NERMN Beach Profile Monitoring

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Cover Photo: *Coastlands*, Piripai Beach, Bay of Plenty, 2006.

Executive Summary

This is the second report detailing the results of the coastal monitoring network initiated by Environment Bay of Plenty in 1990 as part of its Natural Environment Regional Monitoring Network (NERMN) programme. A total of 53 sites are profiled on an annual basis within the current coastal monitoring programme. Some selected sites are monitored quarterly; others are monitored as necessary, i.e. after storm events or where a beach is considered to be of significant concern to the public due to impacts on private property.

Over the course of a year along the Bay of Plenty coastline, changes in the beach morphology result from "cut and fill" processes. The movement of sediment from this process is dependant on wind and wave action as well as sediment properties. These seasonal changes are superimposed on short and long term processes which act to produce periods (tens of years) of erosion, accretion and dynamic equilibrium.

Wave action is the dominant forcing process causing changes in erosion and accretion patterns along the Bay of Plenty coastline. Wave conditions in the Bay of Plenty are moderately influenced by the El Niño Southern Oscillation. More stormy conditions than average tend to occur during La Niña periods, which are associated with an increase in northeasterlies in the New Zealand region. During El Niño years, where a higher occurrence of southwesterlies occurs, wave conditions in the Bay of Plenty are somewhat reduced although episodic extra-tropical cyclones still occur. Given that since 1998 we have entered a negative phase of the Interdecadal Pacific Oscillation where neutral or La Niña conditions may be more likely to occur, it is possible that the Bay of Plenty region may experience increased rates of erosion over the next 20 to 30 years, similar to that experienced in the late 1960s and early to mid 1970s (Bell et. al., 2006).

Over the period of the physical coastal NERMN (typically 16 years of data to date), 53 sites have been monitored to access changes in beach profile position and beach volume.

The overall beach state (Table 1) generally shows common patterns per reported beach system. This is not unexpected as typically these beach systems are affected by sources of localised sediment influx from fluvial sources or are separated by a number of natural obstructions, such as:

- hard-rock coastline north of Waihi Beach
- northern Tauranga Harbour entrance
- southern Tauranga Harbour entrance
- Mount Maunganui
- Town Point, Maketu
- Kohi Point headland, Whakatane
- Ohiwa Harbour entrance

These features punctuate the general direction of littoral drift in the Bay of Plenty of north west to south east flux, though there are areas where the direction of net sediment movement has been modelled to be orientated towards the north west (Bell et. al., 2006; Phizacklea 1993). Littoral drift is the main mechanism by which sediment is supplied to a beach; it is also a value that is difficult to measure directly.

Table 1 Beach state for the NERMN beach profile sites.

Beach system	CCS site	Site Name	Beach state
Hikuwai	1	Opape East	Stable
	2	Waiaua River West	Erosion?
	3	Tirohanga Stream West	Erosion
	4	Hikuwai West	Erosion?
	5	Waiotahi Beach East	Erosion
	6	Waiwhakatoitoi	Erosion?
	7	Waiotahi Spit	Accretion?
	8	Ohiwa Spit	Accretion
Ohope	9	Ohope Spit	Erosion
	10	Ohope	Erosion
	11	West End	Erosion?
Thornton	12	Whakatane Spit	Stable
	13	Piripai	Accretion?
	14	Golf Links Road	Erosion?
	15	Airport	Erosion?
	16	Rangitaiki East	Stable
Matata	17	Rangitaiki West	Stable
	18	Lawrences Farm	Stable
	19	Tarawera East	Accretion?
	20	Matata Domain	Stable
	21	Matata	Accretion?
	22	Murphy's Motor Camp	Stable
	23	Pikowai Motor Camp	Erosion?
	24	Otamarakau	Erosion
Pukehina	25	Rodgers Road	Erosion?
	26	Pukehina Trig	Erosion
	27	Pukehina West	Erosion
	28	Pukehina Middle	Erosion
	29	Pukehina West	Erosion
	30	Makatu Headland	Erosion?
Papamoa	32	Kaituna River East	Accretion?
	33	Kaituna River West	Erosion
	34	Taylor Street	Erosion
	35	Papamoa Beach	Accretion?
	36	Papamoa	Accretion?
	37	Papamoa Surf Club[1]	Accretion?
	38	Te Maunga	Erosion
	39	Mount Maunganui East	Erosion?
	40	Mount Maunganui	Accretion?
Matakana[2]	41	Fire Break Road	Stable
	42	Bird Santuary	Erosion
	43	Tank Road	Accretion?
	44	Matakana Island Centre	Stable
	45	Dead End Road	Stable
	46	Matakana Island North	Erosion
Waihi	47	Waihi Beach South	Erosion?
	48	Waihi Beach- Pio's Point	Erosion?
	49	Waihi Beach Island View	Stable
	50	Waihi Beach Island Loop	Stable
	51	Waihi Beach North	Stable
	52	Waihi Beach Surf Club[1]	Accretion?
	53	Waihi Beach Stream[1]	Accretion
	54	Esplanade Road[1]	Accretion

Note: 1 – data is from 1998 - 2006, 2 – data is from 1992 - 2006

Results from this report show that the following beaches are showing trends of erosion for the period 1990-2006:

- Ohope Beach
- Pukehina Beach
- Southern area of Waihi Beach
- Central section of Hikuwai Beach

A continuation of this NERMN is important in the management regime of this coastal area. There are increasing pressures (development and recreational) in this coastal environment. The profile monitoring provides a baseline dataset for determining the physical state of these beach systems. Additional increasing pressures such as sea level rise further enforce the requirement for this monitoring to continue. A future monitoring schedule has been outlined in Chapter 6 of this report which will allow for timely and representative information to be collected and analysed.

Contents

Chapter 1: Introduction

1.1 Introduction

Environment Bay of Plenty established a coastal monitoring programme in 1990 as a part of a Natural Environment Regional Monitoring programme covering collection of varied environmental data - air quality, climate, hydrological data, surface and ground water chemistries and marine and freshwater biological data. Such information allows managers to assess the present and potential impacts of consent related activities and provides baseline environmental data. Additionally, long term trend detection using environmental baseline data will enable Council to assess the effectiveness of its own policies and plans in maintaining or enhancing the environment and in meeting its statutory obligations under the Resource Management Act.

A total of 53 sites are profiled on an annual basis within the current coastal monitoring programme. Some selected sites are monitored quarterly; others are monitored as necessary, i.e. after storm events or where a beach is considered to be of significant concern to the public due to impacts on private property.

All beaches between Waihi Beach in the west to Hikuwai Beach in the east are covered by the monitoring programme (see Figure 1.1). This monitoring covers 135 kilometres of the open coastline.

An understanding of the Bay of Plenty beach dynamics is essential for planning and resource management purposes. Exposed sandy beaches are very dynamic, showing both short and long term trends in shape, accretion and erosion patterns. Coastal developments, sand and shingle mining, dredging and dams can all affect the supply of sediment to the coastal zone, and therefore the way the beach systems behave.

1.2 Requirements of RMA and Regional Plans

The purpose of the Resource Management Act (1991) is to promote sustainable management of natural and physical resources. Environmental monitoring is a specific requirement of the Act. Part IV, section 35 (1&2a) directs Regional Councils to “gather such information, and or undertake or commission such research, and monitor the state of the whole or any part of the environment of its region or district to the extent that is appropriate, as is necessary to carry out effectively its functions under the Act”. These functions include those set out in sections’ 30 (1) and 104 of the Act.

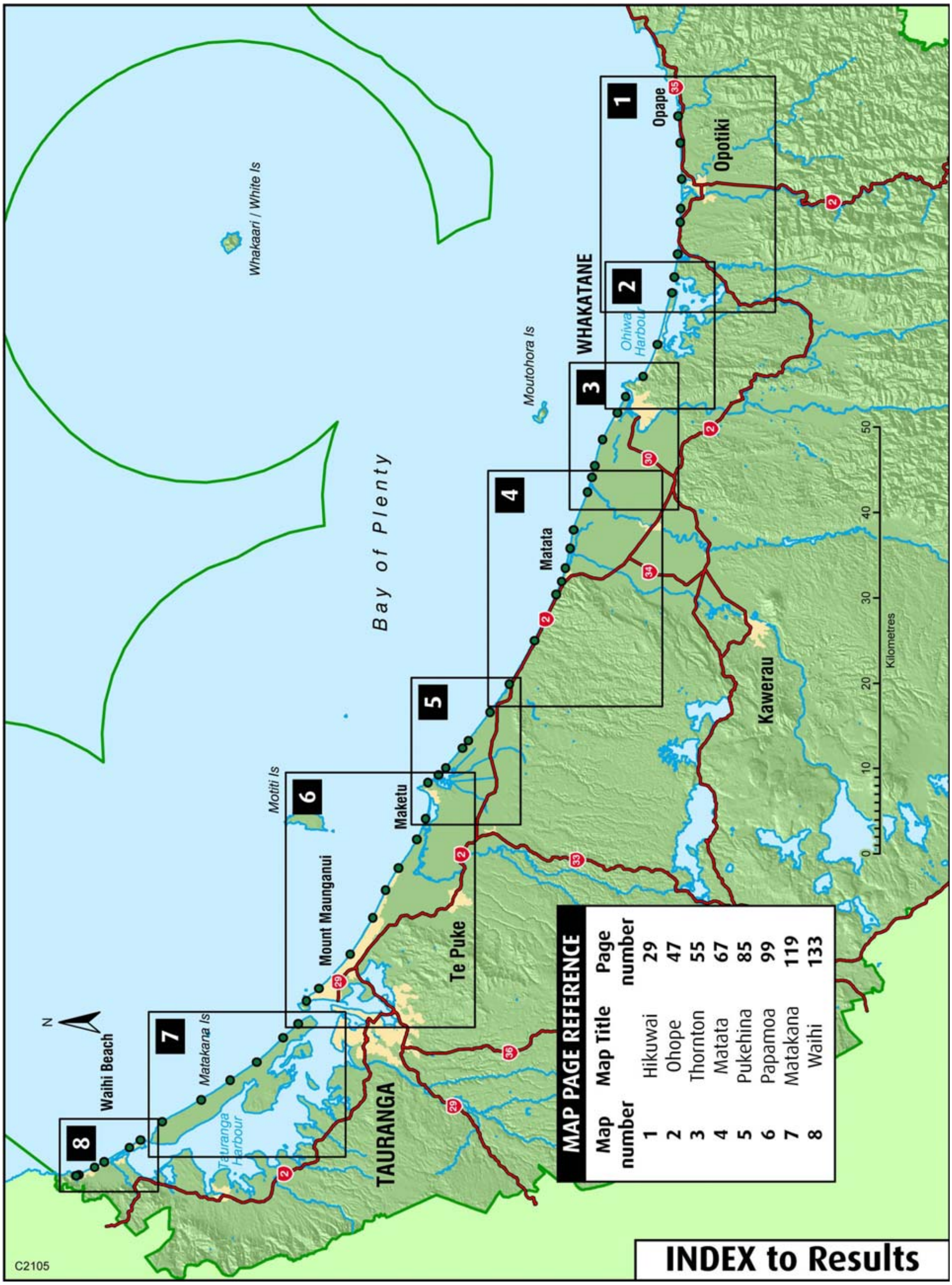


Figure 1.1 Environment Bay of Plenty beach profile monitoring sites

In July 2003 the Bay of Plenty Regional Coastal Environment Plan was made operative. The purpose of this plan is to enable Environment Bay of Plenty to promote the sustainable management of the natural and physical resources of the Bay of Plenty coastal environment. Sustainable management is defined in section 5 of the Act as:

Managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety while –

(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and

(b) Safeguarding the life-supporting capacity of air, water, soil and ecosystems; and

(c) Avoiding, remedying or mitigating any adverse effects of activities on the environment.

Schedule 12.2 outlines plan monitoring and review, information for plan monitoring will be drawn from a range of NERMN monitoring programmes including data collection and analysis performed for this report investigating the change in the active beach system including short and long term trends.

1.3 Report Objectives

This report forms the assessment of the current coastal beach profile monitoring programme for the Bay of Plenty region. The *objectives* are briefly outlined below:

- Assess profile and volumetric changes in Bay of Plenty beaches between 1990 and the beginning of 2006
- To compare current trends with earlier assessments
- To provide information for a review of the current monitoring programme

These objectives will be discussed in Chapters Six and Seven.

1.4 Scope and Structure of Report

This report was prepared in order to summarise existing data and to discuss the changes in beach profiles and volumes over time.

Chapter One forms an introduction to the report, outlining the responsibility of Environment Bay of Plenty under the Resource Management Act to monitor the coastal zone.

Chapter Two covers the monitoring methods.

Chapter Three covers the types of coastal processes and coastal landforms present with the Bay of Plenty, and gives a brief description of the factors affecting the region’s beaches.

Chapter Four covers the climatic conditions affecting the Bay of Plenty.

Chapter Five presents the results of the Environment Bay of Plenty monitoring programme for the period 1990–2006. This section describes the changes in beach profiles, beach volumes and gives an overall assessment of how the beaches have been changing during the period of monitoring. Discussion on why the beach changes have occurred and how these changes relate to prior monitoring work is also included in this chapter.

Chapter Six presents a discussion on the future direction of the monitoring programme.

Chapter Seven presents a regionwide general discussion on the state of the open coast sandy beaches for the 16 years of NERMN monitoring record.

Chapter 2: Monitoring Methods

2.1 Overview of monitoring

Environment Bay of Plenty established a coastal monitoring programme in 1990 as a part of a Natural Environment Regional Monitoring programme. The location of these sites were based on the earlier work conducted by Healy et. al. (1977).

2.1.1 Benchmarks

The 53 coastal monitoring sites all consist of two well established benchmarks. The front benchmark is usually located on or about the frontal dune area, while the back benchmark is placed some distance further back into the dunes. Commonly the distance between benchmarks is approximately 50m, but does vary due to local circumstances.

During installation the benchmarks are surveyed to Moturiki Datum[1] so each benchmark is at a known height above mean sea level. The front benchmark is used for the regular beach profiles at the site, providing a common reference point for each profile. The back benchmark is a more permanent fixture to aid site re-establishment in the event of the loss of the front benchmark (due to erosion or human interference).

Annual inspections are carried out at each site. As a part of the inspection the front and back benchmarks are re-surveyed to account for any change in the benchmark height due to settling, slumping or uplifting.

2.1.2 Profiles

To obtain a true representation of the beach form it is necessary to be able to measure the minor changes in slope present along a sandy beach profile. The spacing of observation points will often be irregular in order to define the beach shape.

The method historically employed by Environment Bay of Plenty staff to collect the beach profiles used in this report is the Emery Pole Technique (Emery, 1961). This technique provides accurate and repeatable surveys using simple and robust equipment. The equipment consists of two poles joined together by a 3m tape. The poles are 1.5m long, graduated in centimetres, with a collar and spike at one end (Figure 2.1). The poles are place vertically in the ground with the collars at ground level at 3m spacings, or at each noticeable change in slope. The horizontal distance is measured by the attached tape, with 3m being the maximum spacing possible. Vertical

[1] A region wide benchmark project is currently underway by Environment Bay of Plenty. One of the aims of this project is to improve the elevation values on benchmarks within the region. The coastal benchmarks are part of this project.

change is measured by lining the top of the lower pole against the horizon. The height differential can then be taken from the higher pole.

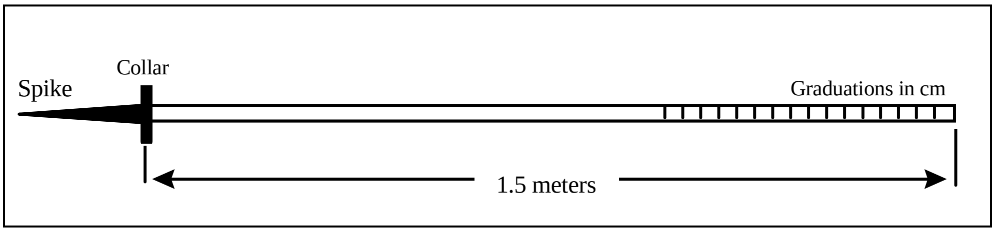


Figure 2.1 Emery Pole construction

In the case of measurement of a down slope the first pole (Pole 1) is at a higher elevation than Pole 2 (Figure 2.2). Therefore Pole 2 is sighted against the horizon with the vertical fall read from the graduations in Pole 1. Conversely on an upslope the second pole (Pole 2) is higher and hence Pole 1 is sighted against the horizon and the reading made from Pole 2 (Figure 2.3). Although the poles are graduated in centimetres an estimate is made to the nearest millimetre. The vertical difference thus recorded is entered into a level book adjacent to the horizontal distance measured.

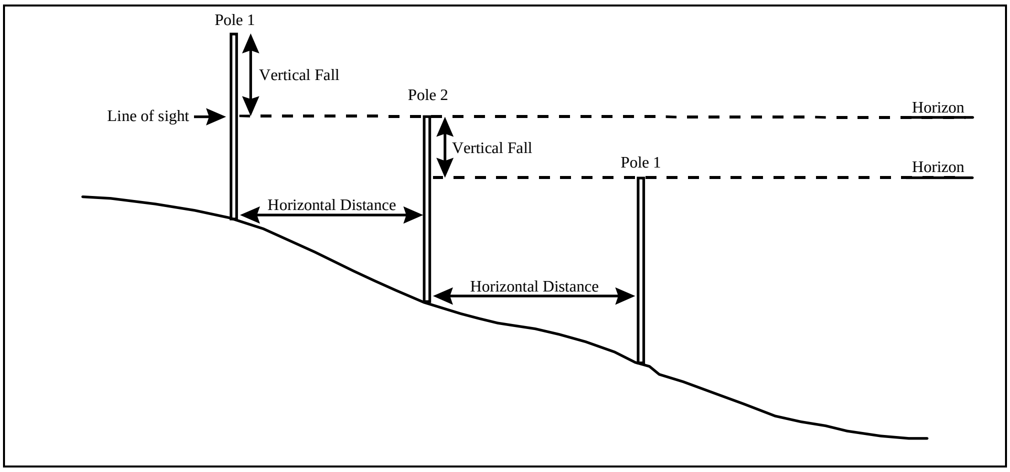


Figure 2.2 Measurement downslope using Emery Pole technique

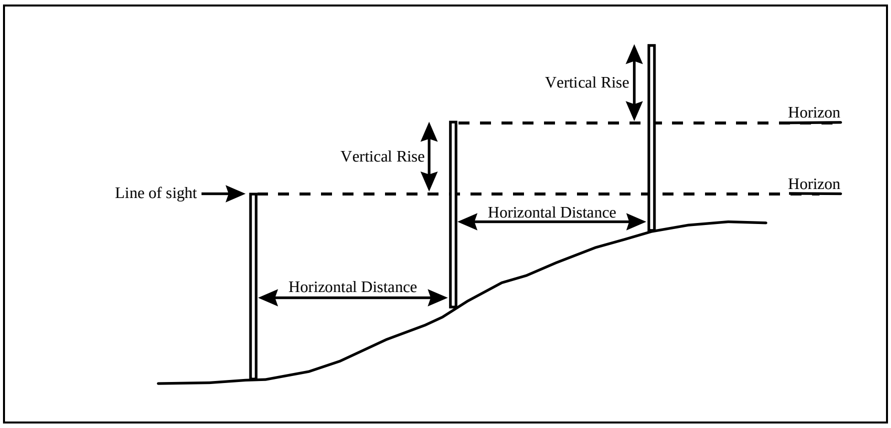


Figure 2.3 Measurement upslope using Emery Pole technique

The rises and falls measured in this way can then be related to the known height of the starting point at the front benchmark. Thus each observation can be given a height above the zero datum at a known horizontal distance from the benchmark. The results have shown good consistency of measurement over time and considering the nature of the terrain, they have accuracy consistent with second order survey techniques.

