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coastalmanagement

Porpoise Bay Beach

Fine Scale Monitoring 2009/10

Prepared for **Environment Southland**

July 2010

Cover Photo: Porpoise Bay Beach Fine Scale Monitoring 2010 - Dr Barry Robertson sorting macrofauna from sieved sediment.

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Prepared for
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By

Barry Robertson and Leigh Stevens

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PORPOISE BAY BEACH - EXECUTIVE SUMMARY

Porpoise Bay Beach

↓

Vulnerability Assessment
Identifies issues and recommends monitoring and management. Preliminary assessment completed in 2008 (Robertson and Stevens 2008)

↓

Porpoise Bay Beach Issues
Habitat Loss (dune erosion and terrestrial margin)
Sea Level Rise and impact on dune erosion

↓

Monitoring

Broad Scale Mapping
Sediment type
Saltmarsh
Seagrass
Macroalgae
Land margin

5 -10 yearly
Undertaken first in 2008.

Fine Scale Monitoring
Grain size, RPD, Invertebrates

4yr Baseline then 5 yearly
1st baseline in 2010. Next Feb 2011.

↓

Condition Ratings
RPD depth, Benthic Community.

Other Information
Previous reports, Observations, Expert opinion

↓

BEACH CONDITION
Low Nutrient Enrichment
Low Sedimentation
Sand Dominated
Habitat Degraded (Dunes, terrestrial margin)

↓

Recommended Management
- Limit intensive landuse.
- Margin dune vegetation enhancement.
- Manage for sea level rise.
- Manage weeds and pests.

This report summarises the results of the 2010 fine scale monitoring for Porpoise Bay Beach, a 5km long, semi-exposed and gradually sloping beach (intermediate/dissipative type) on the Catlins coast. It is a key beach in Environment Southland's (ES) 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 section and table summarises the 2010 monitoring results for the two intertidal sites at Porpoise Bay Beach.

FINE SCALE RESULTS

- Sediment Oxygenation; the Redox Potential Discontinuity (RPD) layer was relatively deep (>15cm depth) at all sites, therefore indicating sediments were well oxygenated.
- Benthic Invertebrate Condition; 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 benthic nutrients are generally sparse on exposed beaches, invertebrate numbers were low and consisted mainly of scavengers and predators.
- Sediment Type: grain size monitoring of the beach sediments showed that the beach consisted of greater than 97.5% sand which, along with the exposed nature of the beach, explains the high level of sediment oxygenation (i.e. deep RPD).

CONDITION RATINGS	Porpoise Bay Beach Site A	Porpoise Bay Beach Site B
	2010	2010
Sediment Oxygenation (RPD Depth)	**Very Good**	**Very Good**
Benthic Community (Infauna and Epifauna)	**Normal Semi-Exposed Beach Community**	**Normal Semi-Exposed Beach Community**
Sediment Type (Grain Size)	**Normal for sandy beach**	**Normal for sandy beach**

ESTUARY CONDITION AND ISSUES

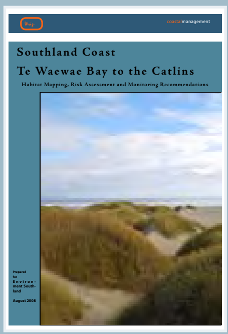
In overview, the 2010 results for a range of physical and biological indicators of beach condition showed that the dominant intertidal habitat (i.e. unvegetated sand) at Porpoise Bay Beach was generally in good condition. The beach sediments consisted of well-oxygenated sands, with a typical semi-exposed beach benthic invertebrate community, dominated by crustaceans (isopods and amphipods), and polychaete worms. Such conditions indicate a nutrient-poor and therefore oligotrophic situation, which is typical of exposed New Zealand beaches.

RECOMMENDED MONITORING AND MANAGEMENT

In order to provide a baseline of beach condition on the Catlins coast (particularly in light of predicted accelerated sea level rise) it is recommended that fine scale monitoring continues for three to four years. After the baseline is completed, reduce monitoring to five yearly intervals or as deemed necessary based on beach condition ratings.
Although not directly monitored at Porpoise Bay Beach, the fine scale monitoring reinforced the need for management of dunes in the general area, as indicated in the recent Southland Coastal Vulnerability Assessment (Robertson and Stevens 2008). 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 expected to be substantially enhanced by restoring the dunes to native sand-binding species (e.g. pingao).

1. INTRODUCTION

OVERVIEW



MATAITAI RESERVE

A mâtaitai reserve has been placed over waters within Waikawa Harbour, Porpoise Bay, Curio Bay and the lower section of the Waikawa River. Such a reserve has the following effect:

- Excludes commercial fishing;
- Does not exclude recreational fishing;
- Does not prevent access to beaches or rivers not on private land;
- Allows for bylaws governing fishing in the reserve to be made by the Minister of Fisheries.
- Any bylaws approved apply to all, with only one exception (the taking of seafood to meet the needs of a marae).

