalmanagement

Castlepoint Beach

Fine Scale Monitoring 2008/09

Prepared for
Greater Wellington Regional Council
May 2009

Cover Photo: Castlepoint Beach Fine Scale Monitoring 2009 - Dr Barry Robertson sieving sand from sediment core bags.

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By

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CASTLEPOINT BEACH - EXECUTIVE SUMMARY

This report summarises the results of the 2009 fine scale monitoring for Castlepoint Beach, a 4.5km long, exposed and gradually sloping beach (intermediate/dissipative type) on the Wairarapa coast. It is a key beach in Greater Wellington Regional Council's (GWRC) long-term coastal monitoring programme and uses sediment health as a primary indicator of beach condition. The report describes the following work:

- Fine scale monitoring of sediment grain size and sediment oxygenation.
- Fine scale monitoring of sediment dwelling plants and animals.

The following table summarises monitoring results for the two intertidal sites at Castlepoint Beach for both 2008 and 2009:

Indicator	Rating	Result
Sediment Oxygenation (RPD Depth)	**Very Good**	The Redox Potential Discontinuity (RPD) layer was relatively deep >15cm depth) at all sites and therefore sediments were likely to be well oxygenated. Such high RPD values fit the "very good" condition rating and indicate that the benthic invertebrate community is likely to be in a balanced "normal" state. This was confirmed by intensive macrofauna sampling at each site (see below).
Benthic Community (Infauna and Epifauna)	**Normal Exposed Beach Community**	The benthic community condition was "balanced", with a typical exposed beach invertebrate community, dominated by crustaceans (isopods, amphipods) and beetles, but also including moderate numbers of polychaetes. Because nutrients are generally sparse on exposed beaches, invertebrate numbers were low and consisted mainly of scavengers and predators.
Sediment Type (Grain Size)	**Normal for sandy beach**	Grain size monitoring of the beach sediments showed that the beach consists of greater than 99% sand which, along with the exposed nature of the beach, explains the high level of sediment oxygenation (i.e. deep RPD).

In overview, the 2008 and 2009 results for a range of physical and biological indicators of beach condition show that the dominant intertidal habitat (i.e. unvegetated sand) at Castlepoint Beach was generally in good condition. The beach sediments consisted of well-oxygenated sands, with a typical exposed beach benthic invertebrate community, dominated by crustaceans (isopods and amphipods), and beetles. Such conditions indicate a nutrient-poor and therefore oligotrophic situation, which is typical of exposed New Zealand beaches.

Future Monitoring

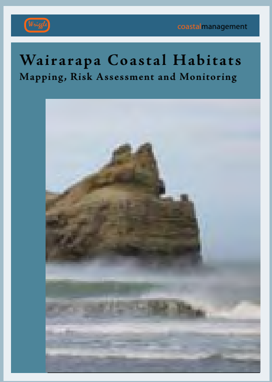
In order to provide a baseline of beach condition on the Wairarapa coast it is recommended that fine scale monitoring continues for three years. After the three year baseline is completed, reduce monitoring to five yearly intervals or as deemed necessary based on beach condition ratings.

Management

Although not directly monitored at Castlepoint Beach, the fine scale monitoring reinforced the need for management of dunes in the general area. In particular, manage the current dominance of introduced marram grass as the main sand-binding species on the beach, which has inferior sand-binding and erosion control capabilities compared to the native sand-binders. Maintenance of a healthy beach ecology, particularly in relation to predicted accelerated sea level rise, is substantially enhanced by restoring the dunes to native sand-binding species (i.e. pingao and spinifex).

1. INTRODUCTION

OVERVIEW



Developing an understanding of the condition and risks to coastal habitats is critical to the management of biological resources. The recent "Wairarapa Coastal Habitats - Mapping, Risk Assessment and Monitoring" report (Robertson and Stevens 2007) identified a moderate risk to soft sediment beach shore ecology on the Wairarapa Coast through predicted accelerated sea level rise and temperature change, erosion and habitat loss. To address this risk, and to provide information on Wairarapa beach ecology, annual long term monitoring of Castlepoint Beach (a representative intermediate/dissipative type beach ecosystem) was initiated in January 2008 (Robertson and Stevens 2008). Wriggle Coastal Management was contracted to undertake the work.

Dissipative-intermediate type beaches are relatively flat, and fronted by a moderately wide surf zone in which waves dissipate much of their energy. They have been formed under conditions of moderate tidal range, high wave energy and fine sand. Their sediments are well sorted (usually fine to medium sand), and they have weak rip currents with undertows. The tidal flat is at the extreme end of dissipative beaches. Castlepoint Beach tends more to the intermediate type. Compared with other beach types their ecological characteristics include the following:

- Interactions within and between species are generally more intense.
- High level of primary production, diversity and biomass of macrofauna.
- Exporters of organic matter.
- More highly regulated by biological interactions.

The township of Castlepoint is situated at the southern end of the beach. At this point, seawalls border the beach and the terrestrial margin consists primarily of baches that are most commonly occupied during holiday periods. Vegetation immediately inland of the township is primarily grassland used for extensive sheep and beef grazing. Further along the beach near the Whakataki Estuary, the beach becomes more exposed and its gradient steepens slightly. High marram covered sandhills border the beach. The monitoring area was located in this latter section of the beach to provide a site that was accessible, a representative example of an intermediate/dissipative beach, and isolated from the localised influence of seawalls and discharges. Monitoring was undertaken by measuring physical and biological parameters collected from the beach along two transects from supratidal (the shore area immediately above the high-tide) to low water.