In the last several years the Emery method has been retired and a Total Station surveying instrument has been used for measuring the shape of the beach and performing the levelling checks between the two benchmarks at each site.

2.1.3 Other Coastal Data

Since 1994, Environment Bay of Plenty staff have recorded distribution of vegetation at the profile site. Staff note the species present, and estimate the proportion of each species occupying a metre wide strip either side of the profile line. The horizontal distance to the seaward edge of the vegetation is noted, as is the position of the recent high water mark at the profile site. The high water mark is determined by change in sand colour, extent of debris, and by the aerated texture of the sand. This information is currently held in several registers.

Chapter 3: Coastal Characteristics

The coastal environment is the area lying at the interface between land and the sea. The area includes both the zone of shallow water within which waves are able to move sediment and the area landward of this zone including beaches, cliffs and coastal dunes. The landward zones are also affected to some degree by waves, tides and currents.

Most coastline landforms are in dynamic equilibrium with prevailing processes. Whether or not a coastline will exhibit erosion or accretionary characteristics is governed by a combination of sediment supply, weather patterns and the long-term relative change in sea level. A holistic approach is required in relating contemporary land forms to current coastal processes because storm events may obscure features of an accretionary coast for short periods of time.

This section briefly outlines coastal processes and land forms relevant to the Bay of Plenty.

3.1 Winds and wave climate

There are four defined regions around New Zealand based on wave climate (Hume et al. 1992, Pickrill & Mitchell 1979). The Bay of Plenty falls into the “Northern New Zealand” zone and is considered to be a low-energy lee shore (wave height = 0.5 - 1.5 m, wave period = 5 - 7s, from NE) extending between East and North Capes. Wave steepness is variable and Pickrill and Mitchell (1979) considered that northern New Zealand should show weak seasonality. Macky et al. (1995) measured waves in 34m of water in Katikati inlet and found most waves less than 1m 70% of the time with spectral density of 10 - 11s.

Swells originate from the following sources - winds blowing around anticyclones to the east, cyclonic systems retreating eastwards, and mid-latitude depressions which have passed over New Zealand (Harris, 1985).

Data from the Environment Bay of Plenty Triaxys wave buoy located 13km north of Pukehina Beach in 62m of water, for the period September 2003 to December 2006 is summarised in Figure 3.1. Maximum recorded H_{max} = 12.5m, average H_s = 1m and average T_s = 6.3s.

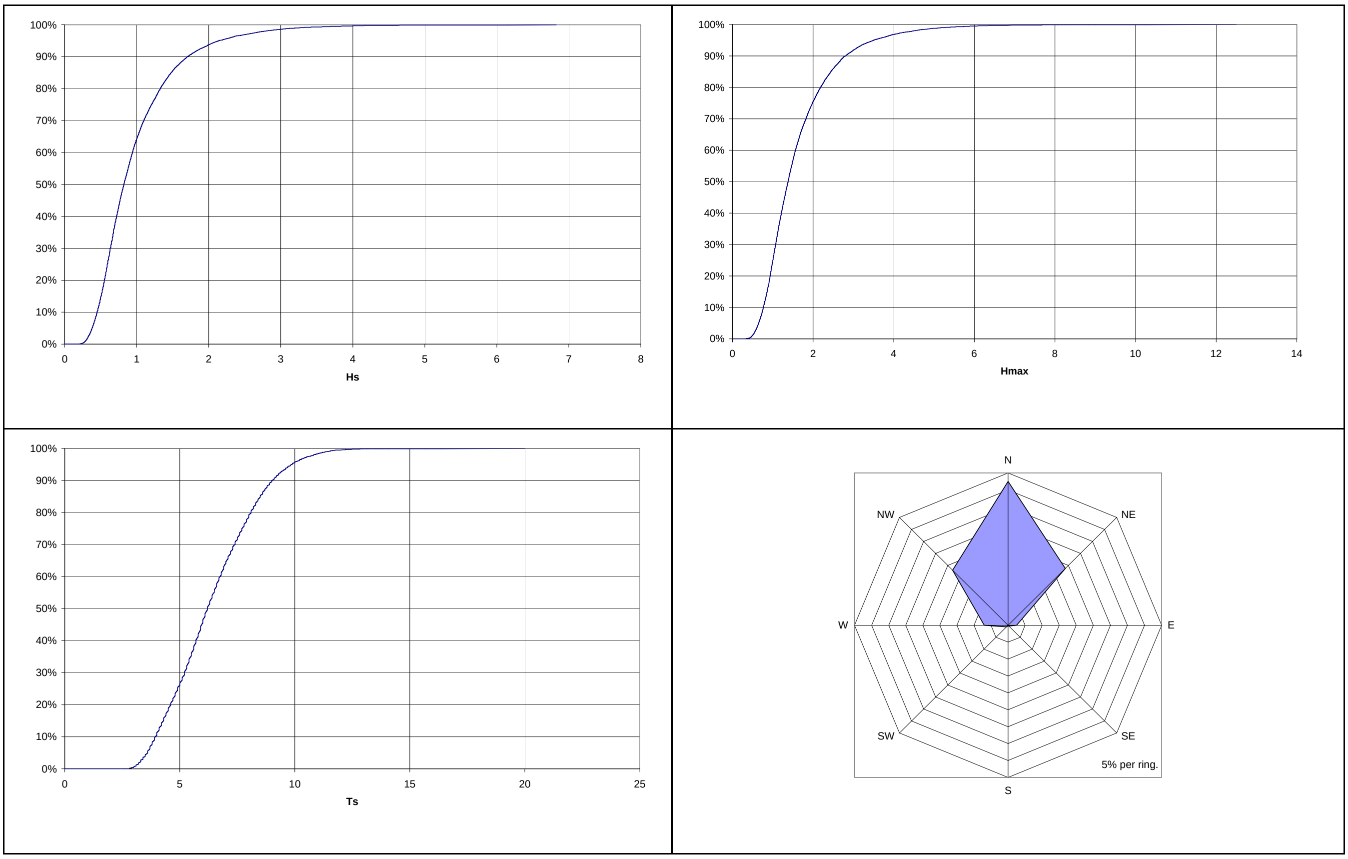


Figure 3.1 *Environment Bay of Plenty wave buoy distribution summary graphs, September 2003 to December 2006. Clockwise from top left – H_s, H_{max}, Wave direction (mag.) and T_s.*

Due to the prevailing westerly flow over the North Island of New Zealand, approximately 20% of waves reaching shores of the Bay of Plenty approach from the west. However, swells from the east and north predominate due to their long fetches (Harris, 1985; Hay, 1991; Macky et. al., 1995). Offshore swells of medium-energy and wave heights around 1.5m dissipate some of their energy over the 20km of continental shelf arriving in the near shore environment aligned near normal to the shoreline with reduced wave heights of approximately 0.6 - 0.8m (Healy et. al., 1977; Macky et. al., 1995).

Depressions originating in all three of the weather systems discussed in the above section are the most common sources of the winds producing higher waves impinging on the Bay of Plenty (Harris, 1985). These weather events generally produce several days of strong wind and rain from the north-east promoting erosion in exposed areas.

Strong winds are more frequent in winter months and during positive ENSO periods. Therefore persistent waves and storm induced erosion are more persistent during warmer La Nina periods (Hay, 1991)

3.2 Storms

Between 1873 and 1990, 153 storms were recorded in the Bay of Plenty with a mean of a little over 1 storm per year (Hay, 1991). However major storms did not occur every year. Most of the severe storms originated from the east-northeast direction and measured grade 8 - 9 on the Beaufort wind speed scale. A smaller number of storms were derived from the east-southeast. (Hay 1991, Macky *et al.,* 1995)

A summary of the more significant storms that occurred during the period reported in this document are summarised in the Table 3.1.

Table 3.1 Significant storms during this report period.

Event
March 1988 – Cyclone Bola
July 1992
September 1993
24 -25 January 1996
30-31 December 1996 – Cyclone Fergus
10-11 January 1997 – Cyclone Drena
11-13 March 1997 – Cyclone Gavin
July & August 1998
November 1998
12-14 April 2001 – Cyclone Sose
20-21 June 2002
16 April 2003
29 February 2004 – Cyclone Ivy
16 July 2004
25 January 2006

3.3 Coastal Landforms

3.3.1 Cliffs and shore platforms

In some areas of the Bay of Plenty (Matata, Te Kaha) steep vertical cliff slopes formed from rock, rise abruptly above either the sea or a basal shore platform. Shore platforms have formed in some areas of the Te Kaha coast as the cliffs retreat under the effects of abrasion.

3.3.2 Beaches

The profile form of beaches is determined by the size, shape and composition of beach material and the tidal range, type and characteristics of incoming waves. The upper section of most sandy beaches consists of a horizontal to slightly landward sloping surface which is known as the berm. The berm is a zone of accretion formed by backwash deposition. The height of the berm is limited by the upper limit of swash. Berms are present on most Bay of Plenty beaches during periods of accretion. The gradient of the beach slope seaward of the berm is normally low angle, ~2°, on sandy beaches and may be up to 20° where beaches are composed of coarse pebbles. Wave height and steepness are also correlated with the angle of the beach face. (Healy,1978; Phizacklea, 1993; Saunders,1999)

Comparisons of selected average profiles show the variation in beach slope and shape throughout the Bay of Plenty (Figure 3.2).

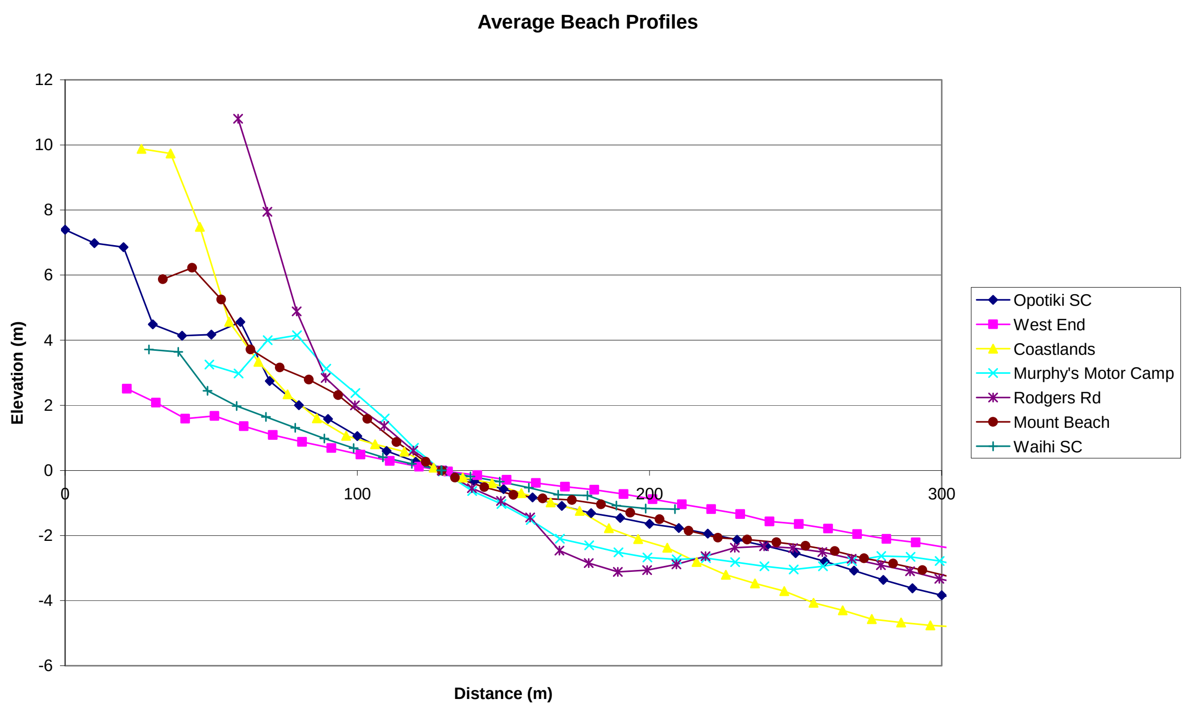


Figure 3.2 Average beach profile variation throughout the region.

Where the beach slope is shallow to moderate, there is typically one or several submerged longshore bars running parallel to shore and separated from the beach by a trough. Such bars develop in response to the action of breaking waves migrating backwards and forward normal to the shoreline (Pickett, 2004).

Bay of Plenty beaches build up in strong westerlies (typical of El Niño weather conditions) when long period waves carry sediment onto beaches and build up berm slopes and dunes.

It is important to note that beach profiles are not static, but rather change their forms over a range of time scales. Bay of Plenty beaches undergo a seasonal cycle of erosion and deposition. The predominance of swell waves in summer is associated with deposition from swash and a phase of beach construction involving the development of a berm just above high water mark. During winter, storm waves either cut back or completely destroy the berm. The eroded sediment is transported just offshore and deposited in longshore bars and also travels eastwards with littoral drift to be deposited along the beach. Such bars are eroded in summer to supply sediment to rebuild berms that were eroded in winter. This process is known as the cut and fill cycle (Komar, 1976). However during the summer, storms that generally move through the Bay of Plenty as a result of tropical cyclones and subtropical depressions, beach berms are destroyed by storm waves which temporarily magnify the rate of erosion of the beaches. This can lead to wave attack on backing cliffs (such as on the northern side of Whale Island), dunes (on beaches such as Ohope) and developed areas where dunes are absent (such as West End Ohope).

3.3.3 Barrier Island

A barrier island (barrier bar) is an elongated offshore ridge of sand running parallel with a mainland coast and separated from it for almost its entire length by a lagoon or harbour. Matakana Island, which separates Tauranga Harbour, from the sea is the only barrier island in the Bay of Plenty. It is 5 km wide at its widest point and 20 km in length.

3.3.4 Spits

Spits are elongated depositional forms attached at one end to the mainland and usually developed where the coast changes direction. The largest spits in the Bay of Plenty separate Ohiwa Harbour, Whakatane River mouth estuary, Maketu Estuary and Waihi Estuary from the sea. A feature of many spits in the Bay of Plenty (such as Ohope and Ohiwa) is their landward curvature at their accreting ends. The curved forms are generated by refraction of incoming waves around the accreting spit hooks and landward movement of sediment supplied by longshore drift. Occasional periods of incident waves from a different direction than normal will also modify the characteristic of the spit.

3.3.5 Dunes

Dunes form when sand is blown landward from beaches. Aeolian transport is favoured by high onshore wind speeds moving sand from thick beach deposits. Larger beaches generally supply greater quantities of sand to dunes than smaller beach surfaces. Coastal areas (such as Coastlands near Whakatane) which receive abundant supplies of sand from rivers generally have the largest coastal dunes complexes. Dunes develop in rows parallel to the coast. The row closest to the coast is the primary dune set which receives sand from the beach. The secondary more inland dunes are maintained as sand is blown inland from the more coastal dunes.

A recent study of 10 sites along the Bay of Plenty coastline (McNutt et. al., 2006) showed on the whole the vegetation structure and species composition are relatively simple which is not unusual for a duneland. Sand fields are the most common vegetation structure, present in all 10 selected sites. They are situated in the foredune with sand binding plants such as spinifex (*Spinifex sericeus*), pingao (*Desmoschoenus spiralis*) and native shore convolvulus (*Calystegia solandri*).

Chapter 4: Climate Change

The beach profiles have been surveyed at all sites on at least and annual basis since 1990. This 16 year record of annual or near annual beach change includes the effects of three periods of persistent La Nina (positive SOI) weather pattern, three periods of persistent El Nino (negative SOI) patterns (Figure 4.1) and 15 storm events which are highlighted in Chapter 3 and deemed significant in the Bay of Plenty. However all the records were taken during a positive period of the Interdecadal Pacific Oscillation (IPO).

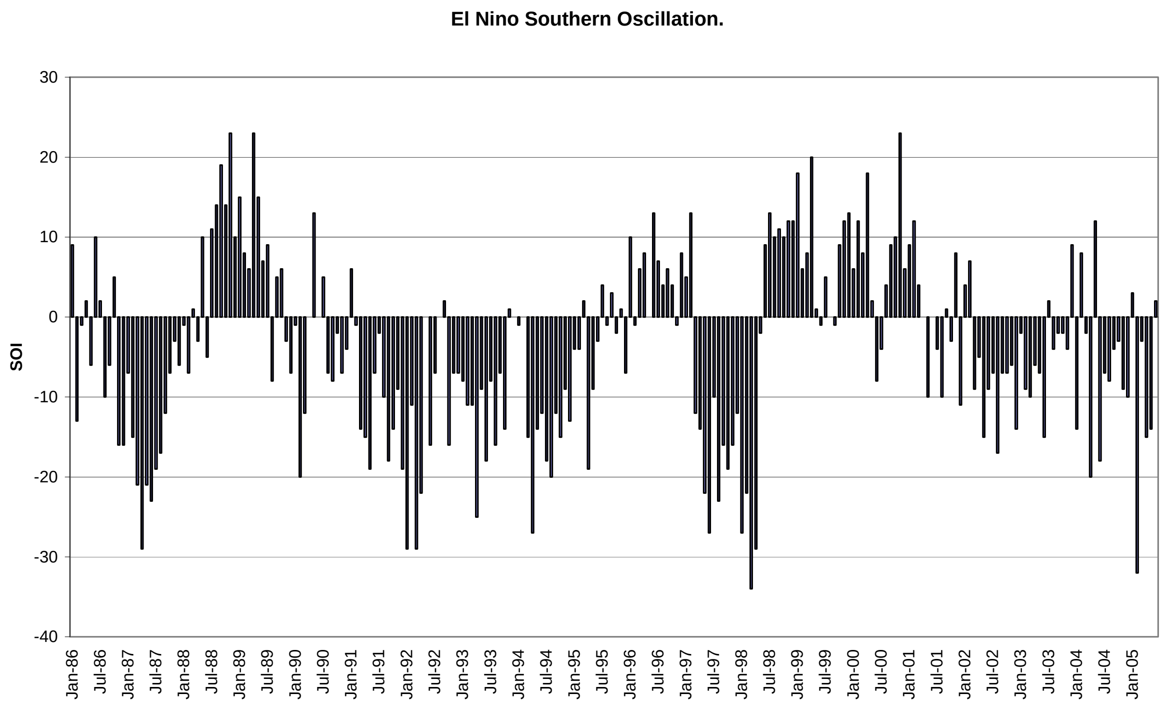


Figure 4.1 El Nino Southern Oscillation timeseries (source: NIWA)

4.1 Climate Change

The Intergovernmental Panel on Climate Change in its Fourth Assessment Report (2006) concluded that there was new and strong evidence that most of the global warming observed over the last 50 years could be attributed to increased greenhouse gas concentrations in the atmosphere due to human activities. Whilst there are still many uncertainties associated with predicting future climatic changes, the broad pattern of change over New Zealand related to coastal areas is expected to consist of:

- floods and storm surges that are very likely to become more frequent and intense,
- sea level is virtually certain to rise.
- by 2050, there is very likely to be degraded beaches.