Developing an understanding of the condition and risks to coastal habitats is critical to the management of biological resources. The recent "Southland Coast - Te Waewae to the Catlins - Mapping, Risk Assessment and Monitoring" report (Robertson and Stevens 2008) identified a moderate risk to soft sediment beach shore ecology on the Porpoise Bay coast through predicted accelerated sea level rise and temperature change, erosion, and habitat loss. To address this risk, and to provide information on Porpoise Bay beach ecology, annual long term monitoring of Porpoise Bay Beach (a representative intermediate/dissipative type beach ecosystem) was initiated in February 2010. 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 fine to medium sands, and they have weak rip currents with undertows. The tidal flat is at the extreme end of dissipative beaches. Porpoise Bay Beach tends more to the intermediate type. Compared with other beach types their ecological characteristics include the following:

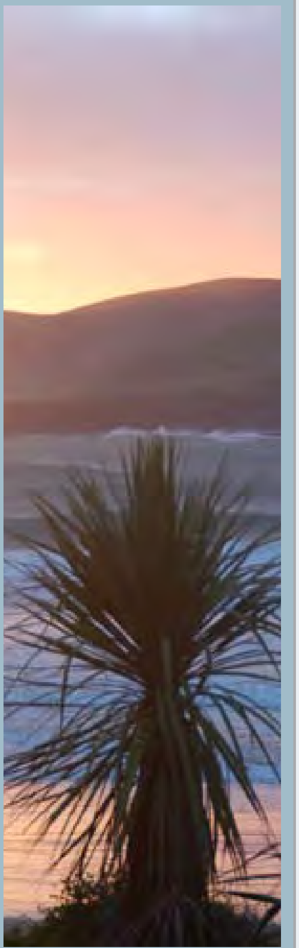
- Interactions within and between species are generally more intense.
- High level of primary production, diversity and biomass of macrofauna.
- Exporters of organic matter.
- More highly regulated by biological interactions.

Porpoise Bay is a partially sheltered, long curving bay with a broad, shallow-gradient beach. The beach is backed by 4-5m high marram-covered, eroding sand dunes. The backdunes are generally grazed and dominated by flax, marram and grasses. At the eastern end, near the mouth of the Waikawa Estuary, the dunes are taller, wider and more ecologically diverse and the beach is more exposed with a steeper gradient. The small settlement of Curio Bay is situated at the more gently sloping and sheltered western end of the beach where the dunes have been developed for residential purposes.

Human use of the beach and associated rocky areas is high in a national context. It is used for walking, swimming, surfing, diving, scientific interest and inshore fishing. Public access is good and it is an important tourist destination. Commercial fishing boats are moored in Waikawa Estuary and access the open sea via Porpoise Bay. In 2008 the area was designated a mataitai reserve (for details see margin inset). Stormwater and sewage leachate from the baches and motor camp drain towards the beach but its impact on the beach ecology is expected to be relatively minor. Cook Creek discharges to the bay via a small "tidal river mouth" type estuary (area ~1ha). The estuary is narrow and shallow (mean depth 0.5-1m) and situated in lowland grazed pasture and dunes. The estuary discharges onto the upper beach at Porpoise Bay, where it forms a shallow lagoon, whose size varies depending on the extent of mouth constriction. Monitoring results for enterococci bacteria at Porpoise Bay Beach near the camping ground at the western end showed 100% compliance with bathing guidelines during 2007-2009 (ES water quality monitoring data).

The current report documents the results of the first year of fine scale monitoring of Porpoise Bay Beach intertidal sites (undertaken in February 2010). The monitoring area was located at the western end of the beach to provide a site that was accessible, representative 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.

1. Introduction (Continued)



The report is the first of a proposed series of three to four, which will characterise the baseline fine scale conditions in the beach annually over a 3-4 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.