Human use of the beach and associated rocky areas is low-moderate in a national context, but is high in a local Wairarapa context. It is used for walking, swimming, quad-biking, surfing, diving, scientific interest and inshore fishing. Public access is generally good. Commercial fishing boats are launched off the beach at the south end of the beach (through the Gap). Stormwater from the village does cross the beach but is relatively minor. Sewage from the township is reticulated and treated via an oxidation pond and wetland before discharge to land (summer) and/or Castlepoint Stream. The stream drains a largely agricultural catchment and discharges directly to Castlepoint Beach. Monitoring results for enterococci bacteria at Castlepoint Beach near the stream show alert levels are occasionally reached during the summer holiday period (Milne and Wyatt 2006).

The current report documents the results of the second year of fine scale monitoring of Castlepoint Beach intertidal sites (undertaken in January 2009), and includes recommended changes to the long term monitoring programme design or management.

1. Introduction (Continued)

The report is the second of a proposed series of three, which will characterise the baseline fine scale conditions in the beach over a 3 year period. The results will help determine the extent to which the beach is affected by major environmental pressures (Table 1), both in the short and long term. The survey focuses on providing detailed information on indicators of biological condition (Table 2) of the dominant habitat type in the beach (i.e. unvegetated intertidal sandflats).

Table 1. Summary of the major environmental issues affecting NZ beaches and dunes.

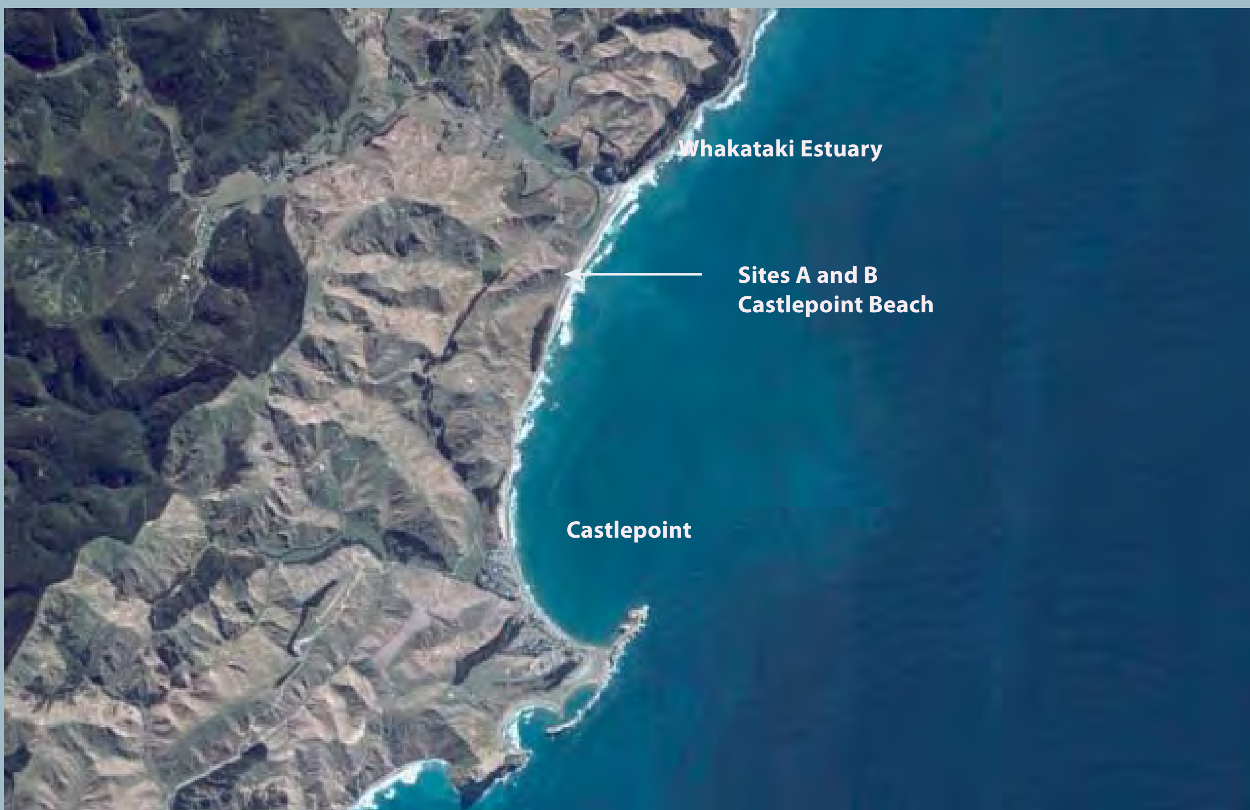
Key Environmental Beach and Dune Issues	
Habitat Loss or Modification	The key stressors of beaches and dunes are; sea level rise, vehicle use, introduced marram grass and stock grazing. **Sea Level Rise.** The general effect of sea level rise on beaches is that they erode. Most sandy beaches world-wide have recorded recession during the last century and the predicted accelerated sea level rise due to climate change will only increase erosion rates. A common response to accelerated erosion is to armour the beach with a seawall. Although this may protect terrestrial property, seawalls can cause damage to the beach and its ecology by eroding at the ends and causing accelerated erosion of the beach in front of the wall. **Vehicle Use.** Vehicle use on dunes and the backshore of sandy beaches (i.e. immediately above the intertidal area) has been demonstrated to be highly damaging to plants and animals, whereas in the intertidal section it appears to be minimal (Stephenson 1999) although available information is limited. **Stock Grazing.** The effect of stock grazing in dunes reduces the height of plants and encourages mobilisation of dunes. It also leads to a decreased organic and nutrient content of the duneland. Stock trampling also encourages sand mobilisation as does sheep rubbing against small blowouts. Low density stock grazing can be used to control weed growth in dunes, particularly in areas well back from the foredune, although excessive grazing leads to high levels of damage. **Marram Grass.** Introduced marram grass, although relatively successful at limiting coastal erosion and stabilising sand drift, does have drawbacks. In particular, marram dunes are generally taller, have a steeper front and occupy more area than dunes of either of the native species (spinifex or pingao). Consequently, they result in overstabilisation and a reduced ability of active dunes to release sand to the foreshore during storm erosion. They also tend to contribute to the loss of biodiversity and natural character (Hilton 2006). As a consequence of their invasive nature and threat to active dune function, as well as threats to ecology and biodiversity, there is now a growing move to remove existing and minimise any further marram grass invasion of active dunes and to replant with native species.
Disease Risk	If pathogen inputs to the coastal area are excessive (e.g. from coastal wastewater discharges or proximity to a contaminated river plume), the disease risk from bathing, wading or eating shellfish increases to unacceptable levels.
Sedimentation	If sediment inputs are excessive, the beach becomes muddier and the sediments less oxygenated, reducing biodiversity and human values and uses.
Eutrophication	Eutrophication on beaches occurs when nutrient inputs are excessive (e.g. in the groundwater feeding a beach), resulting in organic enrichment, anoxic sediments, lowered biodiversity and nuisance effects for local residents. Such effects are rare on exposed beaches.
Toxins	If potentially toxic contaminant inputs (e.g. heavy metals, pesticides) are excessive, beach biodiversity is threatened and shellfish may be unsuitable for eating.