By 2050, vulnerability is likely to be high in a few identified hotspots. In New Zealand, one of the recognised hotspots is the Bay of Plenty where ongoing coastal development is very likely to exacerbate the future risk to lives and property from sea-level rise and storms (NIWA, 2007)

A recent study undertaken by Bell et. al. (2006) for Environment Bay of Plenty to access how potential climate changes may affect the drivers of coastal erosion and inundation hazards. The study specifically summarises the present knowledge of the impacts of potential climate change on:

- tides, storm surges and sea levels within the Bay of Plenty;
- wave conditions along the Bay of Plenty coastline;
- sediment supply from rivers in the Bay of Plenty to the coastline;
- the potential movements of beach sediment and hence impact on the patterns of coastal erosion or accretion along the Bay of Plenty coastline.

The following sections are excerpts from the Bell et. al. (2006) report.

4.2 Tides, storm surges and sea-levels

Sea levels are important along the Bay of Plenty coastline for two primary reasons: a) the tide height governs the likelihood of coastal inundation, especially when combined with storm surge; and b) sea-levels also determine the degree to which waves may become depth limited at the coastline and hence is important in determining factors such as the magnitude of wave run-up, or storm induced beach and dune erosion.

The main component of sea level is the astronomical tide but sea level at any location can be elevated (or lowered) due to:

- climatic fluctuations operating over annual to decadal timescales (for example the 2 – 4 year El Niño Southern Oscillation and the 20 – 30 year Interdecadal Pacific Oscillation);
- storm surge due to atmospheric pressure and wind effects;
- wave breaking and ensuing set-up and run-up at the shoreline.

Storm surge in the eastern Bay of Plenty tends to be higher than that in the western Bay of Plenty. However, storm surge heights measured at sea-level gauges within the Whakatane River and Ohiwa Harbour do not always provide a true indication of storm surge conditions on the open coast in the eastern Bay of Plenty. In Tauranga Harbour, extreme storm-tide levels are generally lower than those recorded at Moturiki.

Sea levels have been rising around New Zealand since the early to mid part of the 1800s. The Port of Auckland sea-level gauge operating since 1899 (the closest long-term tide gauge record to the Bay of Plenty) provides a reasonable indication of how sea levels have risen in the Bay of Plenty (Figure 4.2). This rise in the mean level of the sea has been around 0.14 m over the last 100 years, which is slightly less than the average for New Zealand of 0.16 m, but within the global range of 0.1 to 0.2 m. It is expected that this rate of sea-level rise will accelerate in the future due largely to thermal expansion of the world's oceans and the melting of many of worlds glaciers due to a warmer climate. The general effect of sea level rise on a variety of coastal margins can be seen in Figure 4.3.

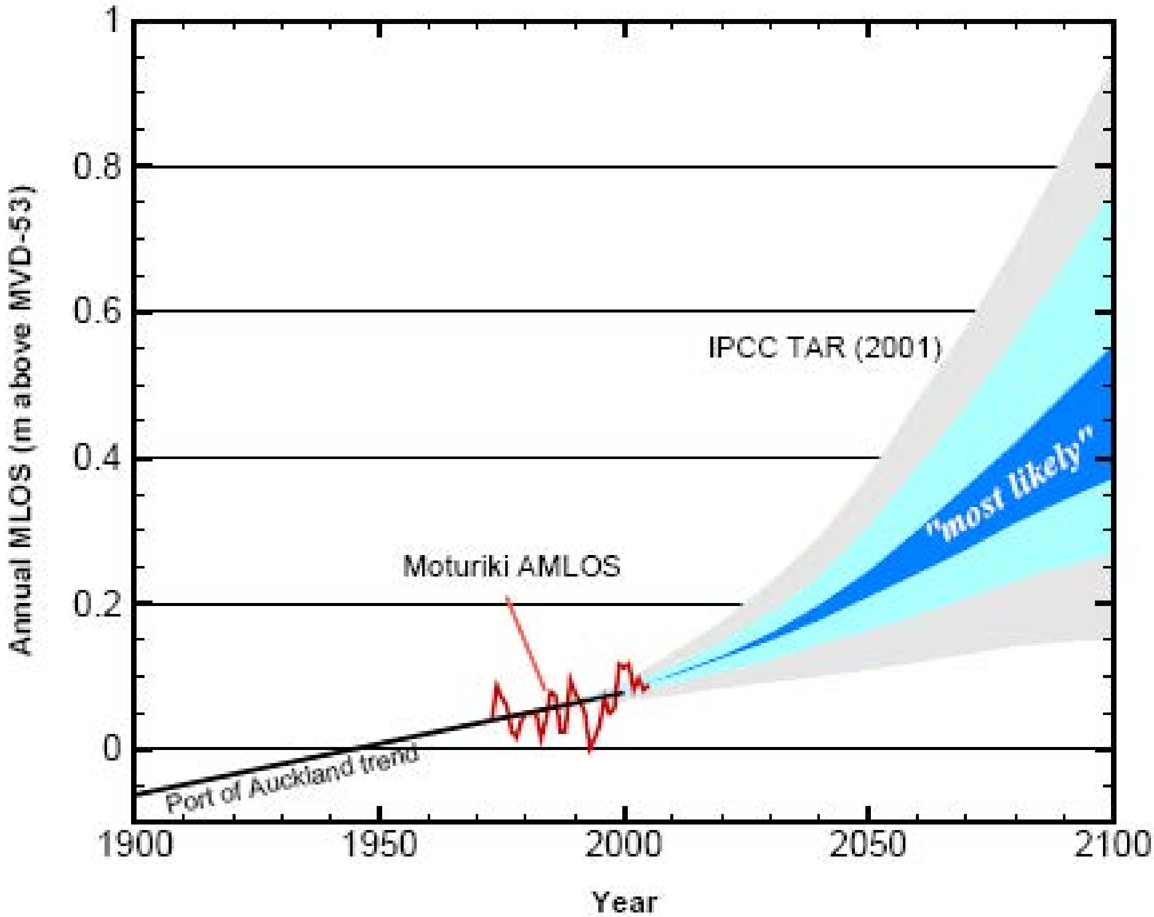


Figure 4.2 Sea level rise projections (Bell et. al., 2006), MLOS = mean level of sea.

Future sea-level rise in the Bay of Plenty region also needs to account for any potential vertical movements in the landmass. For example if the land is subsiding, the relative rate of sea-level rise could be greater, or if tectonic uplift occurs, relative sea-level rise will reduce. Vertical land movements are an important consideration in the Bay of Plenty which has a history of tectonic movements. Over geological timescales, the area between Waihi and Papamoa has been relatively stable. Between Whakatane and East Cape land has been uplifted (hence potentially reducing the relative impact of long-term sea-level rise). The Whakatane Graben region between Maketu and the Whakatane River entrance, (within the Taupo Volcanic Zone), has been subsiding over geological time. However, this tends to occur episodically during seismic events rather than necessarily at a continuous rate.

Until a longer record of continuous vertical land movements is available it is recommended that future rates of sea level rise within the Bay of Plenty be considered similar to the current absolute global estimates. Whilst there is still uncertainty as to the likely magnitude of these estimates, it is recommended for planning purposes that allowance be made for a rise of 0.2 m by 2050 (relative to 1990) and of 0.5 m for 2100 which is in keeping with present guidance from the Ministry of the Environment. This corresponds to a mean level of the sea of 0.26 m relative to Moturiki Vertical Datum-53 by 2050 and 0.56 m Moturiki Vertical Datum-53 by 2100.

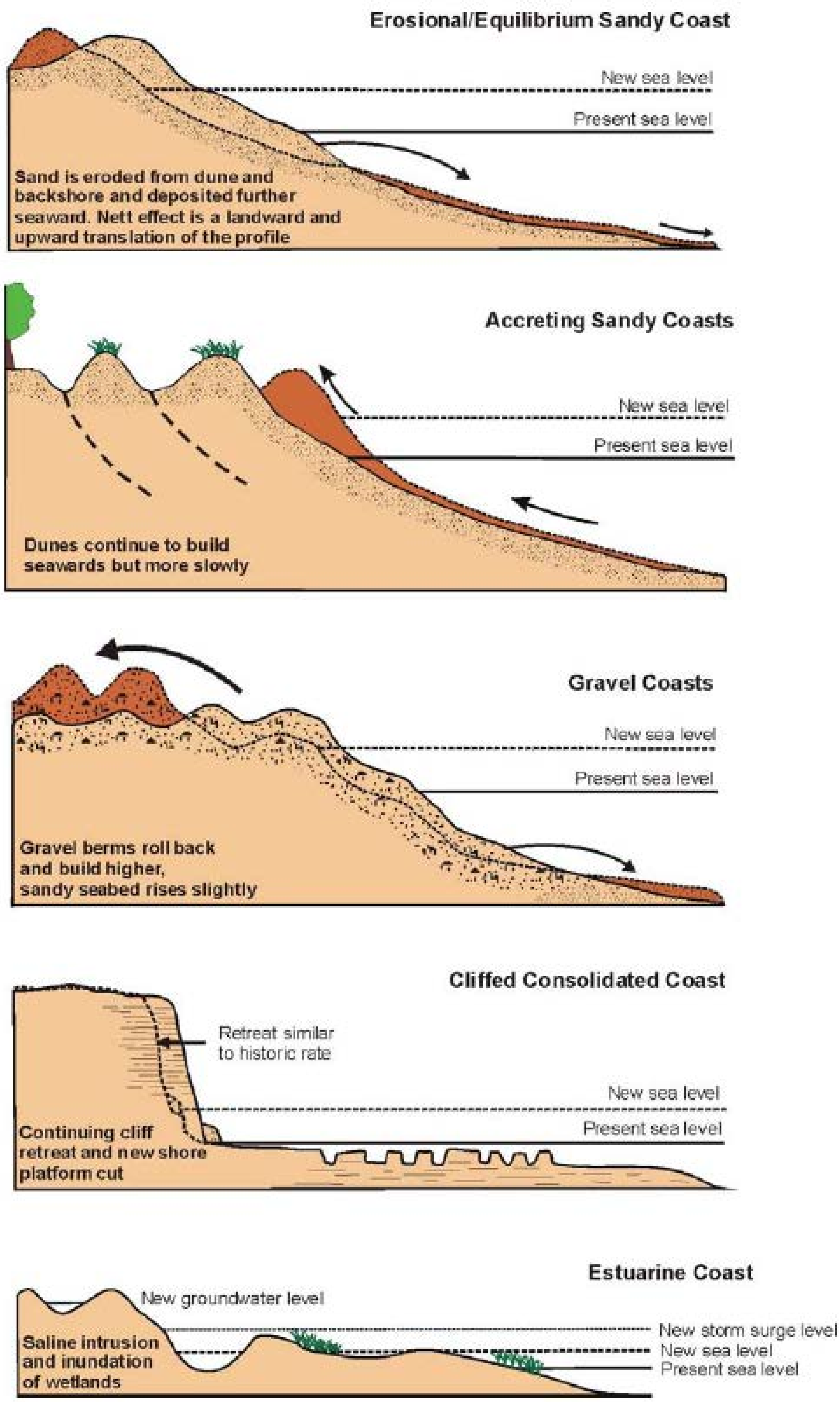


Figure 4.3 Generalised shoreline impacts of sea-level rise and coastal "drivers" on different types of coasts. Indicative only as local conditions and "sand supply" may produce different responses (MfE, 2001).

A window on how the New Zealand coastline might behave with a rise in sea level can be cautiously appraised from examples where the land has subsided suddenly in an earthquake, effectively causing a relative rise in sea level. The Edgecumbe earthquake on 2 March 1987 caused the 9 km coastal margin between the mouth of the Rangitaiki and Tarawera Rivers to subside by about 0.4m (equivalent to an instantaneous rise in sea level). Sea floor sediments adjacent to the Rangitaiki Plains are sand and silty-sand. Historically the trend has been a coastline advancing seaward (Healy et al., 1977), although the beach was relatively stable from 1977 to 1987. The retreat likely to be caused by the 0.4m subsidence was 45m using the Bruun (1962) rule.

What took place was quite different, with the lower foreshore (below 2m elevation above mean sea level) showing a loss of material for the first five years after the earthquake, as expected, followed by accretion to the present, as shown in Figure 4.4 (Smith, NIWA unpublished data). Above 4m elevation the dune deposit maintained a steady accretion rate throughout. In this case, even though the lower foreshore initially eroded in response to the sea-level change, it appears that sufficient sediment supply was available from offshore and alongshore drift to satisfy the sediment demand of what was effectively a localised rise in sea level, and thereby rectify the perturbation (MfE, 2001).

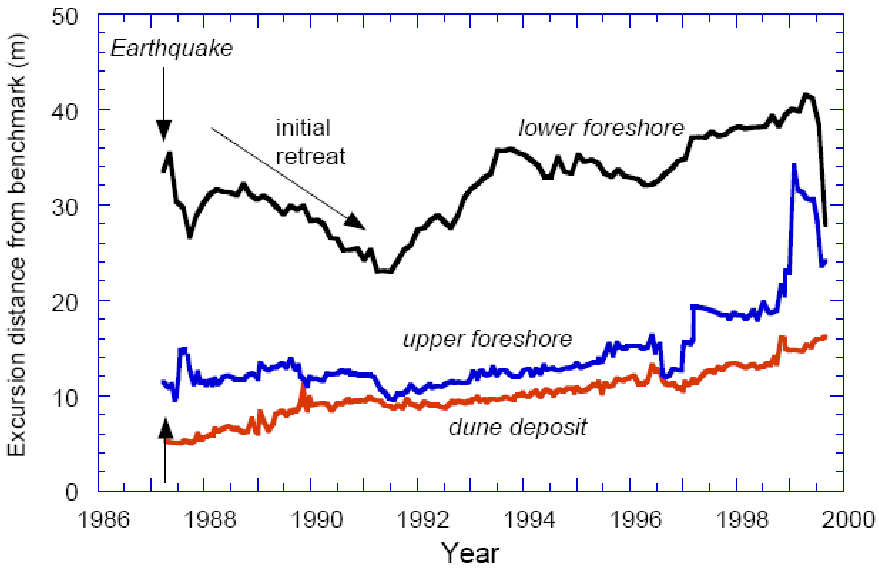


Figure 4.4 Response of a beach profile near Thornton (Bay of Plenty) following the March 2, 1987 Edgecumbe earthquake when the coastal margin subsided by 0.4 m. The upper foreshore and dune deposit lines are 1.5m and 2m respectively above the lower foreshore datum.

4.3 Wave conditions

Wave action is the dominant forcing process causing changes in erosion and accretion patterns along the Bay of Plenty coastline. It also contributes to coastal inundation through locally raising water levels (set-up) at the shoreline and wave run-up on to the land. The potential effects of climate change on wave conditions experienced at the coastline of the Bay of Plenty is complex, depending on the interaction between both changes in regional conditions around New Zealand and in the wider South Pacific (e.g., changes in local and regional winds, storm and cyclone tracks and intensity).

Wave conditions in the Bay of Plenty are moderately influenced by the El Niño Southern Oscillation. More stormy conditions than average tend to occur during La Niña periods, which are associated with an increase in northeasterlies in the New Zealand region. During El Niño years, where a higher occurrence of southwesterlies occurs, wave conditions in the Bay of Plenty are somewhat reduced although episodic extra-tropical cyclones still occur. Given that since 1998 we have entered a negative phase of the Interdecadal Pacific Oscillation where neutral or La Niña conditions may be more likely to occur, it is possible that the Bay of Plenty region may experience increased rates of erosion over the next 20 to 30 years, similar to that experienced in the late 1960s and early to mid 1970s.

Potential changes to swell wave conditions reaching the Bay of Plenty have a considerable influence on wave induced set-up and run-up which, although highly variable along the coastline, could result in increases in annual maximum set-up and run-up of up to around 1 m due to climate change effects.

4.4 Sediment supply and beach erosion and accretion

Remotely generated swell waves are also the dominant factor moving sediment along the Bay of Plenty coast, particularly between Waihi and Opape. The climate change scenarios suggest in general that changes in longshore movements of beach and nearshore sediments will be relatively uniform within the region and relatively small compared to typical present day inter-annual variability.

A further factor influencing coastal-erosion patterns within the Bay of Plenty region are changes to the input of sand and gravel from river sources to the coast. Rainfall is the main climatic driver that affects the amount of sediment transported down rivers, since it affects both the rates of erosion on hillslopes and the transport capacity of runoff down river channels. Bay of Plenty rivers show large inter-annual variability in sediment yields, with annual yields ranging over at least a factor-of-ten. However, in general, there does not appear to be a significant correlation between annual sediment yield and El Niño Southern Oscillation or the Interdecadal Pacific Oscillation index. The exception is the Tarawera River, which tends to have higher yields during La Niña phases.

Projections of future annual average rainfall in the region vary widely, ranging from a 15% decrease to a 2% increase by the 2080s. This translates to anywhere from a 25% reduction in average annual sediment yields to a 3% increase which is small compared to the existing inter-annual variability. Taking this, and the likelihood that changes to the general longshore movement of beach material is also likely to a have relatively small effect at a regionwide scale, suggests that the patterns of erosion experienced along the open coast of the Bay of Plenty region are unlikely to change substantially relative to that occurring at present and over the last few decades. The most susceptible areas to coastal changes will still occur at locations such as estuary and river mouths, adjacent to promontories and along spit features. However, areas that have traditionally been relatively stable, such as to the south of Papamoa, in the lee of Motiti Island, may begin to show a greater tendency to erode.

Chapter 5: Monitoring Results

5.1 Profile monitoring

The purpose of this chapter is to present the results of beach profile monitoring for the 53 coastal cross-section sites along the Bay of Plenty beaches. All beach volume and shoreline trends are determined since 1990 (except where otherwise indicated).

All elevation information is in relation to Moturiki Datum.

The data in this chapter is presented grouped by beach (Figure 5.1) on a site by site basis.