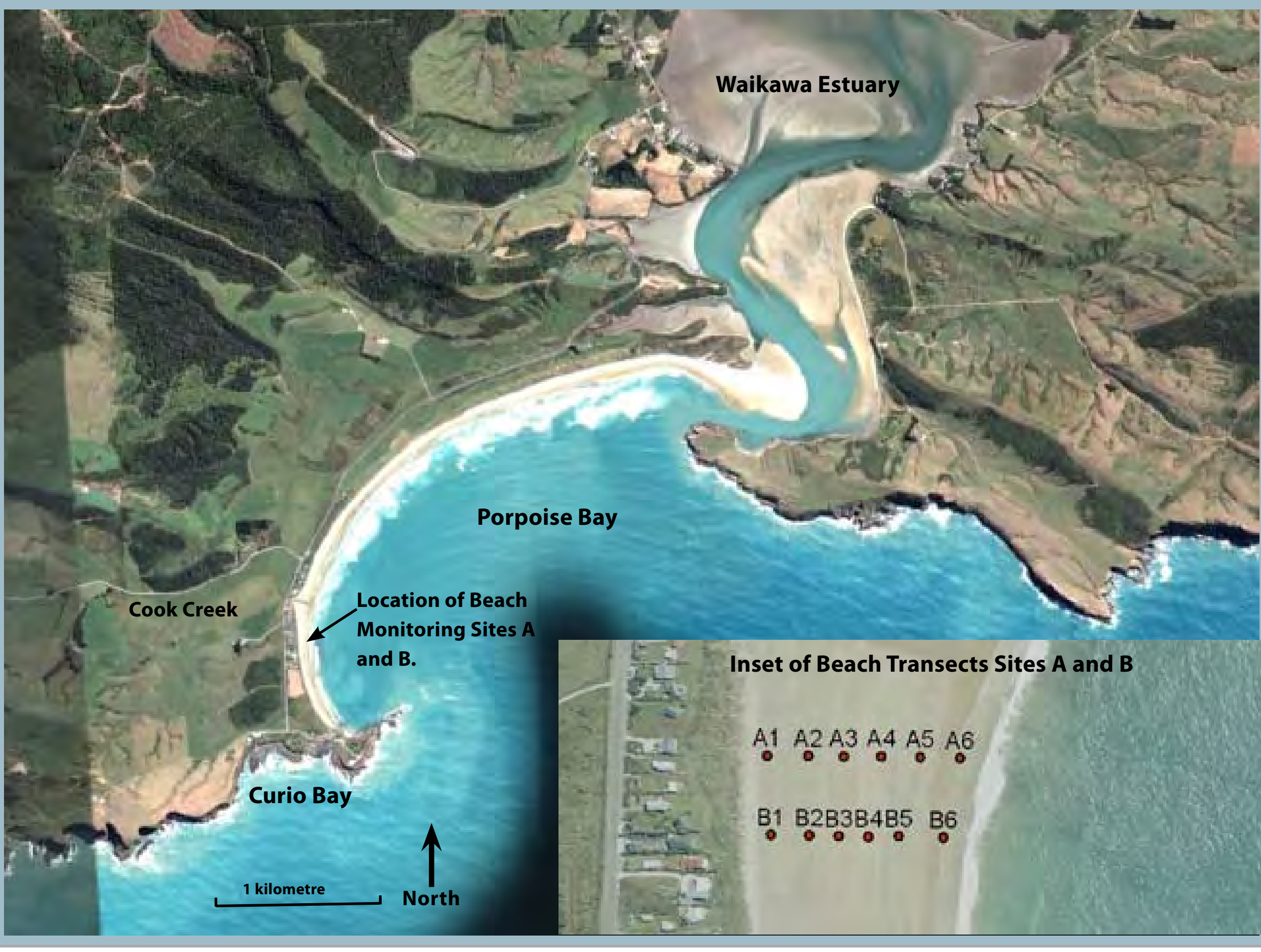
Key Environmental Beach and Dune Issues	
Habitat Loss or Modification	The key stressors of beaches and dunes are; sea level rise, vehicle use, stock grazing, and introduced marram grass. **Sea Level Rise.** The general effect of sea level rise on beaches is that they erode. Most sandy beaches world-wide 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 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. Note; vehicle access east of Cooks Creek on Porpoise Beach is prohibited. **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 sand binding 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 Porpoise Bay 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.

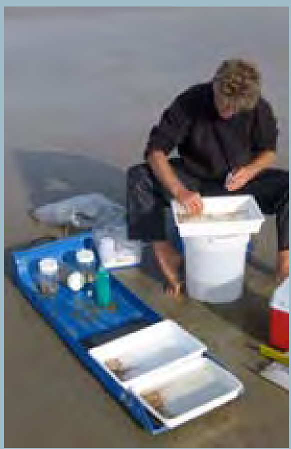
Figure 1. Location of fine scale monitoring sites at Porpoise Bay Beach (Photo; Google Earth)



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 term. To minimise 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 3-4 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 February 2010 when estuary monitoring was being undertaken in the region. The approach was 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 sites were positioned in the swash zone every 60 minutes to distribute stations evenly.
- The relative elevations of the stations were measured using the pole and horizon field surveying technique, 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 a 1mm nylon mesh bag and the contents of the core sieved in nearby seawater. The infauna remaining were carefully emptied into a plastic tray and sorted from remaining beach sediment. Animals were placed in a plastic containe 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 ES interpret their monitoring data, two interim beach "condition ratings" have been proposed. These are firstly, the degree of sediment oxygenation as indicated by the redox discontinuity profile (RPD) and secondly, the benthic community condition as presented below.