1. Introduction (continued)

Table 2. Summary of the broad and fine scale beach indicators (those used for Castlepoint fine-scale are shaded).

Issue	Indicator	Method
Sedimentation	Grain size	Physical analysis of beach sediment grain size - estimates the change in grain size over time.
Eutrophication	Nuisance Macroalgal Cover	Broad scale mapping - estimates the change in the area of any nuisance macroalgal growth (e.g. sea lettuce (*Ulva*), *Gracilaria* and *Enteromorpha*) over time.
Eutrophication	Organic and Nutrient Enrichment	Chemical analysis of total nitrogen, total phosphorus, and total organic carbon in replicate samples from the upper 2cm of sediment. These indicators are only used in situations where nutrient enrichment is likely.
Eutrophication	Redox Profile	Measurement of depth of redox discontinuity profile (RPD) in sediment estimates likely extent of deoxygenated, reducing conditions.
Toxins	Contamination in Bottom Sediments	Chemical analysis of indicator metals (cadmium, chromium, copper, nickel, lead and zinc) in replicate samples from the upper 2cm of sediment. These indicators are only used in situations where metal contamination is likely.
All except Disease Risk	Benthic Community	Type and number of animals living in the upper 15cm of sediments. Relates the sensitivity of the animals present to different levels of pollution or disturbance.
Habitat Loss	Dune, Vegetated Terrestrial Buffer	Broad scale mapping - estimates the area and change in buffer habitat over time.

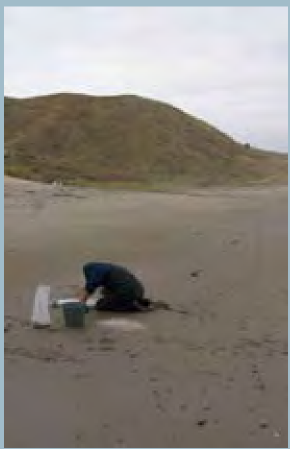
Figure 1 Location of fine scale monitoring sites at Castlepoint Beach (Photo; Google)



2. METHODS

FINE SCALE MONITORING

Fine scale monitoring involves measuring the abundance and diversity of plants and animals in cores collected from the beach along two transects from supratidal to low water tide ranges. The dynamic nature of the beach ecosystem means there will be change over both the short and long terms. To minimize seasonal and spatial variation, monitoring is undertaken at a fixed time each year (January to March) and from cores that have been positioned in habitat that is representative of the wider coastline. To account for year to year changes, a 3 year baseline has been recommended (annual monitoring) after which a review will be undertaken and a possible shift to five yearly monitoring.



Sampling was undertaken by two scientists, during relatively calm sea conditions during January 2009 when estuary monitoring was being undertaken in the region. The approach was a similar to that used by Aerts et al. (2004) in a study of macrofaunal community structure and zonation of an Ecuadorian sandy beach as follows:

- Two transects were sampled 50m apart. Each transect was sampled at six stations: five stations were situated in the intertidal zone, while a sixth one was located on the dry beach.
- Sampling of the intertidal zone started at high tide, following the receding water down the beach.
- Sampling in the swash zone every 60 minutes to distribute stations evenly.
- The relative elevations of the stations were measured using an altimeter and distances between all sample sites were measured and the GPS positions of each station were logged.

Physical and chemical analyses

- At each station along each transect the average RPD depth was recorded.
- At each station, a composite sample of the top 20mm of sediment (each approx. 250gms) was collected for analysis of grain size/particle size distribution (% mud, sand, gravel) - details in Appendix 1.
- Samples were tracked using standard Chain of Custody forms and results checked and transferred electronically to avoid transcription errors.
- Photographs were taken to record the general site appearance.

Infauna (animals within sediments)

- Three sediment cores (each 2m apart) were taken at each station using a 330mm square (area = $0.1089m^2$) stainless steel box corer.
- The box core was manually driven 150mm into the sediments, the sediments removed with a spade and emptied into 1mm nylon mesh bag and the contents of the core sieved in nearby seawater. The infauna remaining were carefully emptied into a plastic container with a waterproof label and preserved in a 70% isopropyl alcohol - seawater solution.
- The samples were then transported to a commercial laboratory for counting and identification (Gary Stephenson, Coastal Marine Ecology Consultants).