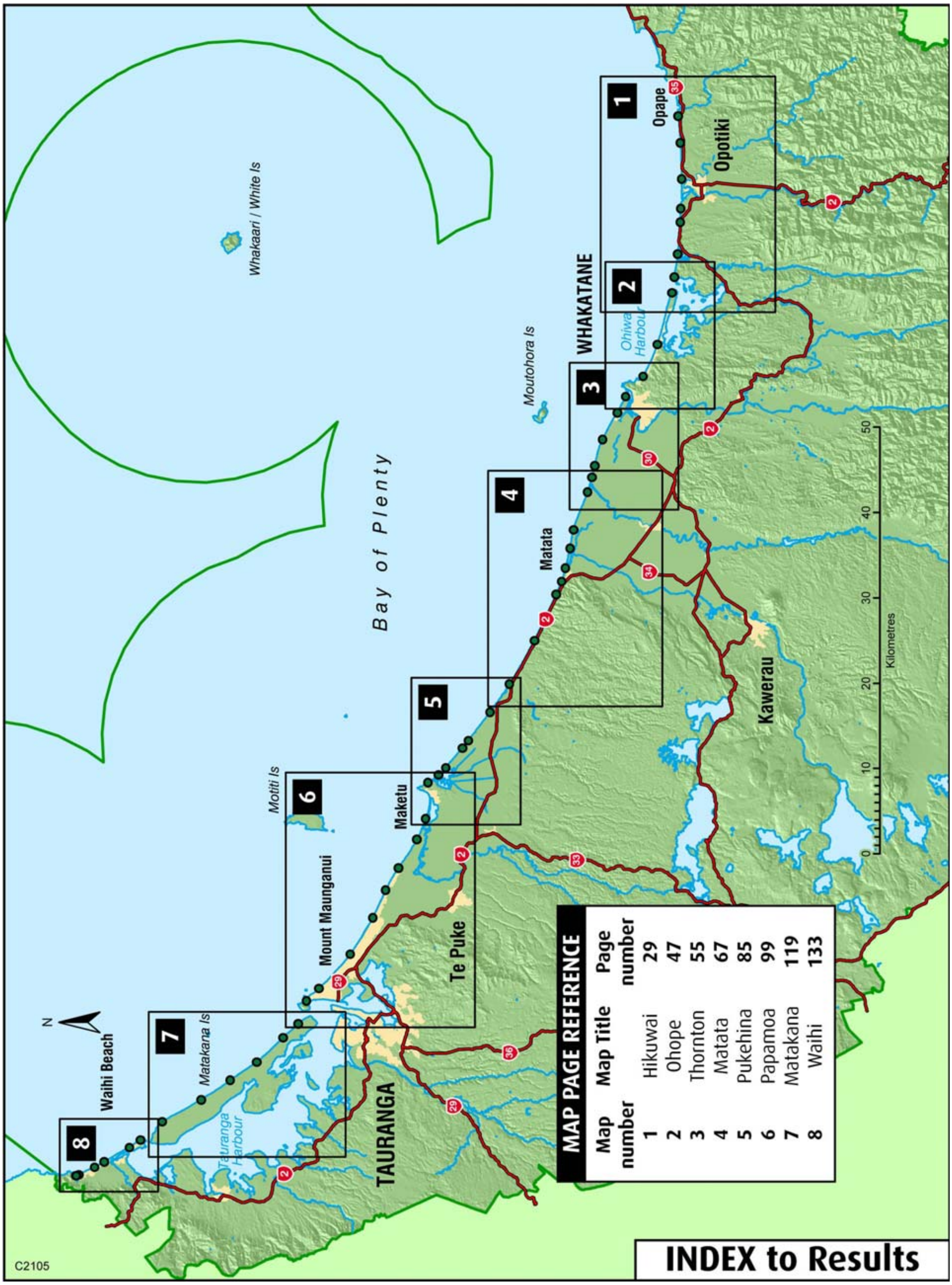


Figure 5.1 Beach profile monitoring sites within the Bay of Plenty.

Each beach summary contains:

- Beach summary map

  Show each beach group with the determined historical beach state.

- Site discussion and analysis

  See description below.

And each site summary contains:

- Discussion

  Comments regarding the summarised data on the adjacent site page.

- Historical photography

  Typically two images are provided for each site. One taken in 1978 as part of the Bay of Plenty Coastal Survey Report 78/1 (Healy, 1978) the second photograph was taken in February and March of 2006, orientation was determined by the 1978 imagery. No photographic record is available for Matakana Island.

- Site summary information

  Shows the state of the selected site (for the period of the NERMN record), location in NZMG, period of the NERMN record, the number of profiles measured, the morphodynamic type (Wright - Short model) (sourced from Pickett, 2004) and the statistical significance (p-level) test on the volume and toe of foredune (TOF) datasets. The result is an estimated measure of the degree to which it is "true" (in the sense of "representative of the population"). More technically, the value of the p-level represents a decreasing index of the reliability of a result. The higher the p-level, the less we can believe that the observed relation between variables in the sample is a reliable indicator of the relation between the respective variables in the population. Specifically, the p-level represents the probability of error that is involved in accepting our observed result as valid, that is, as "representative of the population" (Brownlee, 1960). A p-level of 0.01 was used for assessing the volume and toe of the foredune position datasets. See section 5.2 for an explanation of the state criteria used.

- Seasonal profile distribution chart

  Shows when the dataset records were measured.

- Beach profile summary chart

  Shows the first profile in the NERMN dataset, the last profile in the previous NERMN report (Hodges & Deely, 1997), the last profile in this report, the minimum envelope based on all measured profile points, average profile position based on all reported profiles and the maximum envelope based on all measured profile points.

- MHWS chart

  Showing the variation in the MHWS elevation (based on Tauranga primary port record). The figure of 1.1m was sourced from the LINZ website, Table 3 for regulatory agencies, June 2006.

- Offshore profile summary

  Three profiles have typically been measured at each site on a 5 yearly cycle. Measurements were made by University of Waikato staff. The accuracy of the 2003 sections should be significantly better than that achieved by the 1997 and 1992 surveys due to greater resolution in the depth sounder ($\pm$ 1cm in 2003, compared to $\pm$ 5cm in 1992) and the heave compensation used for the 2003 survey, which removes any significant wave action from the survey data. (Ellery, 2003).

- Assessment of volumetric changes for each profile

  Profile areas are calculated from the front benchmark to mean sea level with the resulting values presented as plots over time. From these plots, the magnitude and rates of changes between monitoring occasions can be visually assessed. Profile areas have the units of a cubic metre per metre of beach profile (m^3/m).

- Assessment of shoreline movement for each profile

  Shoreline movement is determined by calculating the change in the position of the toe of foredune position along the profile. This position has been retrieved from annotations in field books, where not available visual inspection of the profile is undertaken to determine this beach position. Distance is from the benchmark origin in metres.

  As beaches generally go through alternating periods of accretion and erosion depending on such factors as wave climate and sediment supply, the presented trends should not be used as future indicators of beach change, they are only presented as historical trends.

5.2 Statistical analysis criteria

For the classification of beach state a set of objective criteria were determined based on a 0.01 level of significance. The linear regression test was performed on both the volume and toe of foredune (*Systat 9 software*). Were the test proved true (<0.01) the coefficient was then used to determine whether the beach was in an erosion (retreat) or accretion (advance) trend state (Figure 5.2). When the test was false (>0.01) the dataset was deemed stable (or sometimes referred to as being in dynamic equilibrium). Where the two datasets arrived at contradictory results the following rules outlined in Table 5.1 were used.

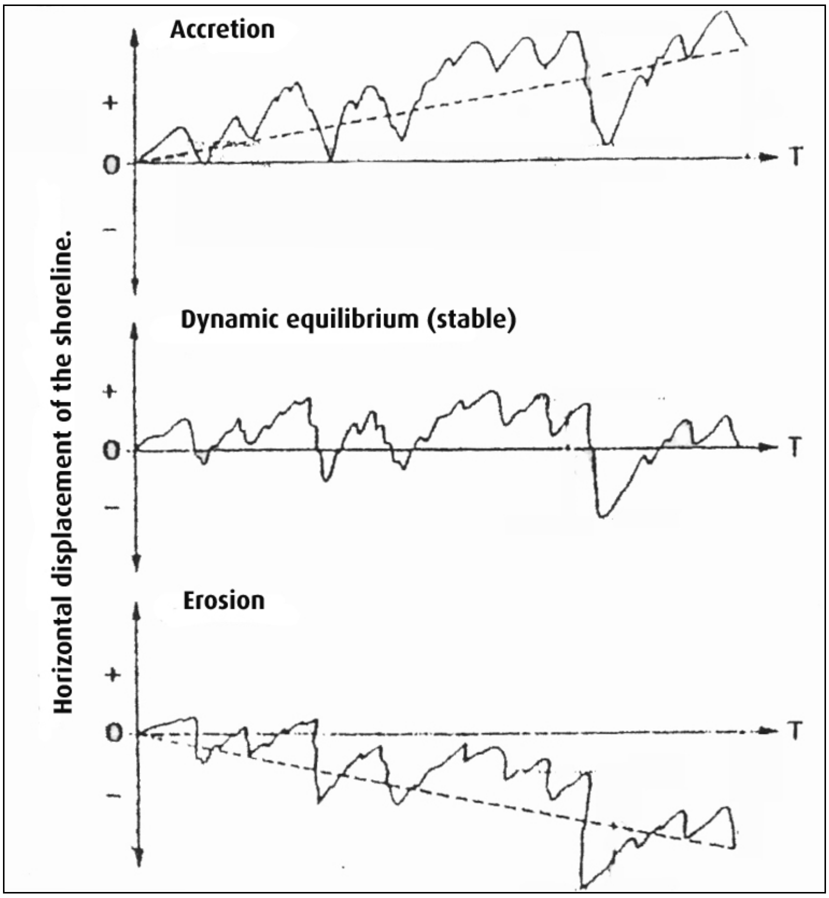


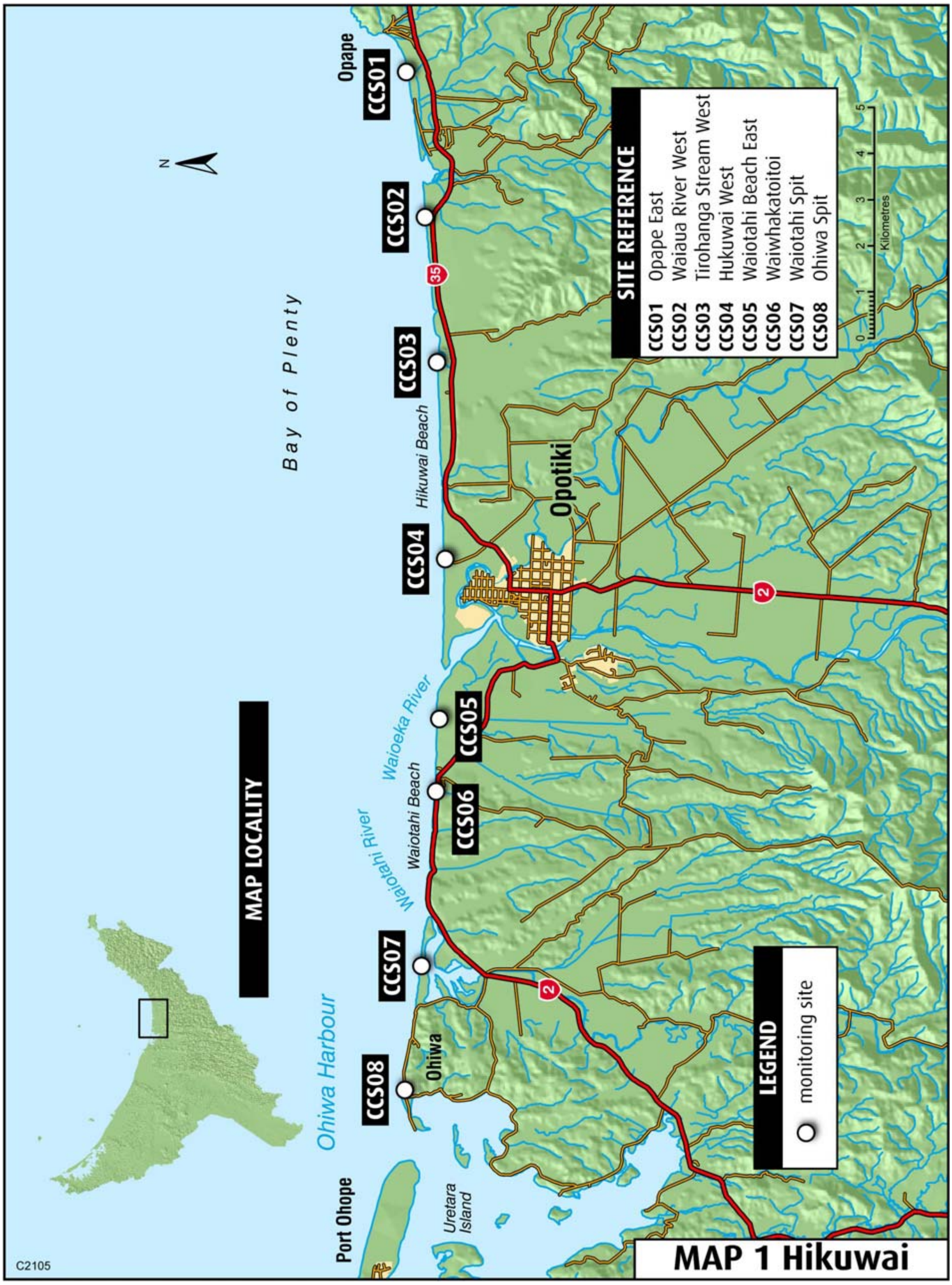
Figure 5.2 Three types of shoreline trends from Gibb (1995).

It should be noted that for Environment Bay of Plenty's state of the environment reporting to date only beach volume change has been used for determining the historical trend in the profile datasets.

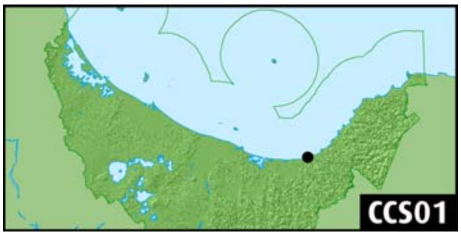
Table 5.1 Trend criteria

Test results (volume & toe of foredune)	Criteria	Comment
Stable and stable	Stable	Dominant stable trend exists in the recorded dataset.
Erosion and erosion	Erosion	Dominant erosion trend exists in the recorded dataset.
Accretion and accretion	Accretion	Dominant accretionary trend exists in the recorded dataset.
Erosion and stable (or vice versa)	Erosion?	In this case when either one of the tests differs from the other, the non stable state was chosen but inclusion of the ? highlights the variability in the dataset and also the requirement for additional/continual monitoring to strengthen the direction of the trend.
Accretion and stable (or vice versa)	Accretion?	In this case when either one of the tests differs from the other, the non stable state was chosen but inclusion of the ? highlights the variability in the dataset and also the requirement for additional/continual monitoring to strengthen the direction of the trend.

5.3 **Hikuwai Beach system**



5.3.1 **Opape East (CCS 01)**

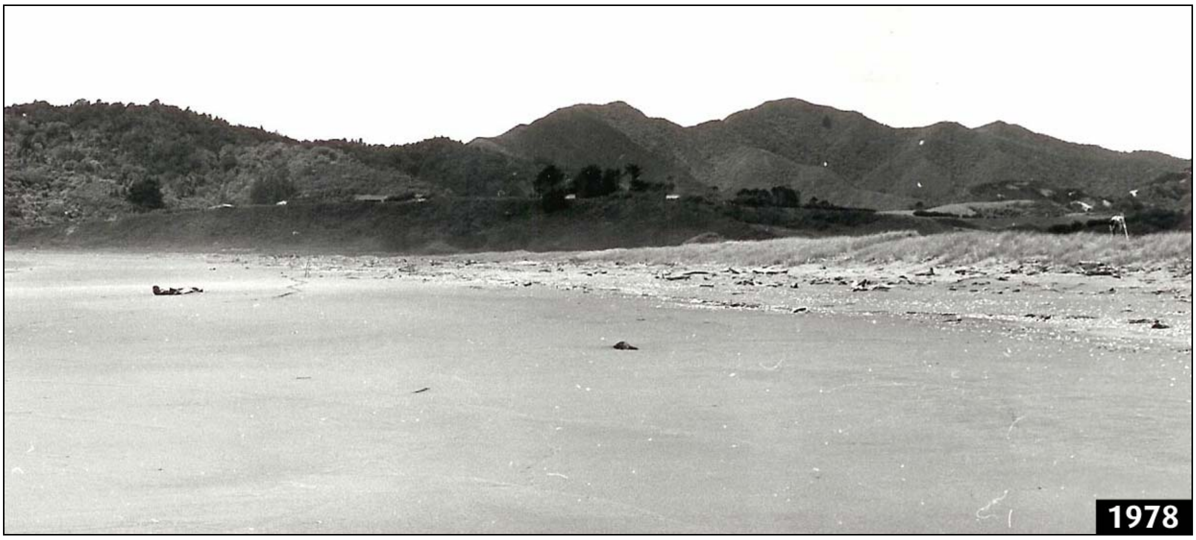


Discussion

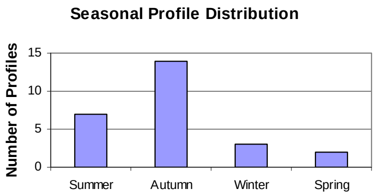
This site is located 1 km to the west of the Tarakeha headland and is approximately centrally located in the 2.5km long sandy beach which is bounded in the west by the Waiaua River. The beach borders a narrow Holocene coastal plain composed of a 140m wide dune barrier protecting a swampy flood plain. Foredune width is ~25m.

Monitoring data indicates that the beach was in it most landward position in 1991 and most accreted position in 1996. The surveys show the establishment of a new frontal dune (see maximum envelope). Offshore profiles show the development of a small offshore bar typical of profiles seen in proximity of other headlands within the Bay of Plenty. A zone of convergence occurs at -6m.

The frontal dune plot shows a seaward building of the frontal dune in the period 1996 to 2001. The frontal dune position is ~10m seaward when compared with the first recorded profile; the volume shows an increase over this period with a marked increase in elevation throughout the near shore profile. The statistical analysis shows that for this record the *beach trend is stable* with marked variation in the dataset and corresponding low correlation coefficients. Gibb (1994) stated the long-term trend (1880-1994) of shoreline retreat of approximately 25m, ranging from 15 to 34m.