The condition ratings are designed to be used in combination with each other and with other information to evaluate overall beach condition and when deciding on appropriate management responses. Expert input is required to make these evaluations. 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 ES 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 Porpoise Bay Beach transects for 2010 is presented in Figure 2. It shows that the beach was backed by a 2-3m high foredune which was covered with marram grass vegetation. The intertidal area was 130-160m 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 Porpoise Bay 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 Porpoise Bay fine scale monitoring is addressing: eutrophication, sedimentation, and habitat modification. 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 Southland coast is assessed separately in ES's recreational water quality monitoring programme.

Figure 2. Cross-section of transects at Porpoise Bay Beach, February 2010.

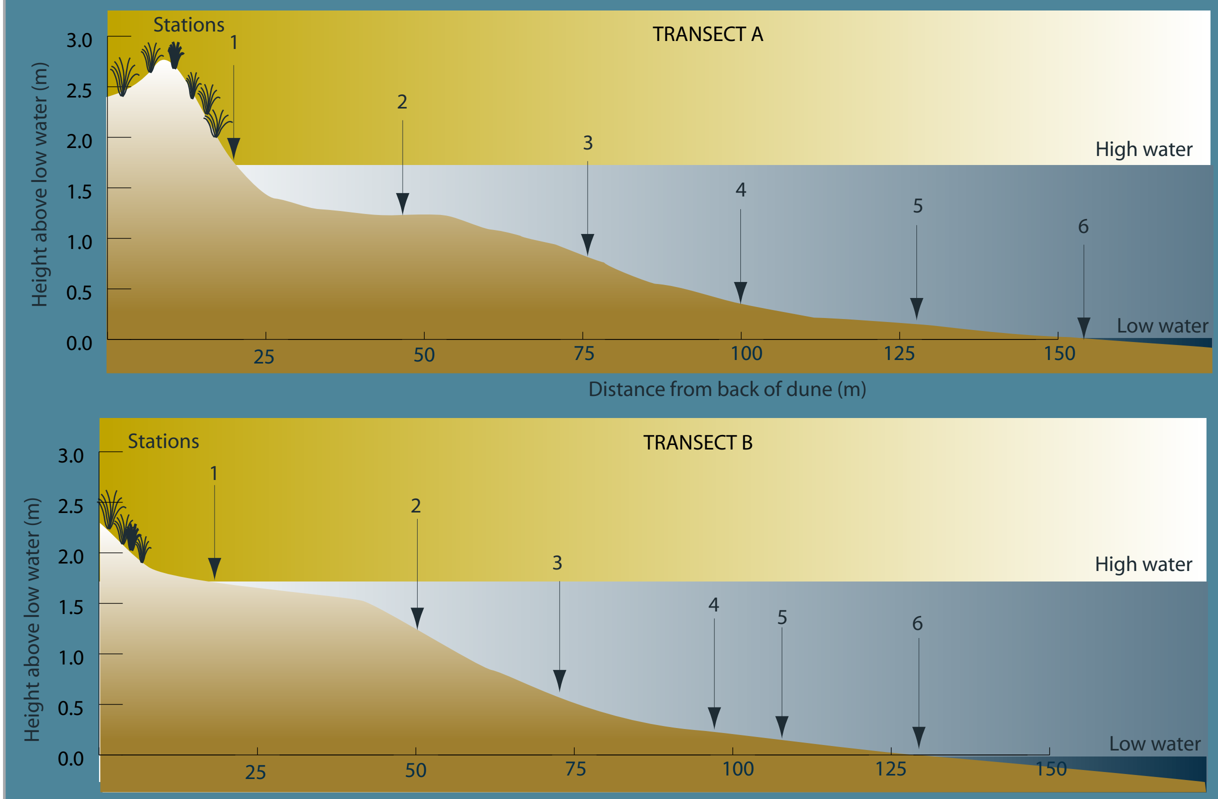


Table 3. Physical and chemical results (means) for Porpoise Bay Beach, 12 February 2010.

Site	Reps	RPD (cm)	Salinity (ppt)	%Mud	%Sands	%Gravel/Shell
Porpoise Bay A	3	>15	33ppt	1.3	98.6	<0.1
Porpoise Bay B	3	>15	33ppt	1.2	98.8	<0.1

Table 4. Macrofauna results (means) for Porpoise Bay Beach, 12 February 2010.

Site	Reps	Mean Total Abundance/m²	Mean Number of Species/Core
Porpoise Bay A	3	8.6	2.6
Porpoise Bay B	3	9.3	3.1

3. Results and Discussion (Continued)

EUTROPHICATION

On semi-exposed beaches like Porpoise Bay, 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. macroalgal (e.g. sea lettuce) and microalgal 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, which are reported in Robertson and Stevens (2007), are the physical dimensions of beach and dune areas.

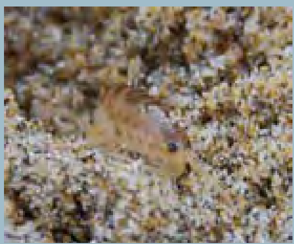
The Redox Potential Discontinuity (RPD)

The depth of the RPD layer (Figure 3) is a critical beach and estuary condition indicator in that it provides a measure of whether nutrient enrichment, for example from sewage leachate seeping through beach sediments, exceeds the trigger leading to nuisance anoxic conditions in the surface sediments. Knowing if the surface sediments are moving towards anoxia and the RPD is 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.