2. Methods (Continued)

CONDITION RATINGS

RATING
Very Good
Good
Fair
Poor
Early Warning Trigger

At present, there are no formal criteria for rating the overall condition of beaches in NZ, and development of scientifically robust and nationally applicable condition ratings requires a significant investment in research and is unlikely to produce immediate answers. Therefore, to help GWRC interpret their monitoring data, two interim beach "condition ratings" (the degree of sediment oxygenation as indicated by the redox discontinuity profile (RPD) and the benthic community condition as presented below) have been proposed.

The condition ratings are designed to be used in combination with each other and with other information (usually involving expert input) when evaluating overall beach condition and deciding on appropriate management responses. The ratings are based on a review of monitoring data, use of existing guideline criteria (e.g. ANZECC (2000) sediment guidelines, Borja et al. 2000), and expert opinion. They indicate the type of condition the monitoring results reflect, and also include an "early warning trigger" so that GWRC is alerted where rapid or unexpected change occurs.

Redox Potential Discontinuity

The RPD is the grey layer between the oxygenated yellow-brown sediments near the surface and the deeper anoxic black sediments. The RPD marks the transition between oxygenated and reduced conditions and is an effective ecological barrier for most but not all sediment-dwelling species. A rising RPD will force most macrofauna towards the sediment surface to where oxygen is available. In addition, nutrient availability in beaches is generally much greater where sediments are anoxic, with consequent exacerbation of the eutrophication process.

RPD CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	>10cm depth below surface	Monitor at 5 year intervals after baseline established
Good	3-10cm depth below sediment surface	Monitor at 5 year intervals after baseline established
Fair	1-3cm depth below sediment surface	Monitor at 5 year intervals. Initiate Evaluation & Response Plan
Poor	<1cm depth below sediment surface	Monitor at 2 year intervals. Initiate Evaluation & Response Plan
Early Warning Trigger	>1.3 x Mean of highest baseline year	Initiate Evaluation and Response Plan (ERP)

Macrofauna Biotic Index

Soft sediment macrofauna can be used to represent benthic community health and provide an estuary/beach condition classification (if representative sites are surveyed). The AZTI (AZTI-Tecnalia Marine Research Division, Spain) Marine Benthic Index (AMBI) (Borja et al. 2000) has been verified successfully in relation to a large set of environmental impact sources (Borja, 2005) and geographical areas (in both northern and southern hemispheres) and so is used here. However, although the AMBI is particularly useful in detecting temporal and spatial impact gradients care must be taken in its interpretation in some situations. In particular, its robustness can be reduced when only a very low number of taxa (1–3) and/or individuals (<3 per replicate) are found in a sample. The same can occur when studying low-salinity locations (e.g. the inner parts of estuaries), some naturally-stressed locations (e.g. naturally organic matter enriched bottoms; *Zostera* beds producing dead leaves; etc.), or some particular impacts (e.g. sand extraction, for some locations under dredged sediment dumping, or some physical impacts, such as fish trawling).

The equation to calculate the AMBI Biotic Coefficient (BC) is a s follows;

$$BC = \{(0 \times \%GI) + (1.5 \times \%GII) + (3 \times \%GIII) + (4.5 \times \%GIV) + (6 \times \%GV)\}/100.$$

The characteristics of the above-mentioned ecological groups (GI, GII, GIII, GIV and GV) are summarised in Appendix 3.

BENTHIC COMMUNITY CONDITION RATING

ECOLOGICAL RATING	DEFINITION	BC	RECOMMENDED RESPONSE
High	Unpolluted	0-1.2	Monitor at 5 year intervals after baseline established
Good	Slightly polluted	1.2-3.3	Monitor 5 yearly after baseline established
Moderate	Moderately polluted	3.3-5.0	Monitor 5 yearly after baseline est. Initiate ERP
Poor	Heavily polluted	5.0-6.0	Post baseline, monitor yearly. Initiate ERP
Bad	Azoic (devoid of life)	>6.0	Post baseline, monitor yearly. Initiate ERP
Early Warning Trigger	Trend to slightly polluted	>1.2	Initiate Evaluation and Response Plan (ERP)

3. RESULTS AND DISCUSSION

OUTLINE

The general layout of the Castlepoint Beach transects for both 2008 and 2009 is presented in Figure 2. It shows that the beach was backed by a 4m high foredune which was covered with marram grass vegetation. The intertidal area was 65m wide, with a very gradual slope in the lower half and steeper in the upper. A summary of the results of the fine scale monitoring of Castlepoint Beach is presented in Tables 3 and 4. Detailed results are presented in Appendix 2. In order to facilitate understanding, the results and discussion section is divided into subsections based on the key beach issues or problems that the Castlepoint fine scale monitoring is addressing: habitat modification, eutrophication and sedimentation. The issues of toxicity and disease risk were not incorporated in the monitoring programme as toxicity was considered to be at such a low risk it was not considered necessary to monitor, whilst the presence of disease risk indicators on the Wairarapa coast is assessed separately in GWRC's recreational water quality monitoring programme.

Figure 2 Cross-section of transects at Castlepoint Beach, January 2008 and 2009.