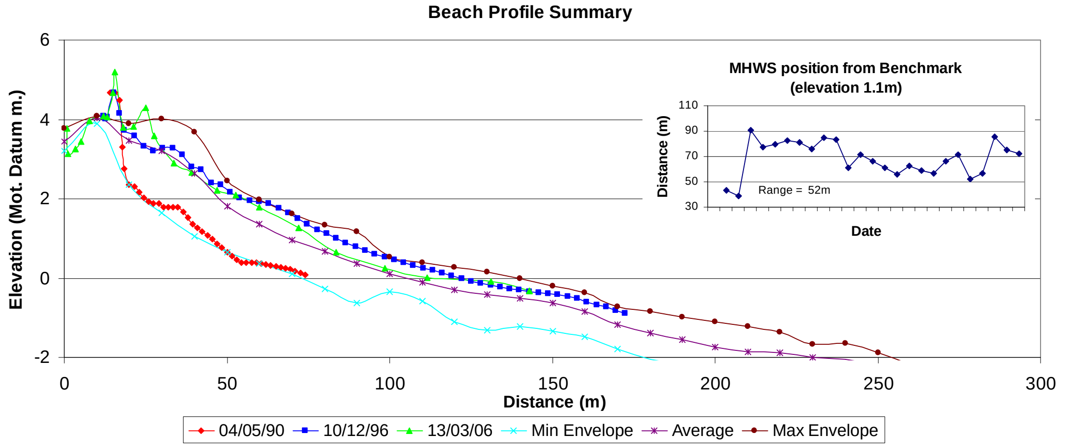


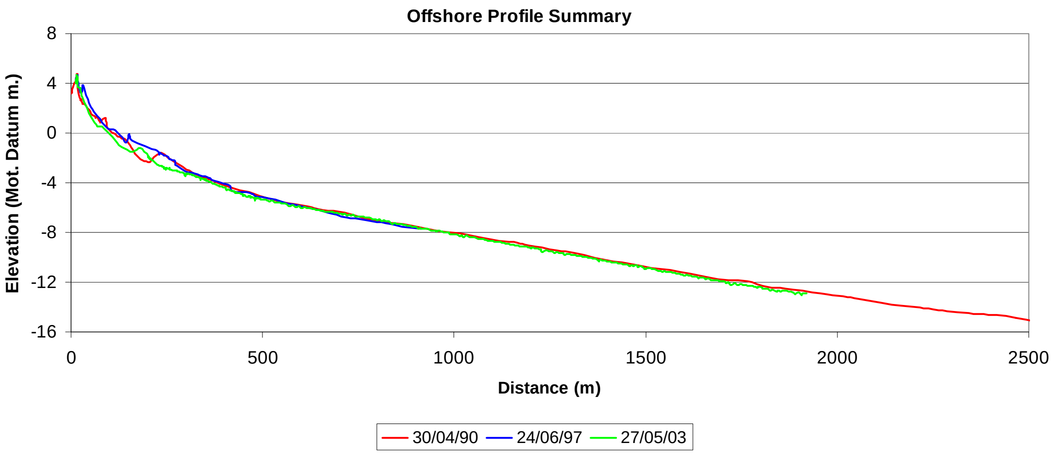
CCS 01 - Opape

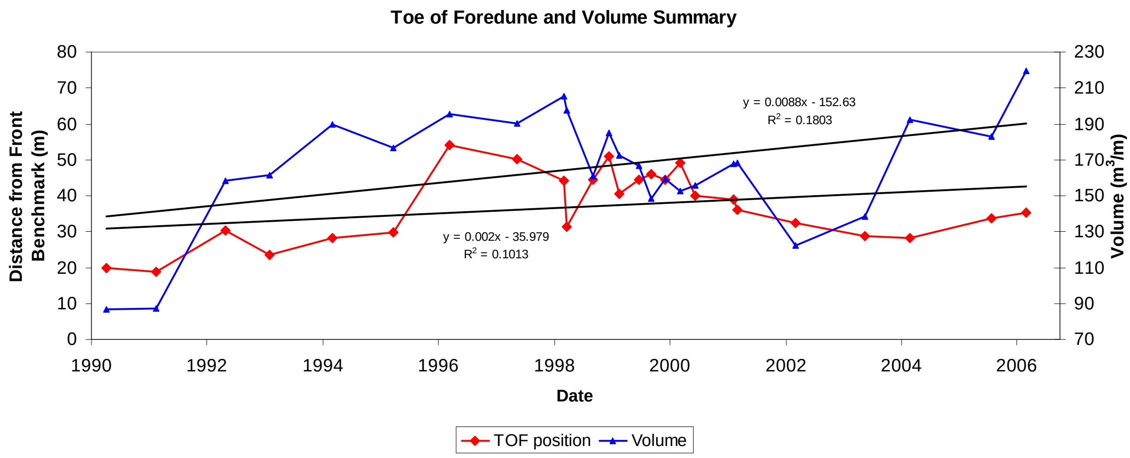


State: Stable

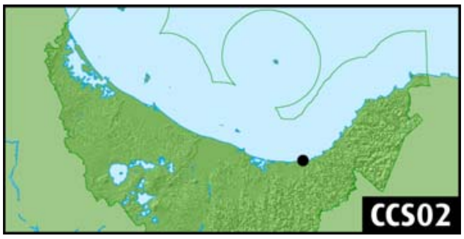
Location: NZMG 2897738E 6348644N
Period of record: 1990 – 2006
No. of profiles: 25
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.03 **TOF p-level –** 0.12







5.3.2 **Waiaua River West (CCS 02)**



Discussion

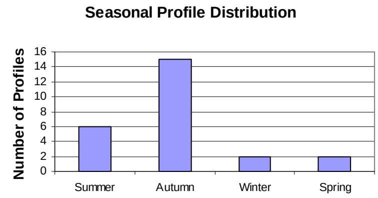
This site is located 700m to the west of the Waiaua River, which has migrated up to 1300m in the past (Gibb, 1994). The foredune barrier has an average elevation of 5m and is subject to wind erosion as shown in the 1978 photograph below. The 2006 photography shows a steeply faced dune with overhanging vegetation (*Carpobrotus edulis*).

The measured profiles show the characteristic shape for a sandy beach. In the 1992 profile a well developed berm exists. Most variation on the profile is shown in the highly active mid to lower section of the beach. A variation of 32m is measured at the projected MHWS position. Offshore profiles are similar to those at CCS1 with a small offshore bar present and a well developed trough in 2003. Convergence occurs at -7m.

The toe of foredune position shows no significant trend with a slight variation of ~5m evident. The volume trend is significant with a negative coefficient highlighting a *possible erosion trend* for this site.

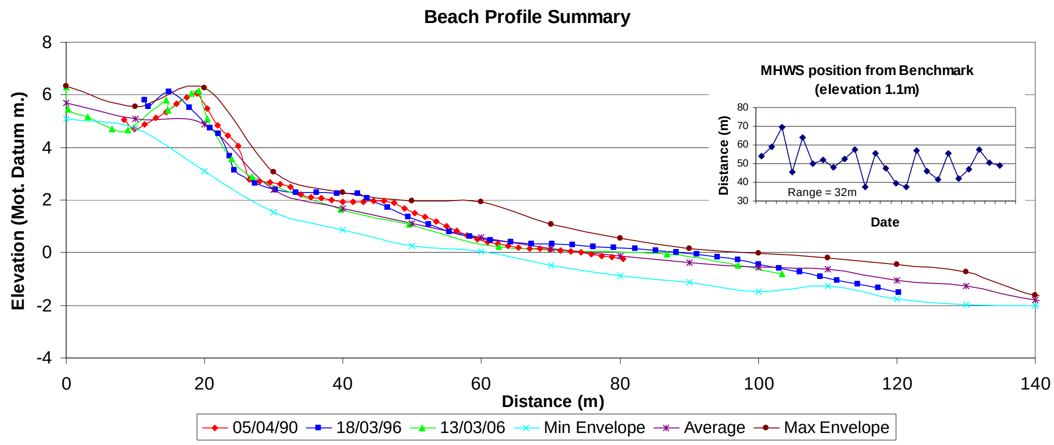
Long-term trend (1866-1994) of stability with short-term fluctuations of 10 to 15m increasing to 20 to 30m near the Waiaua River mouth has been recorded (Gibb, 1994)

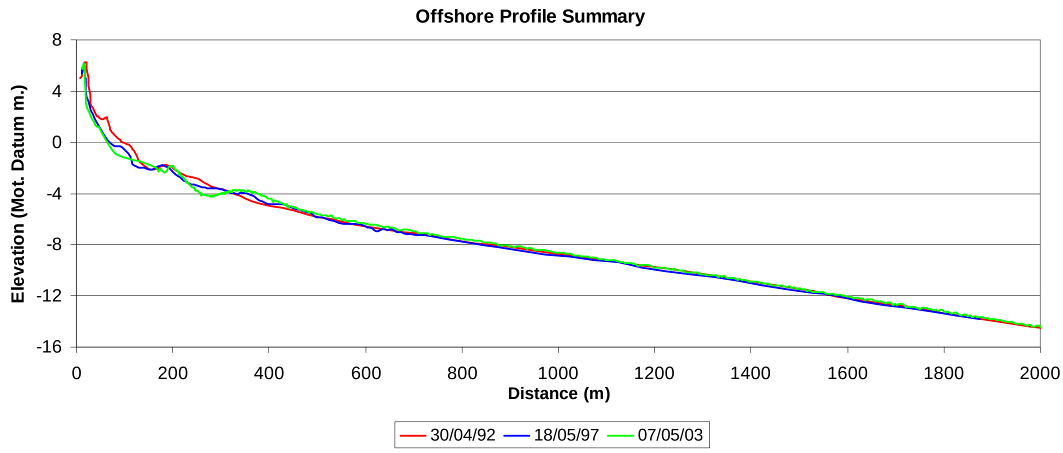
CCS 02 - Waiaua River West (CCS 02)

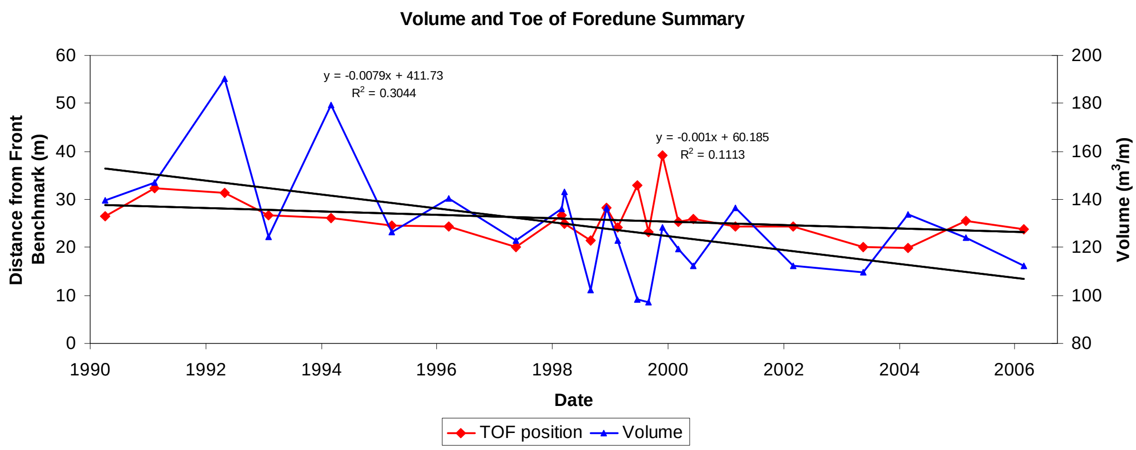


State: Erosion?

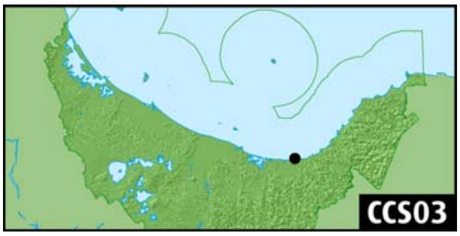
Location: NZMG 2894604E 6348238N
Period of record: 1990 – 2006
No. of profiles: 24
Morphodynamic type (Wright Short model): Rhythmic Bar and Beach
Volume p-level – 0.01 **TOF p-level –** 0.11







5.3.3 **Tirohanga Stream West (CCS 3)**



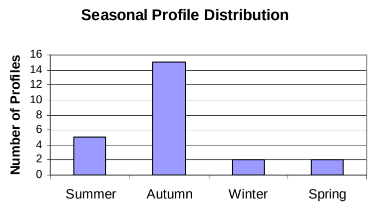
Discussion

CCS3 is located 200m to the west of the Tirohanga Stream. This stretch of beach bounded to the west by the two streams draining the Tablelands area comprises of a 50m wide dune barrier protecting a narrow Holocene coastal plain. The photographic record shows a marked change. In 1978, well developed *spinifex* is present with runners established on the lower section of the frontal dune (some wind erosion is also evident). The 2006 photograph shows an eroded undercut dune with sparse vegetation cover (predominantly grass transported from the dune crest).

The most eroded profiles have been recorded since 2001, a short period of accretion occurred in 1992 to 1995. A maximum horizontal variation of 36m occurs at the berm (~3m elevation). The MWHS position has a variation in position of 32m. The offshore profiles exhibit a zone of convergence at -6m and the seaward movement of the moderately developed bar during the period of monitoring.

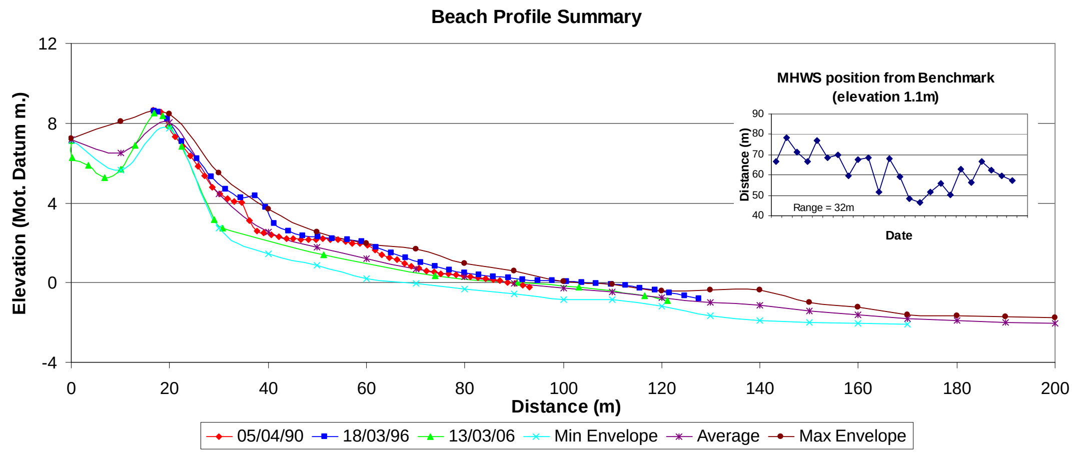
Both statistical tests are strongly significant with negative coefficients calculated for both datasets; the trend for the reported period of record is one of *erosion*. Gibb (1994) states a long-term trend (1866-1994) of shoreline retreat of approximately 20m, ranging from 12 to 26m, averaging 20m, with short-term fluctuations of 10 to 15m.

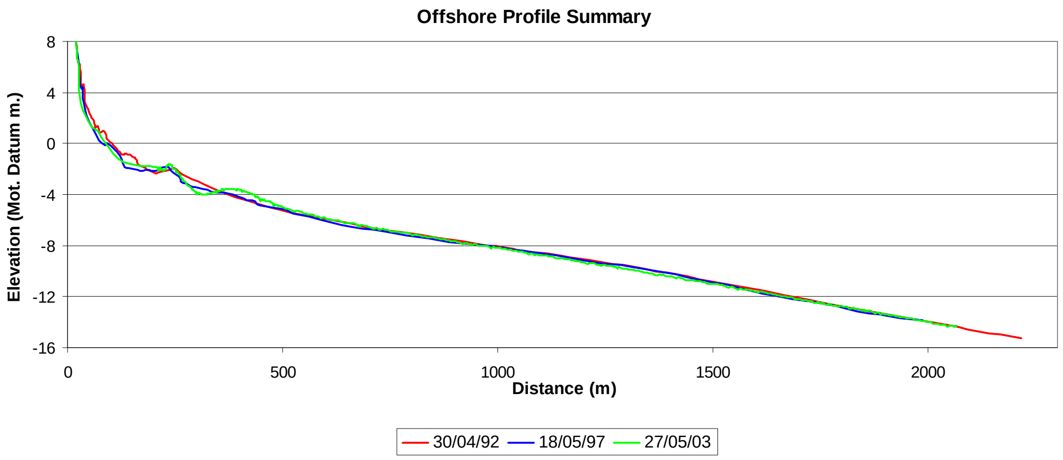
CCS 03 - Tirohanga Stream West

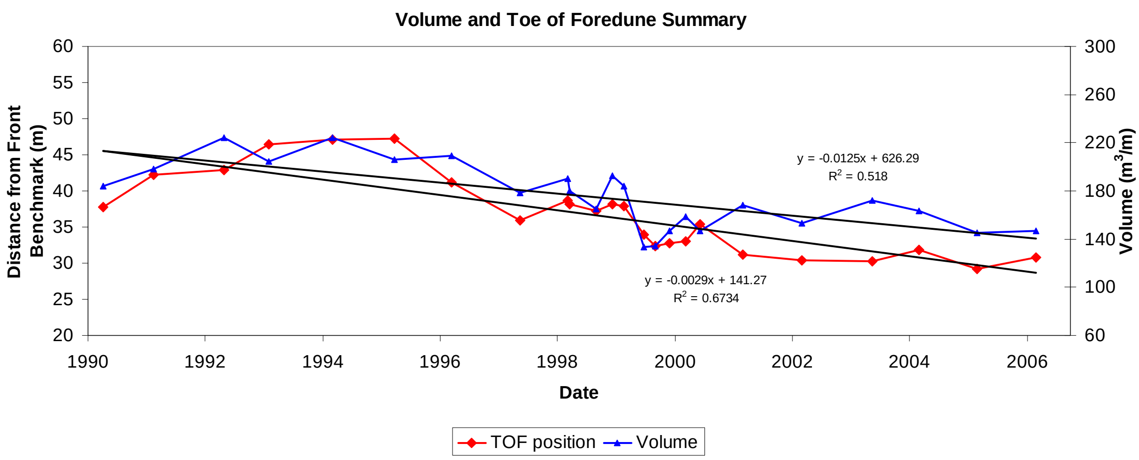


State: Erosion

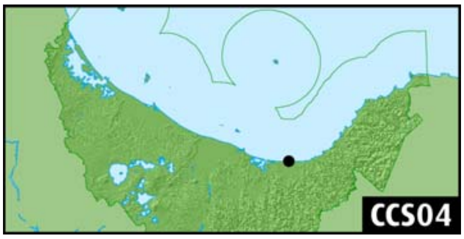
Location: NZMG 2891449E 6347983N
Period of record: 1990 – 2006
No. of profiles: 24
Morphodynamic type (Wright Short model): Rhythmic Bar and Beach
Volume p-level – 0.00 **TOF p-level –** 0.00







5.3.4 **Hukuwai West (CCS 4)**



Discussion

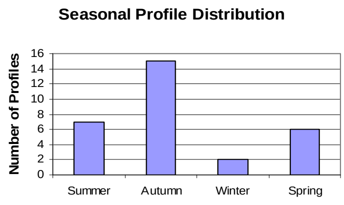
This site is located 2.4km to the east of the Waioeka River entrance. This section of beach borders a 60 to 200m wide dune complex that forms the seaward boundary of the Waioeka fluvial plain. Waiotahi Contractors Limited and their predecessor, Connelly & Hustler Limited have been mining sand from Hikuwai Beach for around 20 years (Lawrie, 1997). In the past up to 4000 m^3 was extracted per year but more recently coastal permit 04 0123 has allowed the removal of 2000 m^3 annually with not more than 300 m^3 taken per month.

Offshore profiles show a low offshore bar and accompanying shallow trough the same pattern exists as recorded at CCS3 with a seaward migration of the offshore bar in 2005. Convergence occurs at -6m.

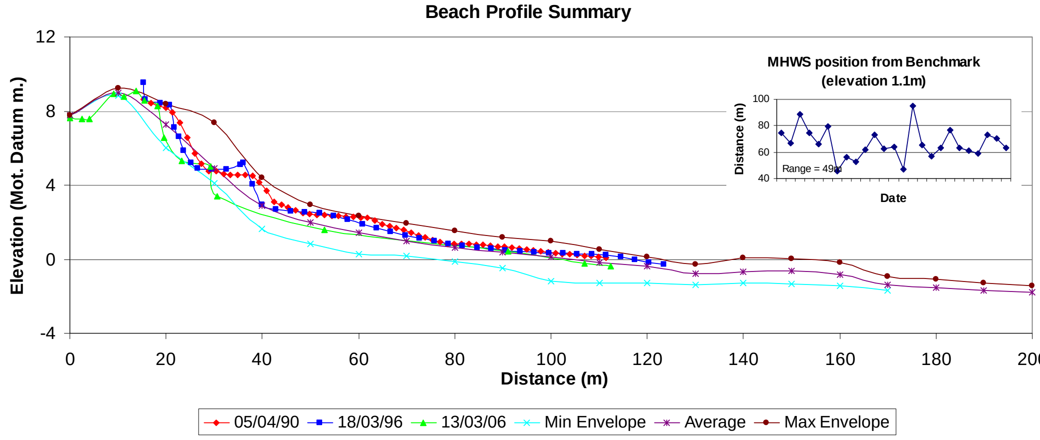
The volume calculations show marked variability during the period of record with no significant trend in this parameter. The photographic and toe of foredune record show signs of erosion with the loss of the *spinifex* covered incipient dune shown in 1978. In 2006 a planar beach surface with no berm present and a partly undercut toe of the frontal dune exists. The trend at this site was determined to be *towards an erosive state*. The long term trend by Gibb (1994) was determined to be of shoreline retreat (1866-1994) of approximately 25m, ranging from 20 to 37m.