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

Nemertean



Amphipod

Isopod

Polychaete *Aglaophamous macroura*

The tendency for sediments to become anoxic is much greater if the sediments are muddy. However, in sandy porous sediments like at Porpoise Bay, the RPD layer is usually relatively deep (>10cm) 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 Porpoise Bay 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 2010 RPD results showed that the depth of the RPD at Porpoise Bay Beach was >15cm at all sites and therefore indicated sediments were 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.

Sediment Biota

The benthic invertebrate community at Porpoise Bay Beach in 2010 was typical of a "normal" semi-exposed beach community where inputs of nutrients or organic matter are low. These conditions resulted in a low abundance (30-280 animals per m^2) and low diversity (1-6 species per m^2) community dominated by organisms that prefer clean, coarse, well-oxygenated sand, a deep RPD, and low organic enrichment levels. The dominant organisms included crustaceans (isopods and amphipods), and polychaetes (Figures 4 and 5).

As is typical for such beaches, the benthic invertebrate organic enrichment rating was in the "low to very low" category for 2010 (Figure 6). Such a rating reflects the predominantly low sediment nutrient concentrations, the sand dominated nature of the beach, and the presence of species that prefer low levels of organic matter. The highest enrichment ratings were recorded along the drift line area at the upper tidal levels on each transect.

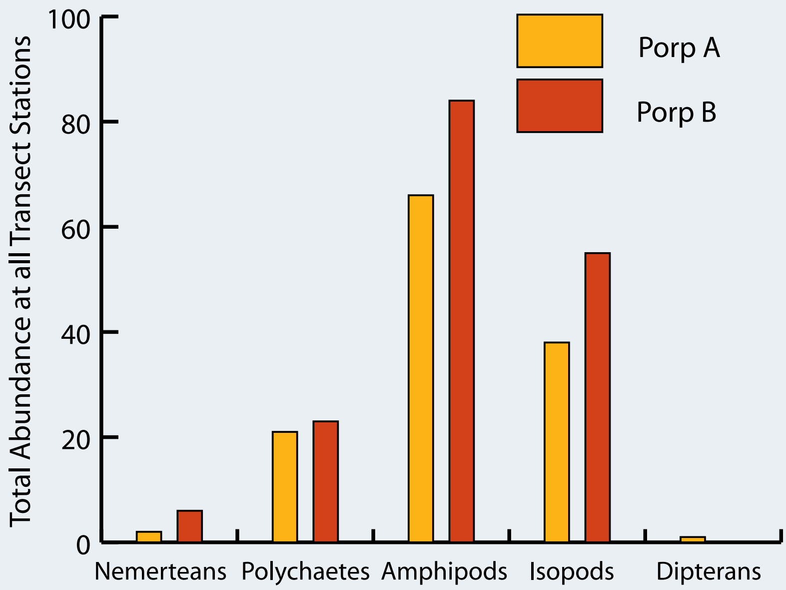


Figure 4. Total abundance of macrofauna groups at Porpoise Bay Beach (sum of all 6 stations at each site) - February 2010.