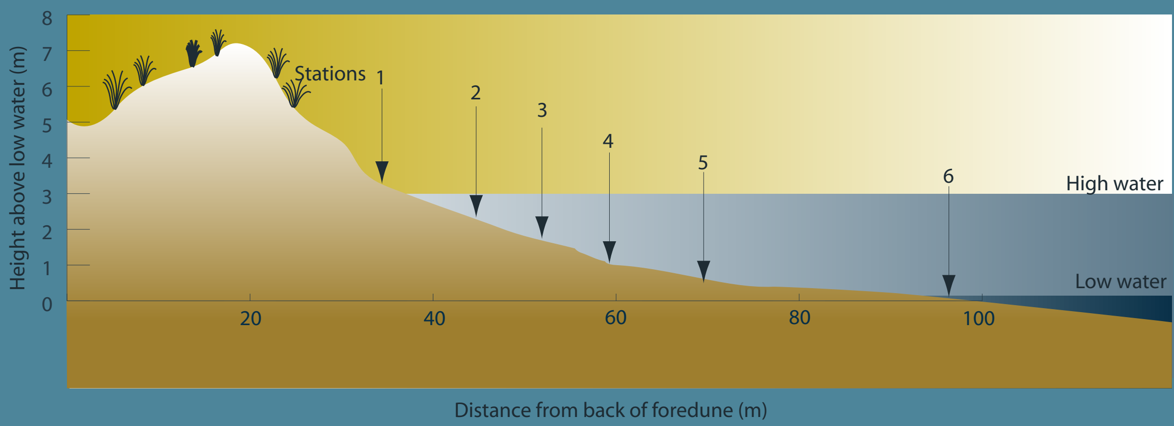


Table 3 Physical and chemical results (means) for Castlepoint Beach, January 2008 and 2009.

Site	Reps	RPD (cm)		Salinity (ppt)		%Mud		%Sands		%Gravel/Shell	
		2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Cas A	3	>15	>15	33ppt	33ppt	0.57	1.48	99.80	98.52	0.22	<0.10
Cas B	3	>15	>15	33ppt	33ppt	0.67	1.18	99.65	98.82	0.35	<0.10

Table 4 Macrofauna results (means) for Castlepoint Beach, January 2008 and 2009.

Site	Reps	Mean Total Abundance/m^2		Mean Number of Species/Core	
		2008	2009	2008	2009
Cas A	3	51.7	38	2.0	2.2
Cas B	3	57.2	72	2.3	2.3

EUTROPHICATION

As reported in the 2008 monitoring report (Robertson and Stevens 2008), on semi-exposed beaches like Castlepoint, there are no major nutrient sources and the sands are well-flushed. Organic matter and nutrients within the sediments are likely to be very low and consequently the usual symptoms of beach eutrophication, e.g. macro-algal (e.g. sea lettuce) and micro-algal blooms, sediment anoxia, increasing muddiness, and benthic community changes are unlikely. In such a low risk situation, the number of primary fine scale indicators are therefore kept small and include grain size, sediment oxygenation (i.e. redox potential discontinuity - RPD boundary), and the sediment-dwelling animals. The broad scale indicators (reported in Robertson and Stevens 2007) are the physical dimensions of beach and dune areas.

3. Results and Discussion (Continued)

The Redox Potential Discontinuity (RPD)

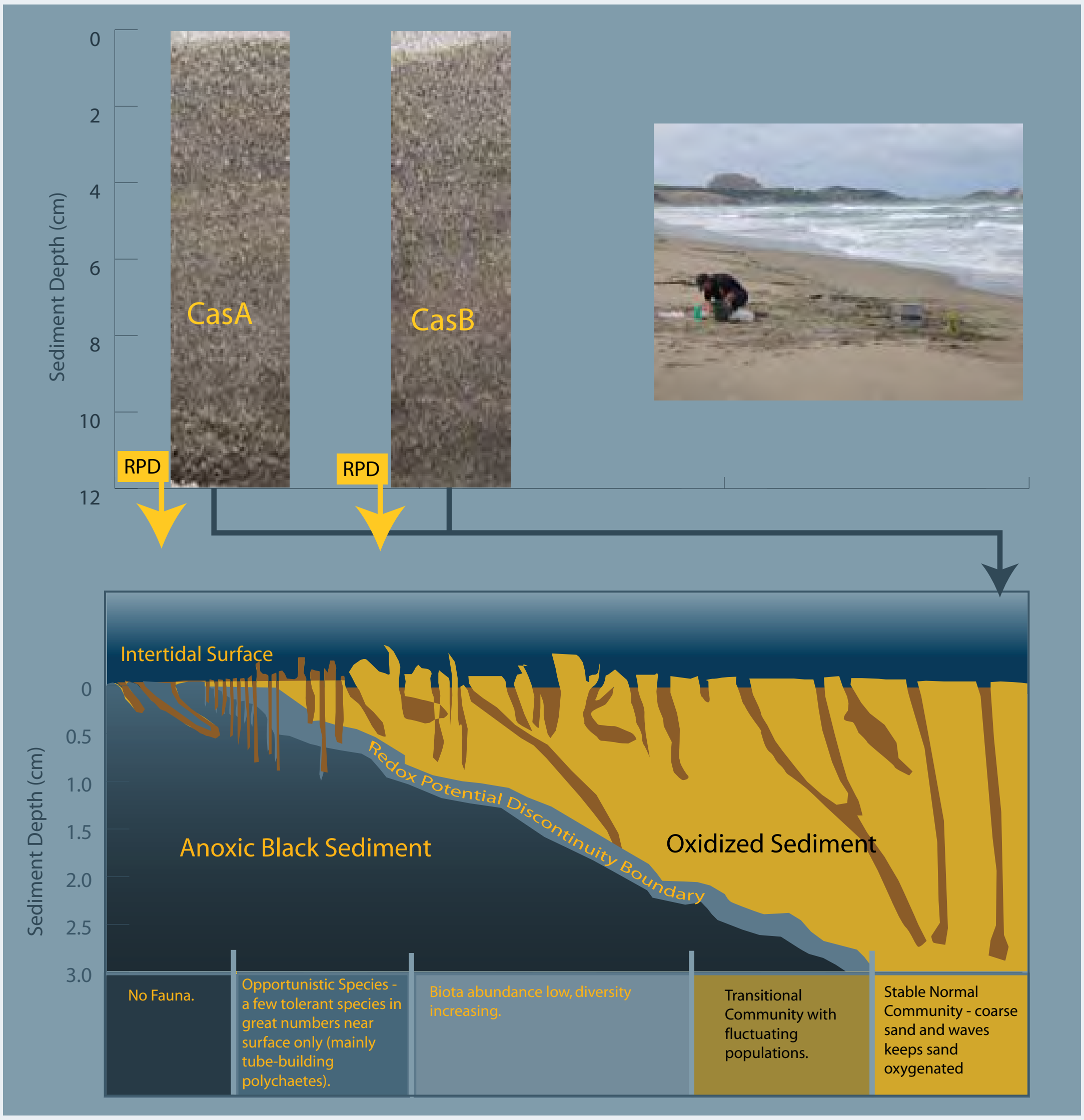
The depth of the RPD layer is a critical beach condition indicator in that it provides a measure of whether nutrient enrichment exceeds the trigger leading to nuisance anoxic conditions in the surface sediments. Knowing if the surface sediments are moving towards anoxia (i.e. RPD close to the surface) is important for two main reasons:

1. As the RPD layer gets close to the surface, a "tipping point" is reached where the pool of sediment nutrients (which can be large), suddenly becomes available to fuel algal blooms and to worsen sediment conditions.
2. Anoxic sediments contain toxic sulphides and support very little aquatic life.

The tendency for sediments to become anoxic is much greater if the sediments are muddy. In sandy porous sediments, the RPD layer is usually relatively deep (>3cm) and is maintained primarily by current or wave action that pumps oxygenated water into the sediments. In finer silt/clay sediments, physical diffusion limits oxygen penetration to <1cm (Jørgensen and Revsbech 1985) unless bioturbation by infauna oxygenates the sediments.

Figure 3 shows the sediment profiles and RPD depths for the Castlepoint Beach transect sampling sites (also Table 3) and indicates the likely benthic community that is supported at each site based on the measured RPD depth (adapted from Pearson and Rosenberg 1978). The 2009 RPD results showed that the depth of the RPD at Castlepoint Beach was >15cm at all sites and therefore likely to be well oxygenated. Such RPD values fit the "very good" condition rating and indicate that the benthic invertebrate community was likely to be in a "normal" state. These results are similar to those reported in 2008.

Figure 3 Sediment profiles, depths of RPD and predicted benthic community type, Castlepoint Beach.



3. Results and Discussion (Continued)

Amphipod

Isopod

Polychaete, ***Hemipodus***

Beetle

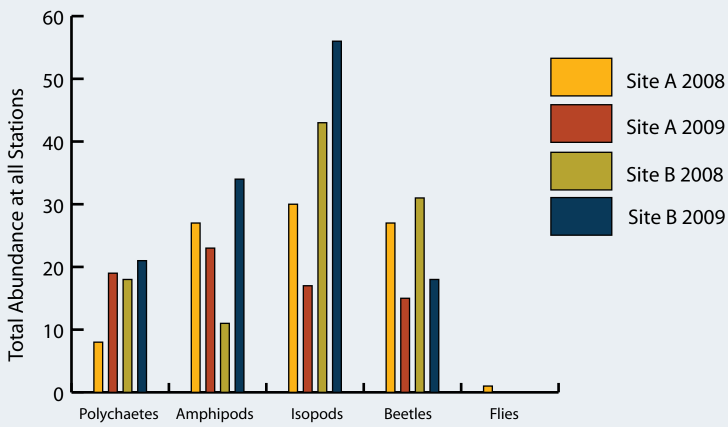
Sediment Biota

The benthic invertebrate community at Castlepoint Beach in 2009 was similar to that present in 2008, that is, a "normal" exposed beach community dominated by crustaceans and insects (in this case beetles), and a few polychaetes (Figure 4).

Such findings are expected given the exposed nature of the beach and the absence of high inputs of nutrients or organic matter. These conditions result in a community dominated by organisms that prefer clean, coarse, well-oxygenated sand, a deep RPD and low organic enrichment levels. At mid-low water levels, they included the nephtyid and glycerid polychaetes, *Aglaophamous macroura* and *Hemipodus simplex* (both very active carnivores that live in the sands), the scavenging isopod, *Pseudaega tertia,* and various sand-burrowing omnivorous amphipods (particularly *Patuki breviuropodus*). At mid to high water, the large scavenging sand hopper *Talorchestia quoyana,* dominated the community near the drift line, along with various beetle species and the isopod *Scyphax ornatus.*

In general the community consisted of species that are usually present in low numbers and are indifferent to enrichment. They included omnivores, carnivores and scavengers. Because there is limited information on the species sensitivities of those species present, it was not possible to allocate an AMBI condition rating (see Appendix 3).

Figure 4 Total abundance of macrofauna at Castlepoint Beach (sum of all 6 stations at each site) - January 2008 and 2009.

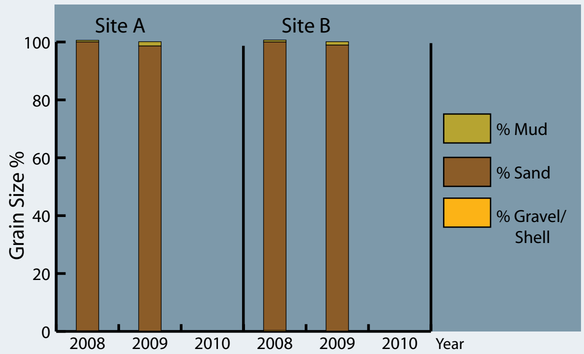


SEDIMENTATION (GRAIN SIZE)

Soil erosion is a major issue in New Zealand and the resulting suspended sediment impacts are of particular concern in many coastal areas. The northern Wairarapa coastal environments are especially at risk in that the erosion ratings for inland catchments feeding the coast are moderate to severe. As a consequence, the waters bathing the coastal areas tend to have a high suspended solids content. Deposition of these solids tends to be offshore, or in sheltered embayments, beaches or estuaries. Castlepoint, being an exposed beach is not expected to be at risk from excessive sedimentation of fine sediments. This was confirmed by the 2008 and 2009 grain size monitoring results which show that all sites were dominated by sandy sediments (> 99% sand) (Figure 5). Interestingly, however, the 2009 results indicated a 1% increase in the mud content at most sites, and a decrease in the gravel/shell component showing that the beach system is temporally variable.