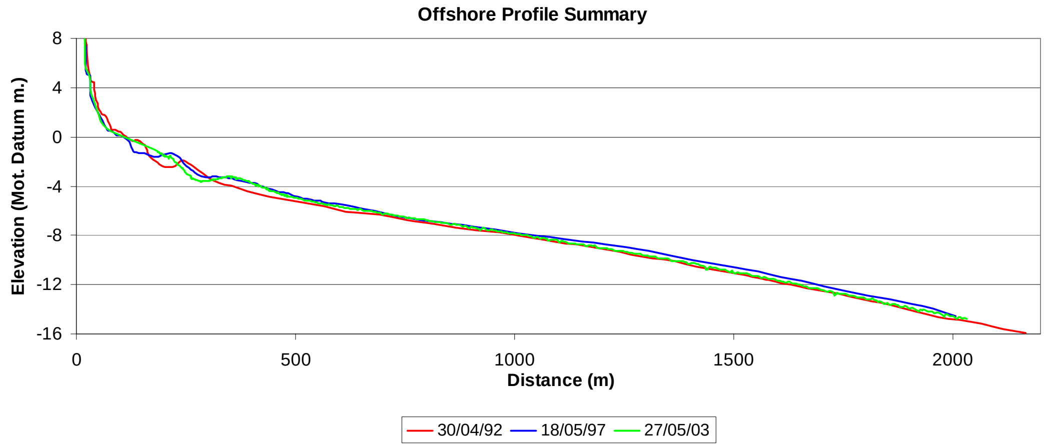
CCS 04 - Hukuwai West

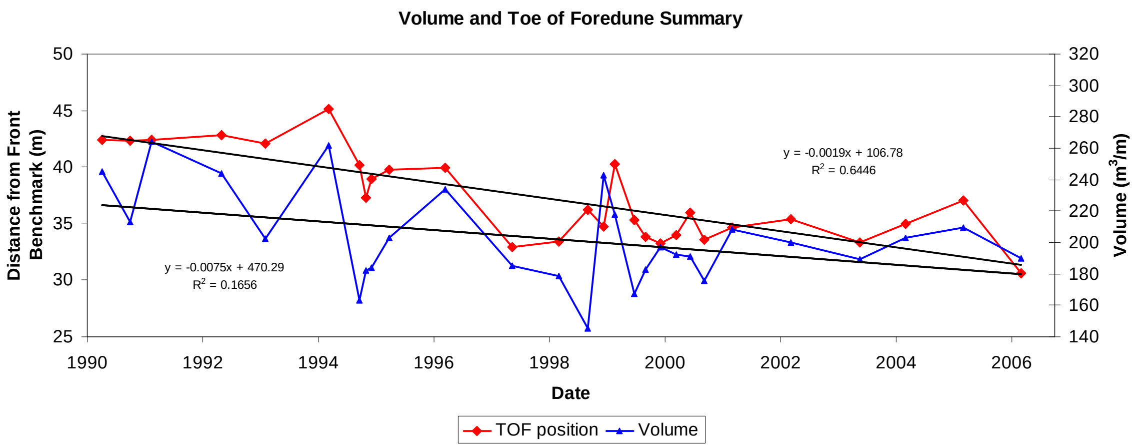
State: Erosion?



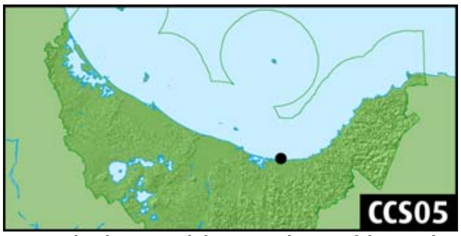
Location: NZMG 2887195E 6347805N
Period of record: 1990 – 2006
No. of profiles: 28
Morphodynamic type (Wright Short model): Rhythmic Bar and Beach
Volume p-level – 0.03 **TOF p-level –** 0.00







5.3.5 **Waiotahi Beach East (CCS 5)**



Discussion

This site is located 680m to the west of the Waioeka River entrance (based on 2003 aerial photography). Gibb (1994) stated that during the period 1866 to 1994 the entrance migrated 2km. This section of beach borders a 200 to 370m wide dune complex built from sediment supplied by the Waioeka River (Eco Nomos Ltd, 2005). As evidenced in the photographic record the foredune is subject to wind erosion, overtopping and inundation from storm wave runup.

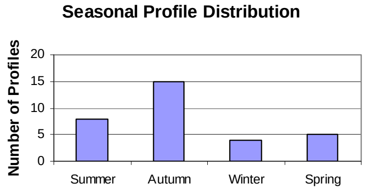
Envelope plots show a mobile beach system with marked variation in berm position and sporadic development of incipient dunes as sediment becomes available. A fixed elevation of 1.1m (MWHS) shows a horizontal variation of 68m for the period of record.

Minor offshore bar development is evident in the two earlier plots. The 2003 profile shows a well developed bar and trough system. These offshore features would be strongly influenced by sediment yield from the adjacent river. Offshore convergence of the profiles occurs at -5.5m.

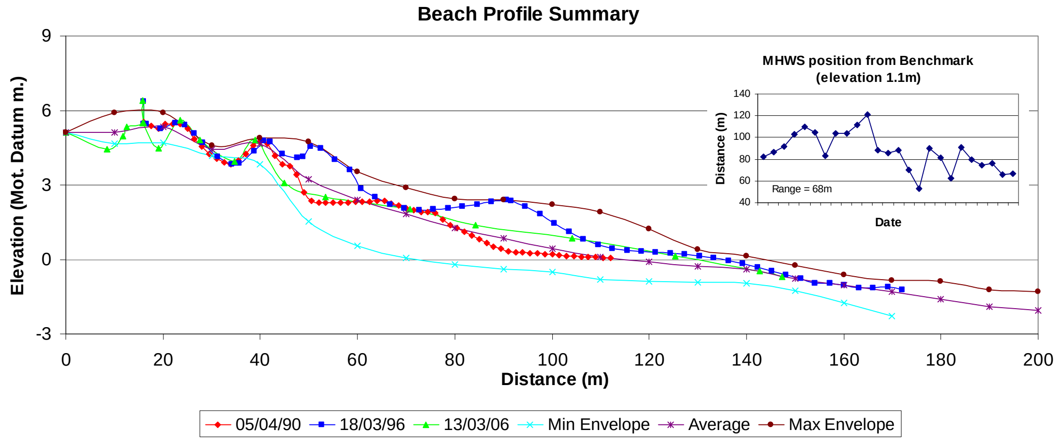
Statistical analysis showed strong trends in the data with both parameters having negative coefficients highlighting an *erosion trend* for this period of record. A long-term trend (1940 - 1994) of shoreline advance of approximately 30m, ranging from 25 to 50m, was determined by Gibb.

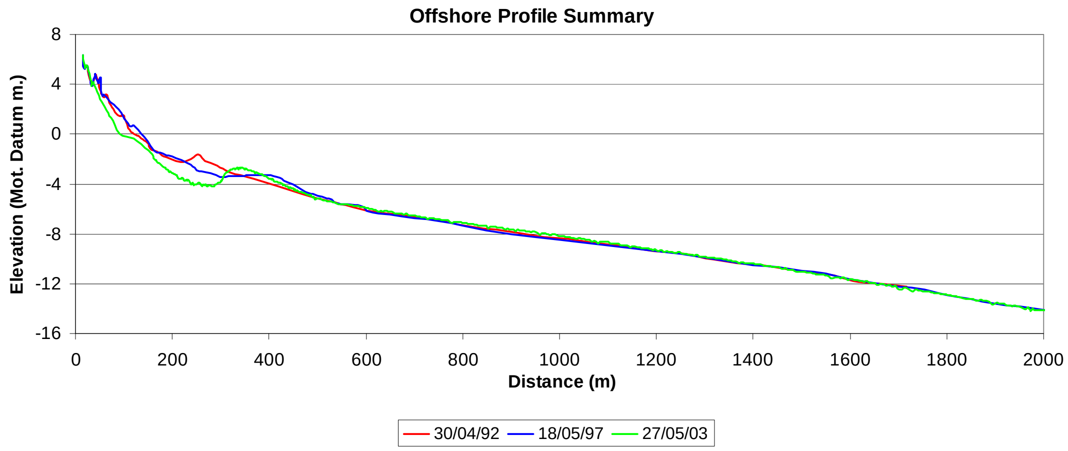
CCS 05 - Waiotahi Beach East

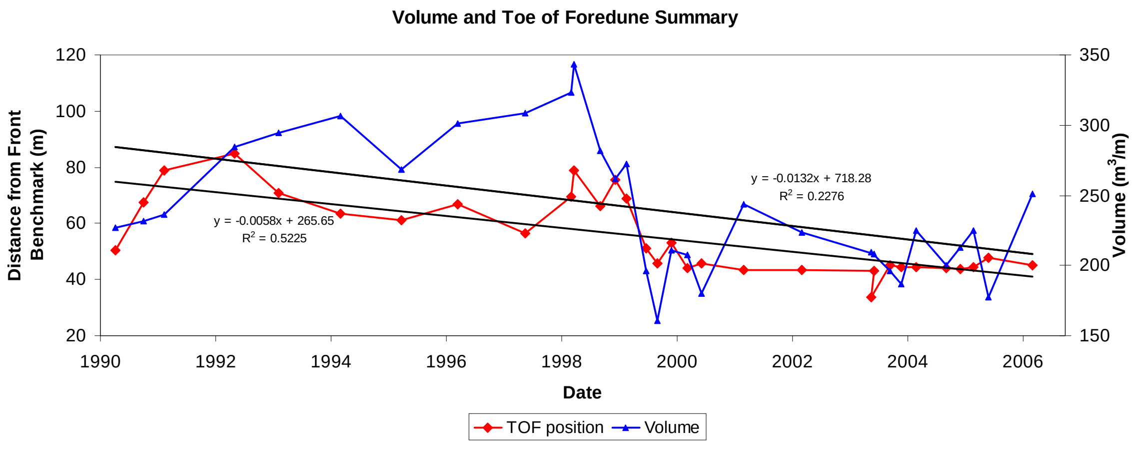
State: Erosion



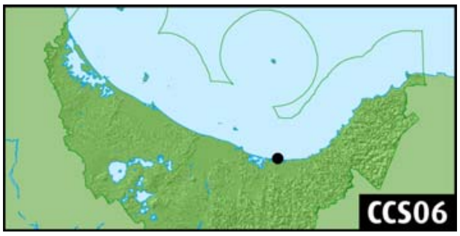
Location: NZMG 2883728E 6347934N
Period of record: 1990 – 2006
No. of profiles: 31
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.01 **TOF p-level –** 0.00







5.3.6 Waiwhakatoitoi (CCS 6)



Discussion

This site is located 300m west of the Waiotahi Surf Life Saving Club and 800m east of Waiwhakatoitoi Stream. This section of beach is bounded landward by stranded seacliffs. Historically the dune has been subject to wind erosion and overtopping. Recent photography shows a vegetated (*spinifex*) lower dune, with pockets of erosion probably caused by human activity accessing the beach from the carpark area located in the back dune.

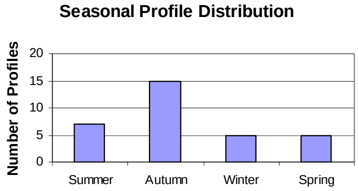
The most eroded profile was measure in February 1993 and accreted profile in March 1992 with a maximum cross shore horizontal distance variability of 39m. Maximum movement of the toe of foredune is determined to be 15m for the period of record analysed.

Offshore profiles show well developed bar and trough structures in the 1997 and 2003 measurements. Convergence occurs at -6m.

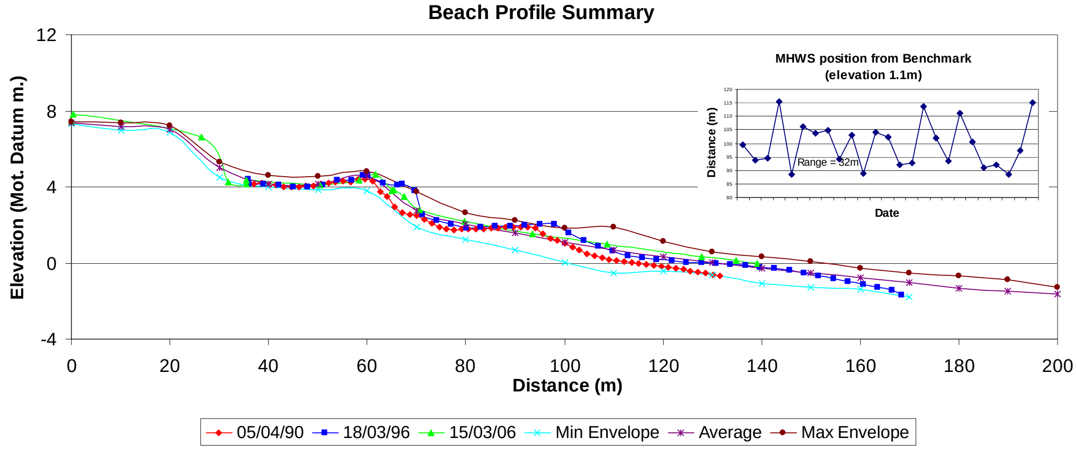
Previous studies Hodge & Deely (1997) and Gibb (1994) have reported an accretionary trend. For the period of record analysed a strong trend in the toe of foredune with a slight negative coefficient highlights a *possible erosive period recently*.

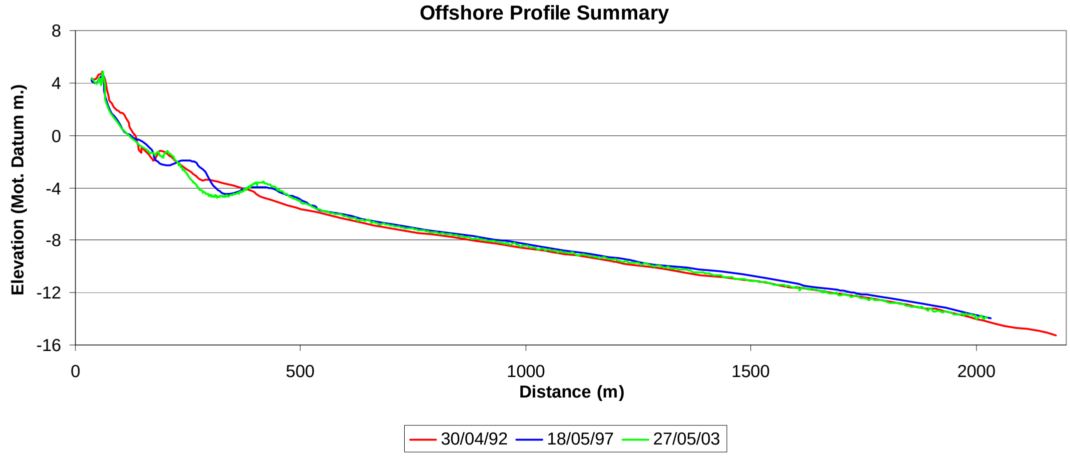
CCS 06 - Waiwhakatoitoi

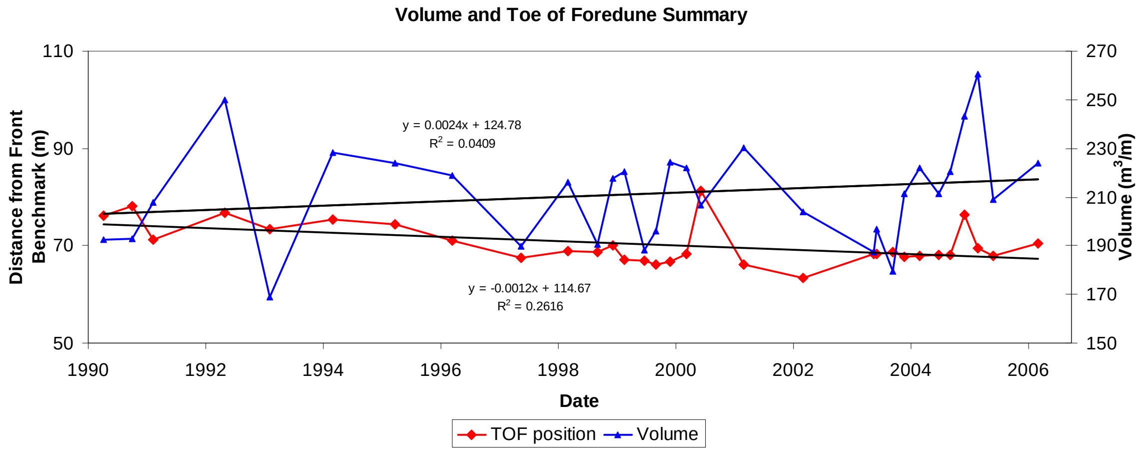
State: Erosion?



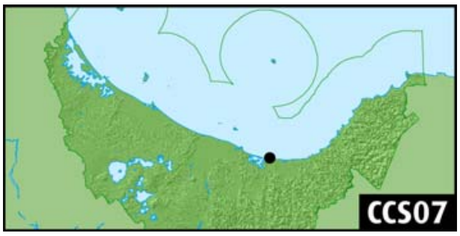
Location: NZMG 2882159E 6348004N
Period of record: 1990 – 2006
No.of profiles: 31
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.28 **TOF p-level –** 0.00







5.3.7 **Waiotahi Spit (CCS 7)**



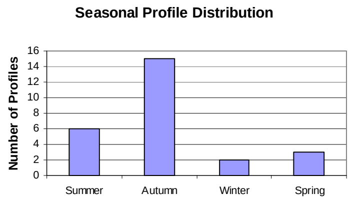
Discussion

This site is located 1.1km to the west of the Waiotahi River entrance. The Waiotahi Spit is a 2.1 km Holocene sand spit that has grown from west to east suggesting a net south easterly longshore drift. At the profile site the spit is 70m wide, the narrowest section measuring only 20m is 370m to the east of the site. The photography shows a badly eroded beach in 1978, this has reversed in the 2006 photography with a well vegetated (spinifex) new fontal dune present and a healthy reservoir of sand on the upper beach.

This dune development and elevated beach shape is reflected in the beach profile summary. The MHWS position has moved approximately 30m seaward. The 2003 offshore profile shows a multiple bar configuration, the convergence with other historical profiles occurs at 7.5m.