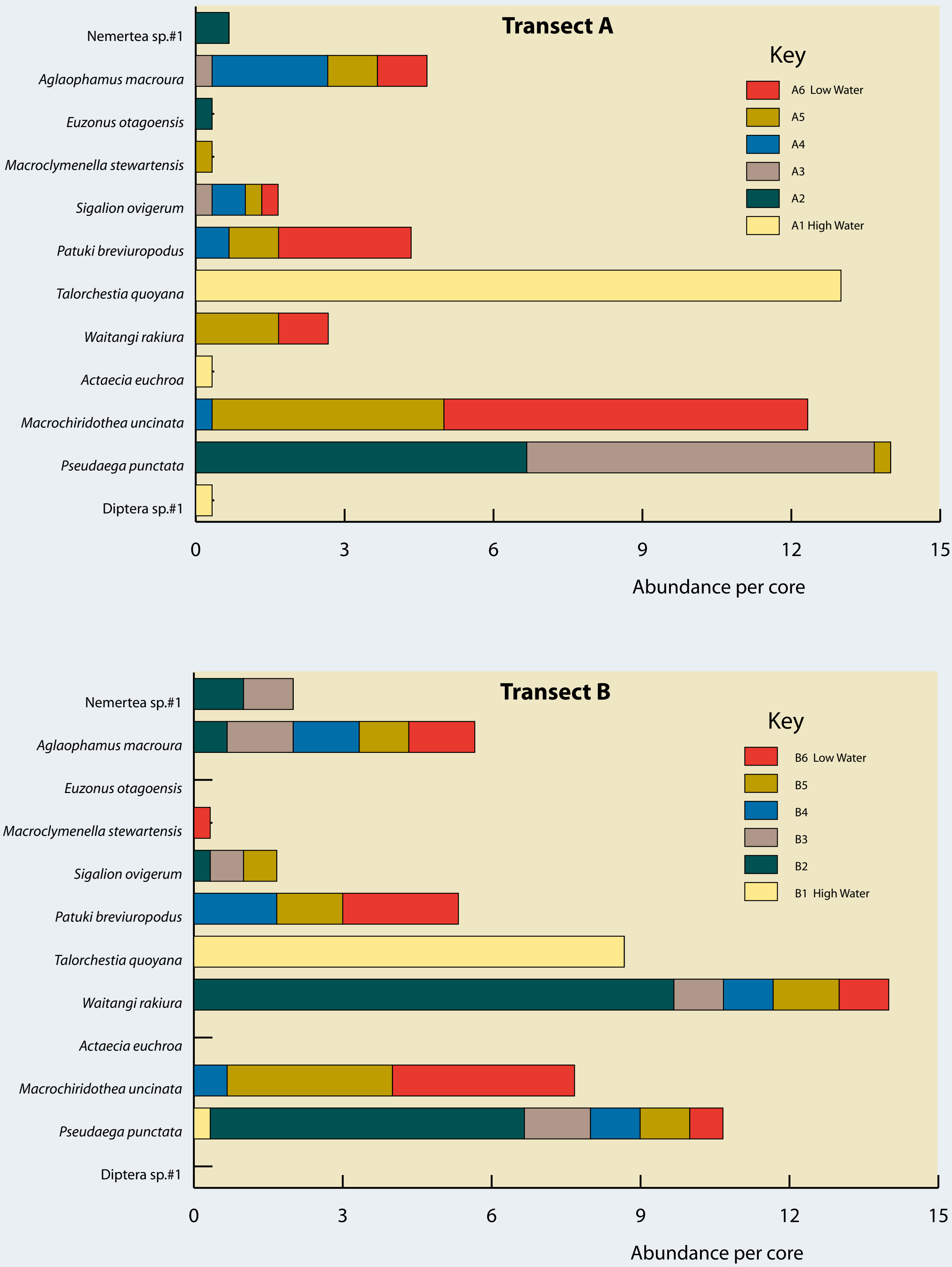
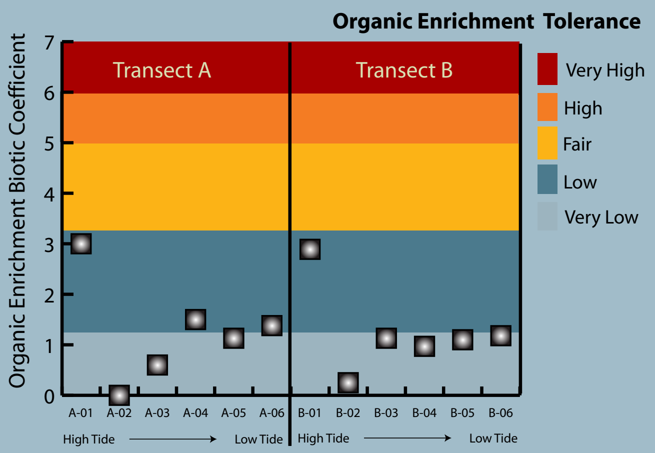


Figure 5. Mean abundance per core of macrofauna species at each site on Transects A and B Porpoise Bay Beach - February 2010.

Figure 6. Benthic invertebrate organic enrichment rating, Porpoise Bay Beach.



The sand hopper *Talorchestia quoyana*, which feeds on algal and other organic material stranded on the upper beach drift line, dominated the fauna at these high water sites despite the fact that the drift line contained very little organic detritus on the day of sampling. This lack of available organic matter was the likely explanation for the absence of the typical upper beach beetle and isopod fauna.

The communities present at other locations on the transects were more diverse. At mid to high water sites the dominant species were the scavenging isopod, *Pseudaega punctata,* predatory nemetean worms, and on Transect B, the phoxocephalid amphipod *Waitangi chelatus*.

At mid-low water levels, they included the nephtyid and scaleworm polychaetes, *Aglaophamous macroura* and *Sigalion ovigerum* (both very active carnivores that live in the sands), and various sand-burrowing omnivorous amphipods, particularly *Patuki breviuropodus*. The dominant species at the low water sites were the idoteid isopod *Macrochiridothea uncinata, Patuki breviuropodus* and *Aglaophamous macroura*.

In general the community consisted of species that are usually present in low numbers, are indifferent to enrichment and include omnivores, carnivores and scavengers.