3. Results and Discussion (Continued)

Figure 5 Grain size at Castlepoint Beach (mean values at each transect).



4. SUMMARY

The first two years of fine scale monitoring results for a range of physical and biological indicators of beach condition show that the dominant intertidal habitat (i.e. unvegetated sand) at Castlepoint Beach was generally in very good condition.

The beach sediments consisted of well-oxygenated sands, with a typical exposed beach benthic invertebrate community, dominated by crustaceans (isopods, amphipods) and beetles. Such conditions indicate a nutrient-poor and therefore oligotrophic situation, which is typical of exposed New Zealand beaches.

5. MONITORING

Castlepoint Beach has been identified by GWRC as a priority for monitoring, and is a key part of GWRC's coastal monitoring programme being undertaken in a staged manner throughout the Greater Wellington region. Based on the 2008 and 2009 monitoring results, it is recommended that monitoring continue as outlined below:

- **Fine Scale Monitoring**. Complete the three years of the scheduled baseline monitoring at Castlepoint Beach in Jan 2010. After the three year baseline is completed, reduce monitoring to five yearly intervals or as deemed necessary based on beach condition ratings.

6. MANAGEMENT

Although not directly monitored at Castlepoint Beach, the fine scale monitoring reinforced the need for management of dunes in the general area. In particular, the current dominance of introduced marram grass as the main sand-binding species on the beach, which has inferior sand-binding and erosion control capabilities compared to the native sand-binders. Maintenance of a healthy beach ecology, particularly in relation to predicted accelerated sea level rise, is substantially enhanced by restoring the dunes to native sand-binding species (i.e. pingao and spinifex).

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APPENDIX 1. DETAILS ON ANALYTICAL METHODS

Indicator	Analytical Laboratory	Method	Detection Limit
Infauna Sorting and Identification	Gary Stephenson*	Coastal Marine Ecology Consultants	N/A
Grain Size (%mud, sand, gravel)	R.J Hill Laboratories	Air dry (35 degC, sieved to pass 2mm and 63um sieves, gravimetric.	N/A

* Coastal Marine Ecology Consultants (established in 1990) specialises in coastal soft-shore and inner continental shelf soft-bottom benthic ecology. Principal Gary Stephenson (BSc Zoology) has worked as a marine biologist for more than 25 years, including 13 years with the former New Zealand Oceanographic Institute, DSIR. Coastal Marine Ecology Consultants holds an extensive reference collection of macroinvertebrates from estuaries and soft-shores throughout New Zealand. New material is compared with these to maintain consistency in identifications, and where necessary specimens are referred to taxonomists in organisations such as NIWA and Te Papa Tongarewa Museum of New Zealand for identification or cross-checking.

APPENDIX 2. 2009 DETAILED RESULTS

Station Locations

Castlepoint A						
Station	1	2	3	4	5	6
NZMGEAST	2781628	2781639	2781646	2781653	2781663	2781679
NZMGNORTH	6031520	6031517	6031511	6031513	6031509	6031502

Castlepoint B						
Station	1	2	3	4	5	6
NZMGEAST	2781609	2781620	2781626	2781633	2781645	2781664
NZMGNORTH	6031467	6031472	6031465	6031467	6031461	6031458

Physical and chemical results for Castlepoint Beach, 19 January 2009.

Transect	Station	RPD	Salinity	Mud	Sands	Gravel
		cm	ppt	%		
Cas A	1	>15	33	1.1	98.9	<0.1
	2	>15	33	1.1	98.9	<0.1
	3	>15	33	1.3	98.7	<0.1
	4	>15	33	1.2	98.8	<0.1
	5	>15	33	1.3	98.7	<0.1
	6	>15	33	2.9	97.1	<0.1
Cas B	1	>15	33	0.4	99.6	<0.1
	2	>15	33	0.9	99.1	<0.1
	3	>15	33	1.2	98.8	<0.1
	4	>15	33	1.9	98.1	<0.1
	5	>15	33	1.3	98.7	<0.1
	6	>15	33	1.4	98.6	<0.1

APPENDIX 2. 2009 DETAILED RESULTS (CONTINUED)

Infauna (numbers per 0.1089m² core) - Castlepoint Transects A and B (Jan 2009)

Species	AMBI Group	A1a	A1b	A1c	A2a	A2b	A2c	A3a	A3b	A3c	A4a	A4b	A4c	A5a	A5b	A5c	A6a	A6b	A6c
POLYCHAETA																			
Aglaophamus macroura	II															1			
Hemipodus simplex	II							3	2	1	3	4	1	1	1	2			
Lumbrineris brevicirra	II																		
CRUSTACEA AMPHIPODA																			
Diogodias littoralis	I																		
Patuki breviuropodus	NA									1	2	6	2	3	1	2	1		
Talorchestia quoyana	NA						2					1	1						
Waitangi chelatus	I																		1
CRUSTACEA ISOPODA																			
Actaecia euchroa	NA				2														
Macrochiridothea uncinata	NA																1		
Pseudaega tertia	NA											3	1	2	1	1			
Scyphax ornatus	NA				1	1	3									1			
INSECTA COLEOPTERA																			
Chaerodes trachyscelides	NA		2																
Coleoptera sp.2	NA	1	3	1															
Coleoptera sp.3	NA		1																
Coleoptera sp.4	NA		1																
Total species in sample		1	4	1	2	1	2	1	1	2	2	4	4	3	3	5	2	0	1
Total individuals in sample		1	7	1	3	1	5	3	2	2	5	14	5	6	3	7	2	0	1