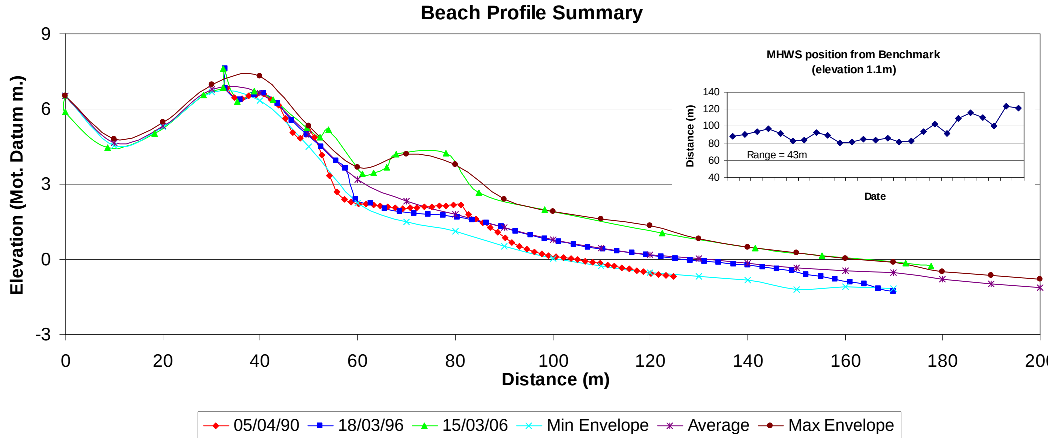
Both the volume and toe of foredune plots show similarity in their patterns of movement. The volume statistical test was strong and coupled with a positive coefficient, the trend for the reporting period is pointing towards a *period of accretion*. The result adds to the earlier work of Gibb (1994) which states a long-term trend (1867-1994) of dynamic equilibrium with short-term shoreline fluctuations of 20 to 40m for the Waiotahi Spit.

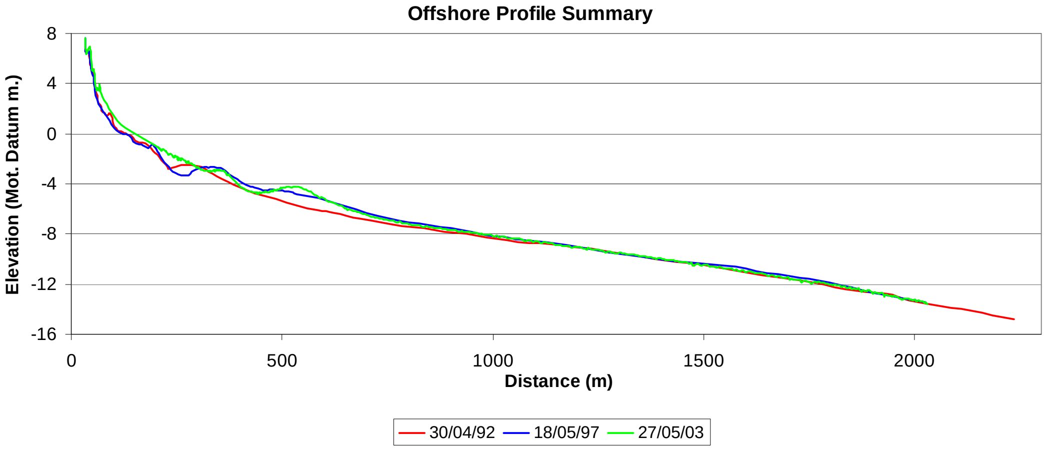
CCS 07 - Waiotahi Spit

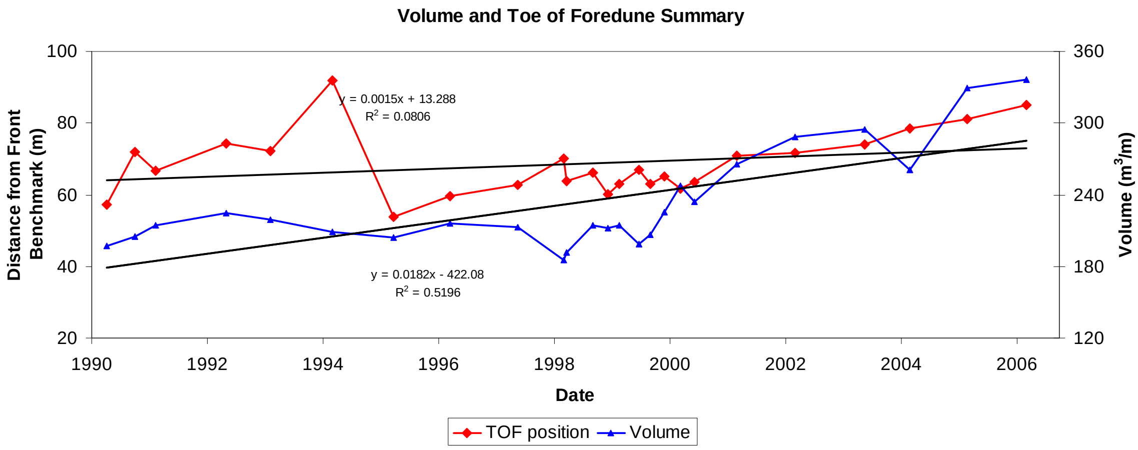


State: Accretion?

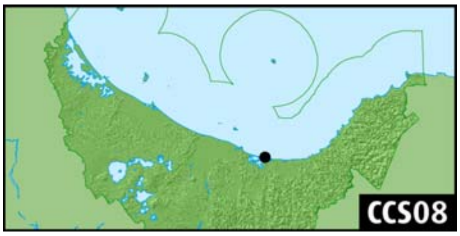
Location: NZMG 2878381E 6348325N
Period of record: 1990 – 2006
No. of profiles: 25
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.00 **TOF p-level –** 0.17







5.3.8 **Ohiwa Spit (CCS 8)**



Discussion

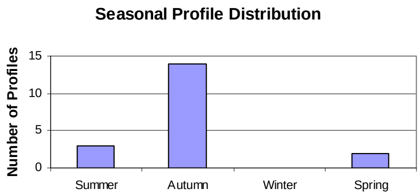
This site is located 850m to the east of the Ohiwa Harbour entrance (based on 2003 photography) on the Ohiwa Spit (Te Mawhai). Historically dwellings have been lost to erosion with the most recent episode occurring in the late 1970's. The 1978 photograph illustrates the effort that was put into halting the erosion. The beach elevation had dropped resulting in no high tide beach and a dramatically eroded dune with a 7-8m scarp in places. The 2006 photograph shows a marked reversal with a well vegetated dune system having developed.

The profile summary highlights the seaward development of a dune system at this site. The MHWS position has moved 220m seaward.

The offshore profile for 2003 shows a large accumulation of sand in the nearshore zone with multiple bars present. This area of the profile is also affected by lateral channels associated with the tidal inlet and ebb tide delta.

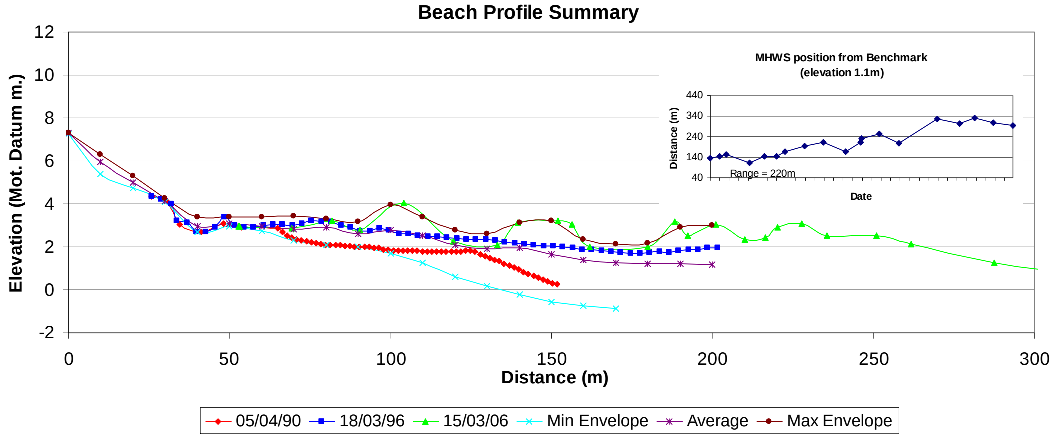
Statistical analysis gives strong results for both parameters highlighting the obvious *accretionary trend* for this period of the record. Assessing an earlier period of record, Gibb (1994) documented a long-term trend (1945-1994) of shoreline retreat of 50 to 60m, with short-term shoreline fluctuations of 100 to 150m for the Ohiwa Spit.

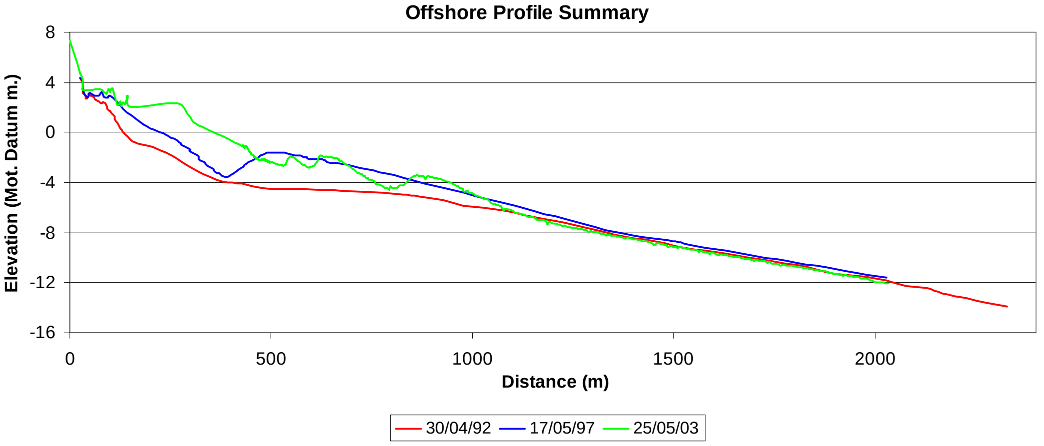
CCS 08 - Ohiwa Spit

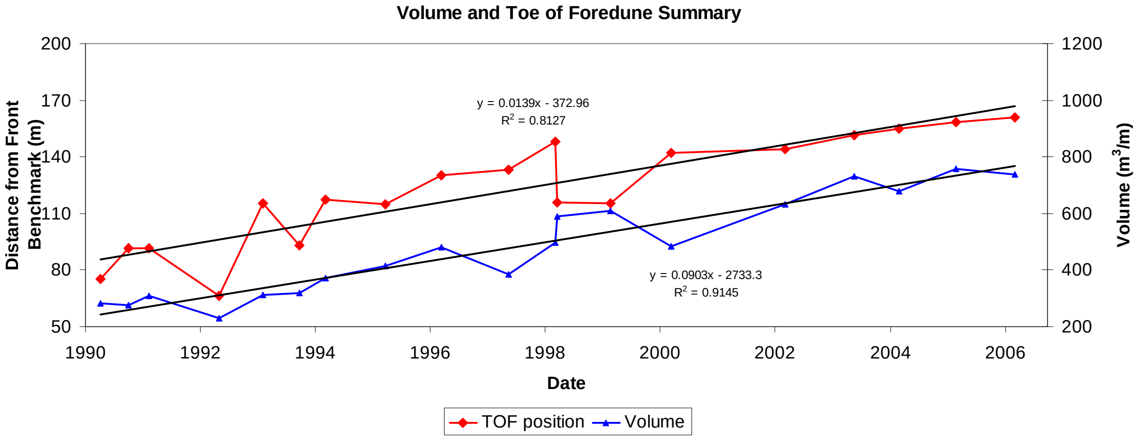


State: Accretion

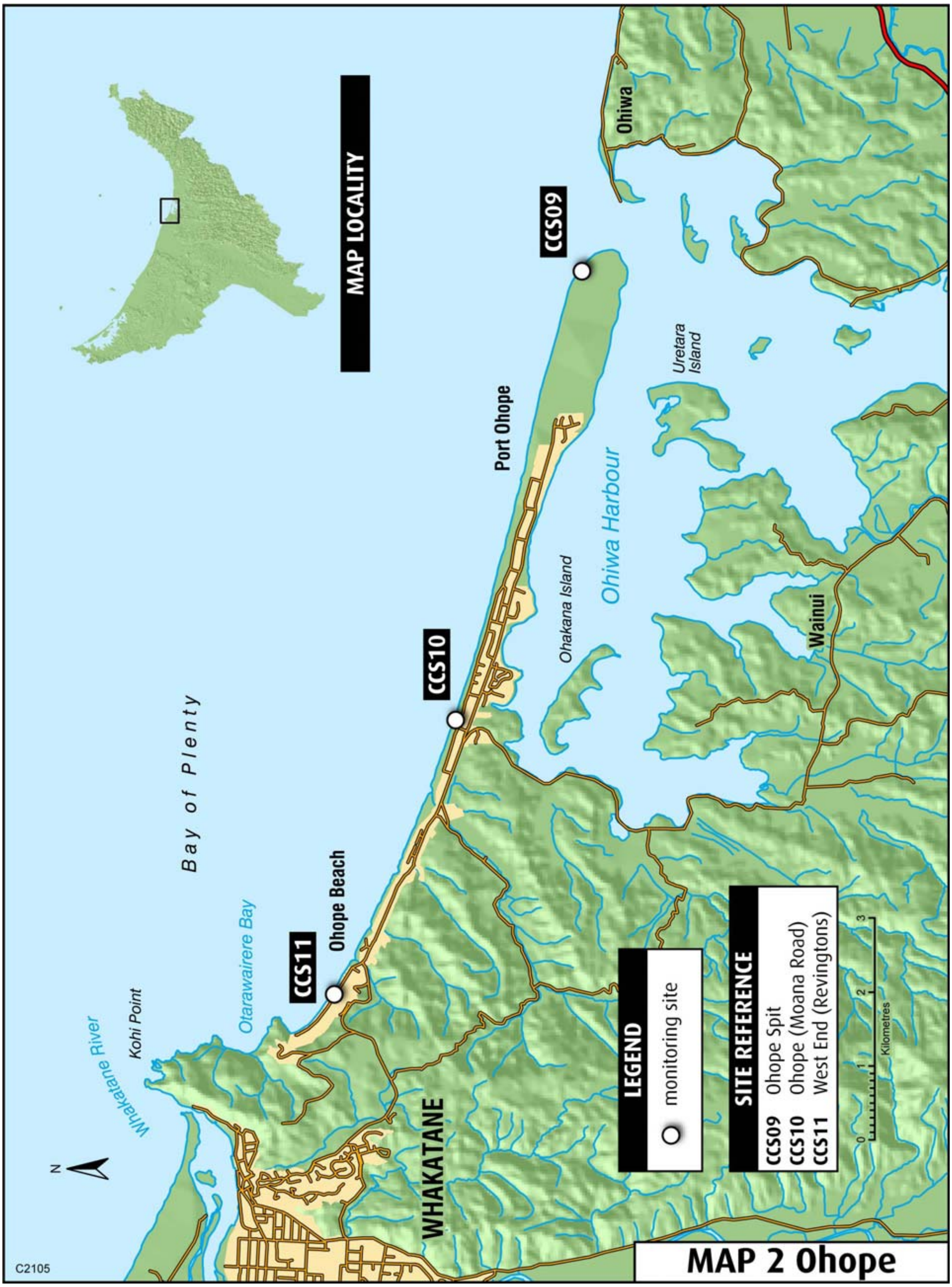
Location: NZMG 2875700E 6348676N
Period of record: 1990 – 2006
No. of profiles: 19
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.00 **TOF p-level –** 0.00



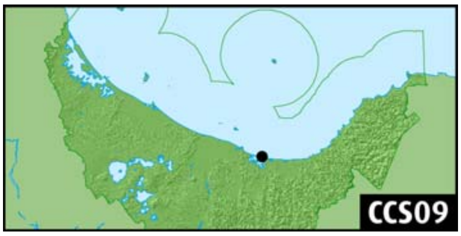




5.4 **Ohope Beach system**



5.4.1 **Ohope Spit (CCS 9)**



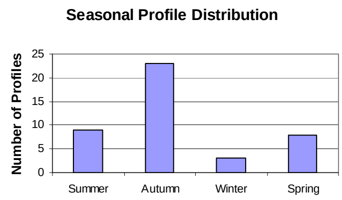
Discussion

The site is located 200m to the west of the Ohiwa Harbour entrance. The Ohope Spit evidently formed rapidly through longshore drift in the late Holocene (c. 2000 calendar years BP) Richmond et al. (1986); Beanland & Berryman (1992). Murdoch (2005) has proposed a new mid-Holocene evolutionary model. The model is based around new radiocarbon ages obtained from subsurface shells, in situ tree stumps, together with tephrochronology and investigations of buried soil horizons. The spit attained its current (historical) length by 4190 cal. yrs B.P. based on a shell date of this age near the spit's eastern end. A dominant feature is the series of six well vegetated sub parallel dune ridges that recurve on the distal eastern end towards the harbour (Julian, 2006).

Ohiwa and Ohope Spits appear to be in a state of dynamic equilibrium, as Ohiwa Spit is now in a state of strong accretion; the Ohope Spit is currently in a *state of strong erosion*. This trend is highlighted in the profile summary and the statistical analysis. Conversely, Gibb (1994) when reporting on the trend for 1944-1994 stated a shoreline advance of approximately 200m.

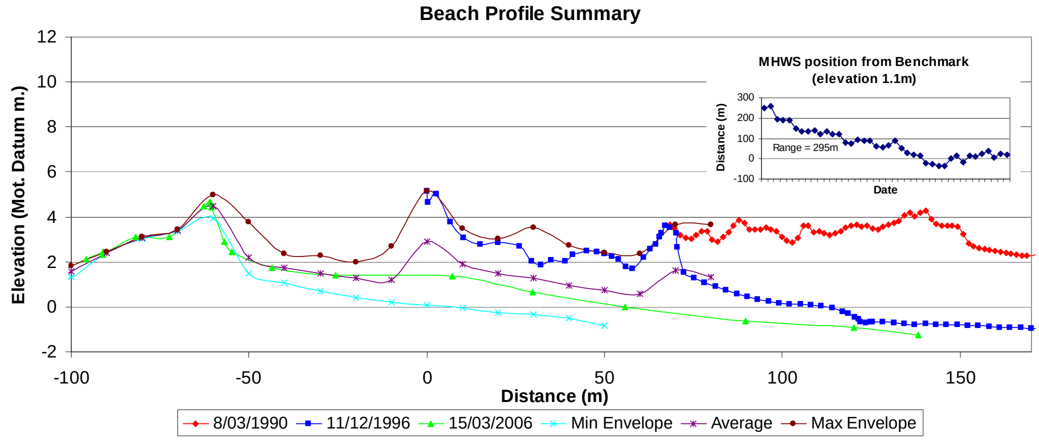
The offshore profiles show a significant loss of the sand when comparing the 2003 against the 1992 profile. A dominance of El Nino conditions (Figure 4.1) would result in an increased eastward drift and a resulting loss of material from the Ohope Spit and corresponding renourishment of the Ohiwa Spit/Bryans Beach section (as evidenced in Section 5.3.8).