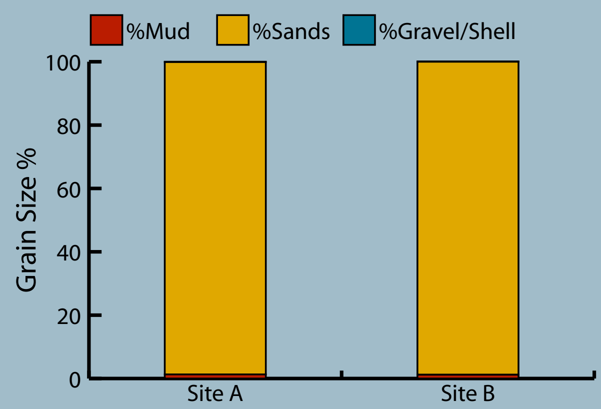


Figure 7. Grain size of sediments at Porpoise Bay Beach, 2010.

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 Southland/Catlins coastal environments are at risk in that the erosion ratings for developed inland catchments feeding the coast are often elevated. As a consequence, the waters bathing the coastal areas during high rainfall periods tend to have a high suspended solids content. Deposition of these solids tends to be offshore, or in sheltered embayments, beaches or estuaries. Porpoise Bay Beach, being a semi-exposed beach is not expected to be at risk from excessive sedimentation of fine sediments. This was confirmed by the 2010 grain size monitoring results which show that all sites were dominated by sandy sediments (> 97.5% sand), with very low mud contents (0.4-2.3%) (Figure 7).

4. MONITORING

Porpoise Bay Beach has been identified by ES as a priority for monitoring, and is a key part of ES's coastal monitoring programme being undertaken in a staged manner throughout the Southland region. Based on the 2010 monitoring results, it is recommended that monitoring continue as outlined below:

- **Fine Scale Monitoring**. Complete the three to four years of the scheduled baseline monitoring at Porpoise Bay Beach. Next monitoring is scheduled for February 2011. After the baseline is completed, reduce monitoring to five yearly intervals or as deemed necessary based on beach condition ratings.

5. MANAGEMENT

Although not directly monitored at Porpoise Bay Beach, the fine scale monitoring reinforced the need for management of dunes in the general area. In particular, introduced marram grass currently dominates as the main sand-binding species on the beach. However, it 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 species).

6. ACKNOWLEDGEMENTS

This survey and report has been undertaken with organising, field assistance and editing from Greg Larkin (Coastal Scientist, Environment Southland), and editing from Maz Robertson (Wriggle) for which we are very grateful.

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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. 2010 DETAILED RESULTS

Station Locations

Porpoise Bay Beach A						
Station	A1	A2	A3	A4	A5	A6
NZTM East NZGD2000	1301795	1301824	1301850	1301877	1301905	1301933
NZTM North NZGD2000	4825746	4825747	4825748	4825749	4825750	4825750

Porpoise Bay Beach B						
Station	B1	B2	B3	B4	B5	B6
NZTM East NZGD2000	1301801	1301829	1301850	1301871	1301893	1301925
NZTM North NZGD2000	4825664	4825664	4825665	4825665	4825667	4825667

Physical and chemical results for Porpoise Bay Beach, 12 February 2010.

Transect	Station	RPD	Salinity	Mud	Sands	Gravel
		cm	ppt		%	
Porp A	1	>15	33	0.6	99.4	< 0.1
	2	>15	33	1.2	98.8	< 0.1
	3	>15	33	1.3	98.7	< 0.1
	4	>15	33	2.3	97.6	< 0.1
	5	>15	33	1.2	98.8	< 0.1
	6	>15	33	1.4	98.5	< 0.1
Porp B	1	>15	33	0.4	99.6	< 0.1
	2	>15	33	1.4	98.6	< 0.1
	3	>15	33	1.8	98.2	< 0.1
	4	>15	33	1.3	98.7	< 0.1
	5	>15	33	1.2	98.8	< 0.1
	6	>15	33	1.2	98.8	< 0.1

APPENDIX 2. 2010 DETAILED RESULTS (CONTINUED)

Infauna (numbers per 0.1089m² core) - Porpoise Bay Beach Transects A and B (12 Feb 2010)

Species	AMBI Group	A1a	A1b	A1c	A2a	A2b	A2c	A3a	A3b	A3c	A4a	A4b	A4c	A5a	A5b	A5c	A6a	A6b	A6c
NEMERTEA																			
Nemertea sp.	III									2									
POLYCHAETA																			
Aglaophamus macroura	II							1			2	4	1	1	1	1	2	1	
Euzonus otagoensis	I				1														
Macroclymenella stewartensis	I															1			
Sigalion ovigerum	II							1				1	1		1				1
CRUSTACEA AMPHIPODA																			
Patuki breviuropodus	II												2		1	2	2	3	3
Talorchestia quoyana	III	6	27	6															
Waitangi rakiura	I								4	2				1	3	1	1		2
CRUSTACEA ISOPODA																			
Actaecia euchroa	NA			1															
Macrochiridothea uncinata	II										1			6	3	5	11	6	5
Pseudaega punctata	I				2	18		3		2					1				
INSECTA DIPTERA																			
Diptera sp.	NA		1																
Total species in sample		1	2	2	2	1	0	3	1	3	2	2	3	3	6	5	4	3	4
Total individuals in sample		6	28	7	3	18	0	5	4	6	3	5	4	8	10	10	16	10	11