Species	AMBI Group	B1a	B1b	B1c	B2a	B2b	B2c	B3a	B3b	B3c	B4a	B4b	B4c	B5a	B5b	B5c	B6a	B6b	B6c
POLYCHAETA																			
Aglaophamus macroura	II													1				1	
Hemipodus simplex	II								1	4	4	1	7		1				
Lumbrineris brevicirra	II													1					
CRUSTACEA AMPHIPODA																			
Diogodias littoralis	I														1				1
Patuki breviuropodus	NA							1			4	4	5				1	1	2
Talorchestia quoyana	NA	8	4			1	1												
Waitangi chelatus	I																		
CRUSTACEA ISOPODA																			
Actaecia euchroa	NA			2	1		1												
Macrochiridothea uncinata	NA																		
Pseudaega tertia	NA										11	4	12	1	4	1		4	5
Scyphax ornatus	NA		2		2	3	3												
INSECTA COLEOPTERA																			
Chaerodes trachyscelides	NA	2	2																
Coleoptera sp.2	NA		12	2															
Coleoptera sp.3	NA																		
Coleoptera sp.4	NA																		
Total species in sample		2	4	2	2	2	3	1	1	1	3	3	3	3	3	1	1	3	3
Total individuals in sample		10	20	4	3	4	5	1	1	4	19	9	24	3	6	1	1	6	8

APPENDIX 3. INFAUNA CHARACTERISTICS

Group and Species		AMBI Group	Details
Polychaeta	*Aglaophamous macroura*	II	An intertidal and subtidal nephtyid that prefers a sandier, rather than muddier substrate. Feeding type is carnivorous.
Polychaeta	*Hemipodus simplex*	II	A glycerid, or bloodworm, found in clean sand sites in estuaries and on clean sandy beaches. Are cylindrical, very muscular and active large predators and detritivores living in sands and sandy muds.
Polychaeta	*Lumbrineris brevicirra*	II	A non-selective deposit feeding lumbrinereid polychaete. Preyed on by flounders. Muscular, elongate, cylindrical worms that are carnivorous.
Crustacea Isopoda	*Actaecia euchroa*	NA	A very small isopod which makes shallow burrows in the supralittoral zone. The species may be active during the day on damp sand and if disturbed rolls itself up into a ball.
Crustacea Isopoda	*Eurylana arcuata*	NA	A cirolanid isopod and a scavenger - often a numerically dominant component of the middle and upper intertidal on New Zealand exposed sandy beaches.
Crustacea Isopoda	*Macrochiridothea uncinata*	NA	An idotheid isopod from the lower intertidal of exposed beaches.
Crustacea Isopoda	*Pseudaega tertia*	NA	A cirolanid isopod and a scavenger - often a numerically dominant component of the middle and upper intertidal on New Zealand exposed sandy beaches.
Crustacea Isopoda	*Scyphax ornatus*	NA	A large isopod which lives on New Zealand sandy beaches. Adults of this species spend the day in burrows near the high water mark and make nightly foraging excursions on the uncovered intertidal beach down to the edge of the swash.
Crustacea Amphipoda	*Diogodias littoralis*	I	A phoxocephalid amphipod that inhabits the intertidal, especially of exposed beaches. Is a sand-burrowing omnivore.
Crustacea Amphipoda	*Patuki breviuropodus*	NA	A oedicerotid amphipod that inhabits the intertidal, especially of exposed beaches. Is a sand-burrowing omnivore.
Crustacea Amphipoda	*Talorchestia quoyana*	NA	This talitrid amphipod is found on the backshore of New Zealand sandy beaches and is dependent on drift for food.
Crustacea Amphipoda	*Waitangi chelatus*	I	A phoxocephalid amphipod that inhabits the intertidal, especially of exposed beaches. Is a sand-burrowing omnivore.
Insecta Coleoptera	*Chaerodes laetus*	NA	A beetle, common on the backshore of sandy beaches.
Insecta Coleoptera	*Chaerodes trachyscelides*	NA	A highly specialised, flightless burrowing beetle confined to the narrow strip of sand at and just above high water level on sandy marine beaches in New Zealand.
Insecta Coleoptera	Coleoptera sp.#1	NA	An unidentified beetle, from the backshore of sandy beaches.
Insecta Coleoptera	Coleoptera sp.#2	NA	An unidentified beetle, from the backshore of sandy beaches.
Insecta Coleoptera	*Pericoptus truncatus*	NA	A beetle, common on the backshore of sandy beaches.
Insecta Coleoptera	*Phycosecis atomaria*	NA	A beetle, common on the backshore of sandy beaches.
Insecta	Diptera sp.#1	NA	An unidentified fly.

AMBI Sensitivity to Stress Groupings (from Borja et al. 2000)

Group I. Species very sensitive to organic enrichment and present under unpolluted conditions (initial state). They include the specialist carnivores and some deposit-feeding tubicolous polychaetes.

Group II. Species indifferent to enrichment, always present in low densities with non-significant variations with time (from initial state, to slight unbalance). These include suspension feeders, less selective carnivores and scavengers.

Group III. Species tolerant to excess organic matter enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations). They are surface deposit-feeding species, as tubicolous spionids.

Group IV. Second-order opportunistic species (slight to pronounced unbalanced situations). Mainly small sized polychaetes: subsurface deposit-feeders, such as cirratulids.

Group V. First-order opportunistic species (pronounced unbalanced situations). These are deposit-feeders, which proliferate in reduced sediments.

The distribution of these ecological groups, according to their sensitivity to pollution stress, provides a Biotic Index with 5 levels, from 0 to 6.