Species	AMBI Group	B1a	B1b	B1c	B2a	B2b	B2c	B3a	B3b	B3c	B4a	B4b	B4c	B5a	B5b	B5c	B6a	B6b	B6c
NEMERTEA																			
Nemertea sp.	III						3		3										
POLYCHAETA																			
Aglaophamus macroura	II					2		3	1				4	1		2	2	1	1
Euzonus otagoensis	I																		
Macroclymenella stewartensis	I																	1	
Sigalion ovigerum	II						1	1		1					1	1			
CRUSTACEA AMPHIPODA																			
Patuki breviuropodus	II										3	2			2	2		3	4
Talorchestia quoyana	III	15	7	4															
Waitangi rakiura	I				8	10	11	1		2	2	1		1	2	1	2		1
CRUSTACEA ISOPODA																			
Actaecia euchroa	NA																		
Macrochiridothea uncinata	II											1	1	2	3	5	5	1	5
Pseudaega punctata	I			1	9	7	3	3		1	1		2		1	2	2		
INSECTA DIPTERA																			
Diptera sp.	NA																		
Total species in sample		1	1	2	2	3	4	4	2	3	3	3	3	3	5	6	4	4	4
Total individuals in sample		15	7	5	17	19	18	8	4	4	6	4	7	4	9	13	11	6	11

APPENDIX 3. INFAUNA CHARACTERISTICS

Group	Species	AMBI Group	Details
Nemertea	Nemertea sp.	III	Ribbon or Proboscis Worms, mostly solitary, predatory, free-living animals. Intolerant of anoxic conditions.
Polychaeta	*Aglaophamous macroura*	II	An intertidal and subtidal nephtyid that prefers a sandier, rather than muddier substrate. Feeding type is carnivorous.
	Euzonus otagoensis	I	An opheliid polychaete. Most *Euzonus* species inhabit intertidal sandy beaches consisting of well-sorted, medium to fine sands. Intolerant of enriched conditions.
	Macroclymenella stewartensis	I	Belongs to the Maldanidae, Bamboo worms. *Macroclymenella* sp., a sub-surface deposit-feeder found in tubes of fine sand or mud to depths of 15cm and has a key role in the re-working sediment. This worm may modify the sediment conditions, making it more suitable for other species (Thrush et al., 1988). *Macroclymenella* is common in estuaries. Intolerant of anoxic conditions.
	Sigalion ovigerum	II	A polychaete worm belonging to the Suborder Phyllodicidae, Family Sigalionidae. Sigalionids are predatory scale worms found burrowing in sands and muds. Classified as a subtidal species (see NIWA's Worm Register, http://www.annelida.net/nz/Polychaeta/Family/F-Sigalionidae.htm.
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.
	Macrochiridothea uncinata	II	An idoteid isopod from the lower intertidal of exposed beaches.
	Pseudaega punctata	i	An isopod of the Family Eurydicidae, a scavenger that is fiercely carnivorous, biting any animal it comes upon including humans. When the tide is in it actively swims about hunting food, but while the tide is out it lies buried in the sand. Often a numerically dominant component of the middle and upper intertidal on New Zealand exposed sandy beaches. Common on Stewart Island beaches. Fills a similar niche to the Northern hemisphere *Eurydice pulchra* and on this basis is conservatively classified as highly intolerant of excessive sediment, synthetic chemicals, nutrients and low oxygen conditions (Fincham 1973, Budd 2007).
Crustacea Amphipoda	*Patuki breviuropodus*	II	A oedicerotid amphipod that inhabits the intertidal, especially of semi-exposed beaches. Is a sand-burrowing omnivore. Common on very clean semi-exposed beaches at Stewart Island and therefore is expected to be pollution intolerant.
	Talorchestia quoyana	III	This talitrid amphipod is found on the backshore of New Zealand sandy beaches and is dependent on drift for food. Individuals of this species are great consumers of algal and other organic material stranded on the beach. They are typical of wave-washed sandy shore, i.e. beaches that have low anthropogenic effects and with low sediment (sand) metal concentrations. Although they are found in large numbers near sources of rich organic material, they are not present in permanently eutrophic, low oxygen sediments. In this case, *Talorchestia* has been assigned in the group of species tolerant to excess organic matter enrichment (Group III). These species may occur under normal conditions, but their populations are stimulated by organic enrichment (slight unbalance situations).
	Waitangi chelatus	I	A phoxocephalid amphipod that inhabits the intertidal, especially of exposed beaches. Is a sand-burrowing omnivore.
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, such 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.