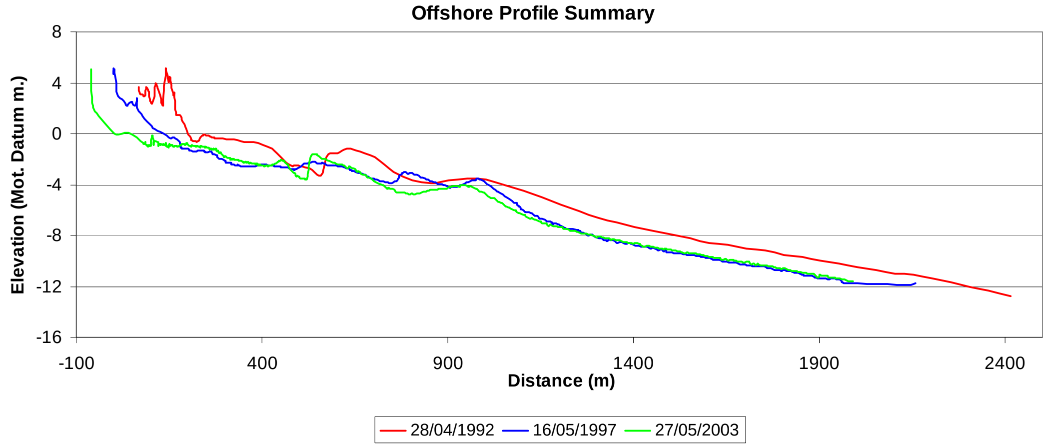
CCS 09 - Ohope Spit

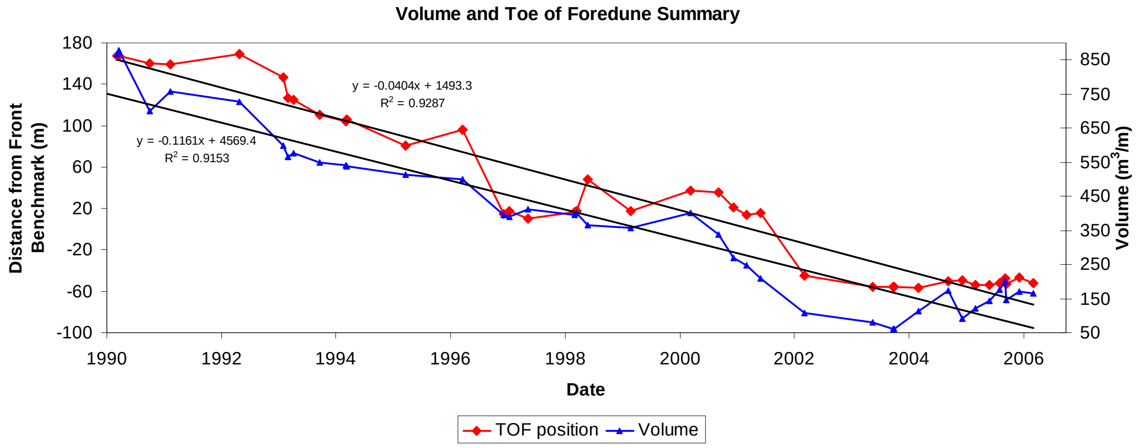


State: Erosion

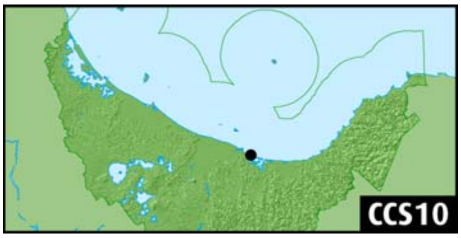
Location: NZMG 2873878E 6348979N
Period of record: 1990 – 2006
No. of profiles: 39
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.00 **TOF p-level.-.**0.00







5.4.2 Moana Street (CCS 10)



Discussion

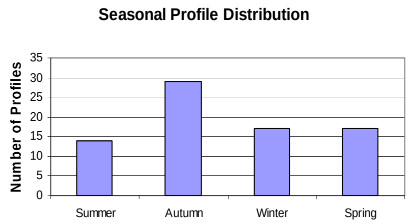
This site is located 7km from the Ohiwa Harbour entrance. Like CCS9, the photographic evidence shows that a significant landward beach position change has occurred along this section of the Spit. Faceted dune scarps exhibiting deficient vegetation growth along central Ohope Beach and Ohope Spit provide visual evidence of an actively eroding beach profile (Julian, 2006).

Investigation of the profile summary shows a landward retreat of the frontal dune at this site. This trend is supported by the MWHS plot showing a 44m horizontal range at a fixed elevation of 1.1m.

The offshore profile record shows the seaward movement of sediment and the development of a sizable offshore bar. Dissipative beaches normal do not normally exhibit marked offshore bars but in this erosive state material could well be stored some distance offshore.

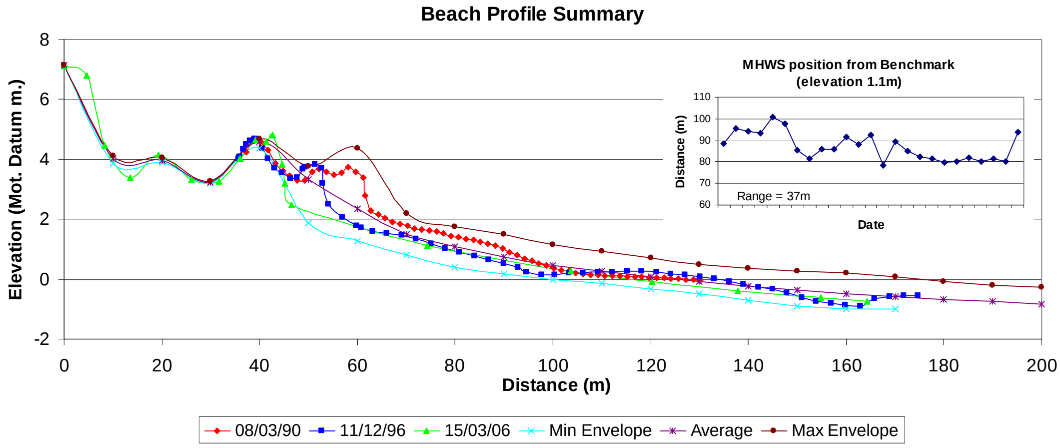
Statistical analysis of the toe of foredune position and beach volume show strong negative sloped trends indicating a *state of erosion* for this site. As with CCS9, Gibb stated a long-term trend (1944-1994) of shoreline advance of approximately 65m, ranging from 45 to 80m for this section of beach.

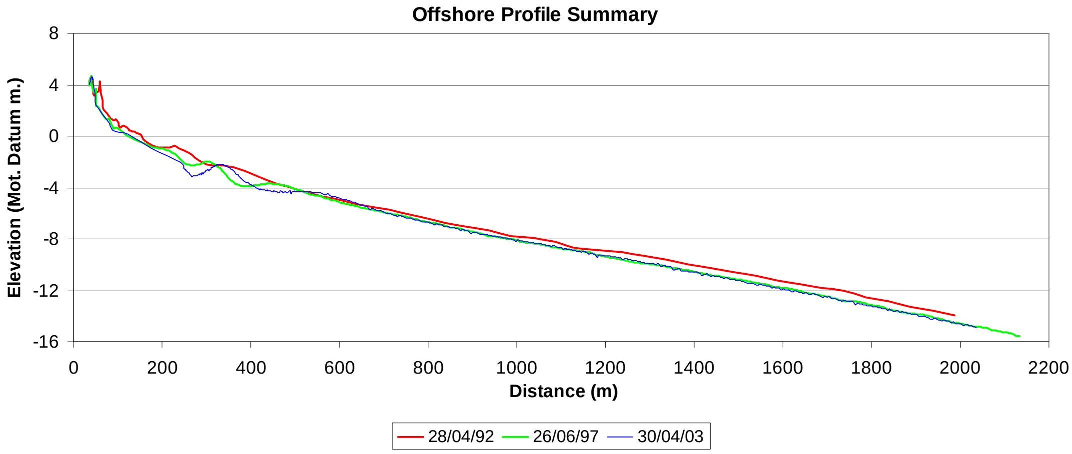
CCS 10 - Moana Street

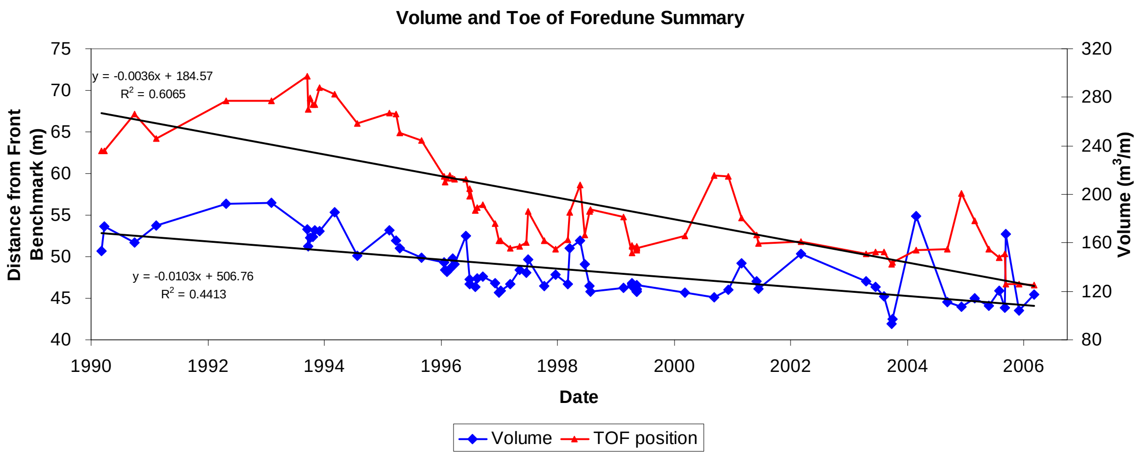


State: Erosion

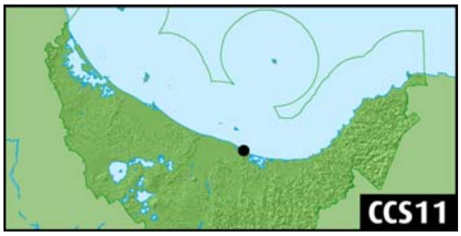
Location: NZMG 2867816E 6350682N
Period of record: 1990 – 2006
No. of profiles: 77
Morphodynamic type (Wright Short model): Dissipative
Volume p-level – 0.00 **TOF p-level –** 0.00







5.4.3 West End (CCS 11)



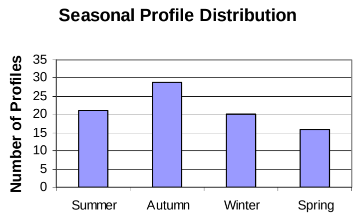
Discussion

This site is located 800m to the east of the Kohi Point headland. This section of Ohope Beach has a north-north east aspect. Steep cliffs shelter the beach from south and south easterly winds (Saunders, 1999). The photographic history shows a well vegetated low profile upper beach area. The 2006 photograph shows the effects of several significant storms and the introduction of a number of exotic vegetation species.

The profile summary shows the retreat of the frontal dune position. Most of this landward movement occurred during the three events listed in Table 3.1 (January 1996, December 1996 (Cyclone Fergus) and January 1997 (Cyclone Drena)). Not only was there a horizontal retreat measured, but also a significant reduction in beach elevation, as material was removed off the upper beach. The offshore profiles show no significant offshore bar (sand reservoir). When discounting the divergent 1992 profile (700 – 1700m offshore) the remaining two profiles converge at -6m.

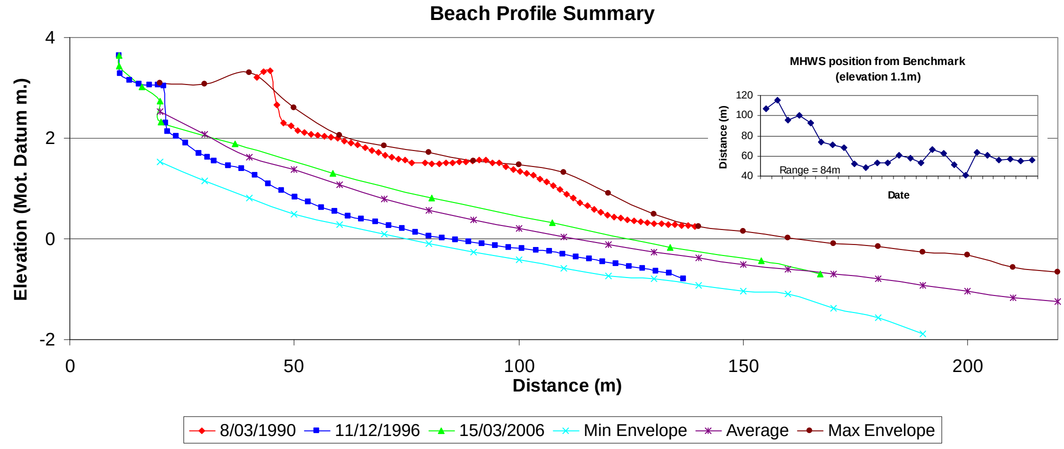
The statistical analysis shows a significant retreat in the toe of foredune position. The volume record is markedly different for the period 1999 to 2003 when there was significant vertical growth in the beach profile. The state proposed for this site is *heading toward erosion*. As with the other Ohope Beach sites, Gibb (1994) when analysing an earlier period of record calculated a long-term trend (1944-1994) of shoreline advance of approximately 15m for this section of beach.

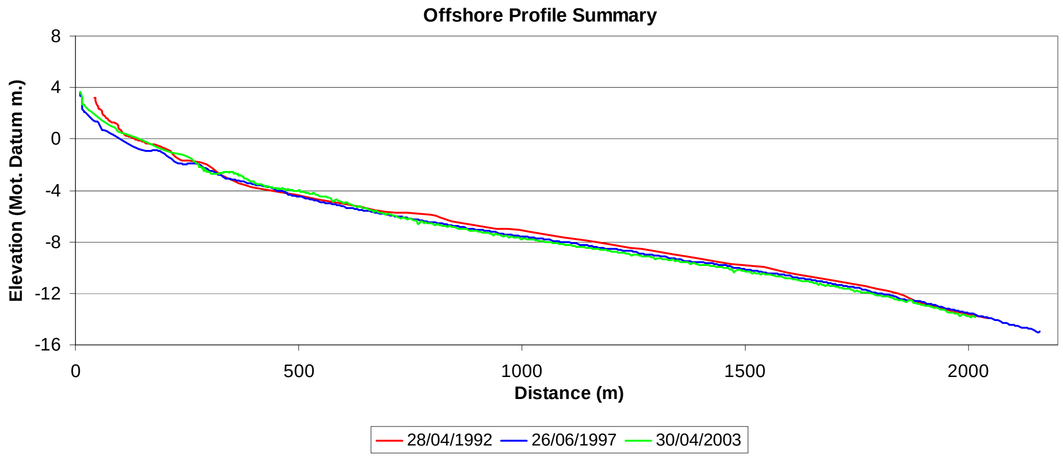
CCS 11 - West End

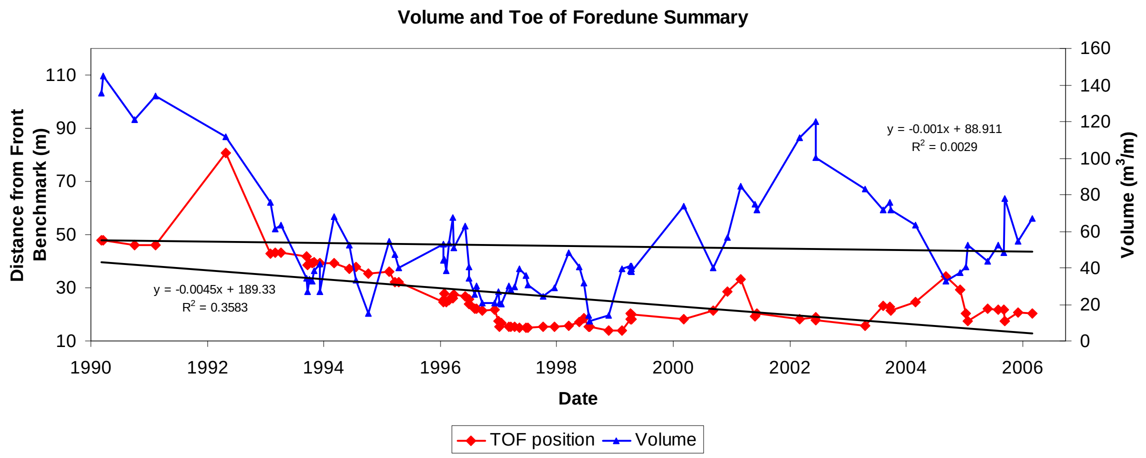


State: Erosion?

Location: NZMG 2864107E 6352323N
Period of record: 1990 – 2006
No. of profiles: 85
Morphodynamic type (Wright Short model): Dissipative
Volume p-level – 0.91 **TOF p-level –** 0.00

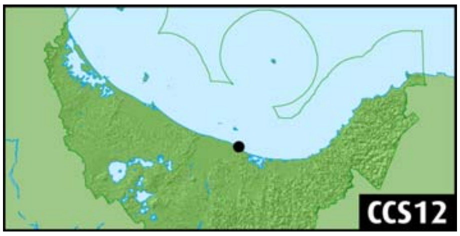






5.5 Thornton Beach system

5.5.1 **Whakatane Spit (CCS 12)**



Discussion

This site is located 700m to the west of the Whakatane River entrance. Healy (1983) used old survey plans and aerial photography to determine the movements of the Whakatane Spit. The analysis suggests the spit has been is a state of dynamic equilibrium since 1923.

The profile record shows a significant change for the period 1990 to 1996, during this period the section volume has been increasing at a rate of ~26m^3/m/year with a shoreline advance of ~8m/year.

The offshore profiles measured in 1997 and 2003 show stability in the nearshore zone, this pattern turns to marked deposition in the zones, 600-1200m and 1400-1800m offshore. The upper elevation of these two deposition lobes matches the profile measured in 1992. This deposition would be the result of pulses of sediment supplied to the coast from the Whakatane River during periods of elevated flow.

The statistical tests performed on the volume and toe of foredune datasets didn't meet the significance level, hence a *state of stable* has been proposed for this site.

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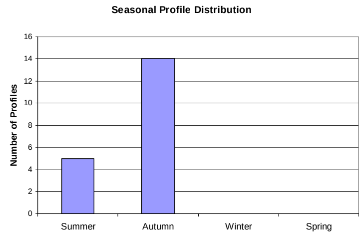
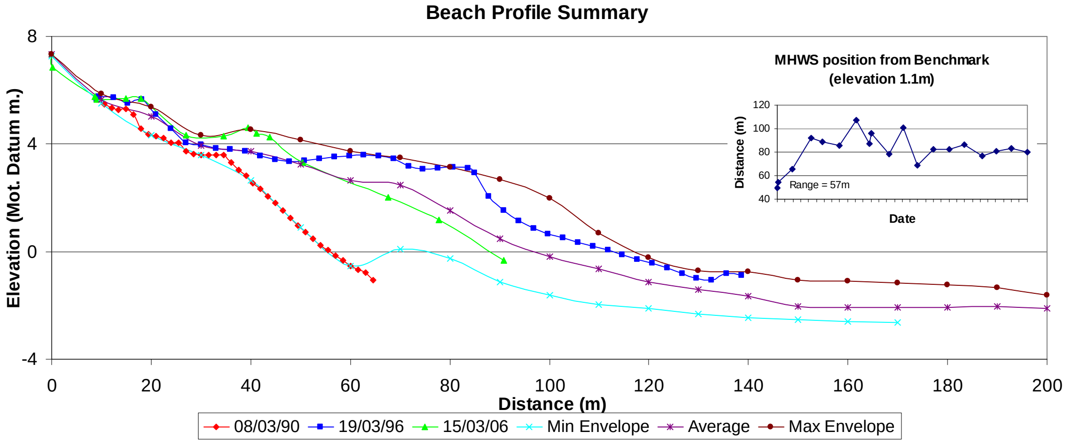
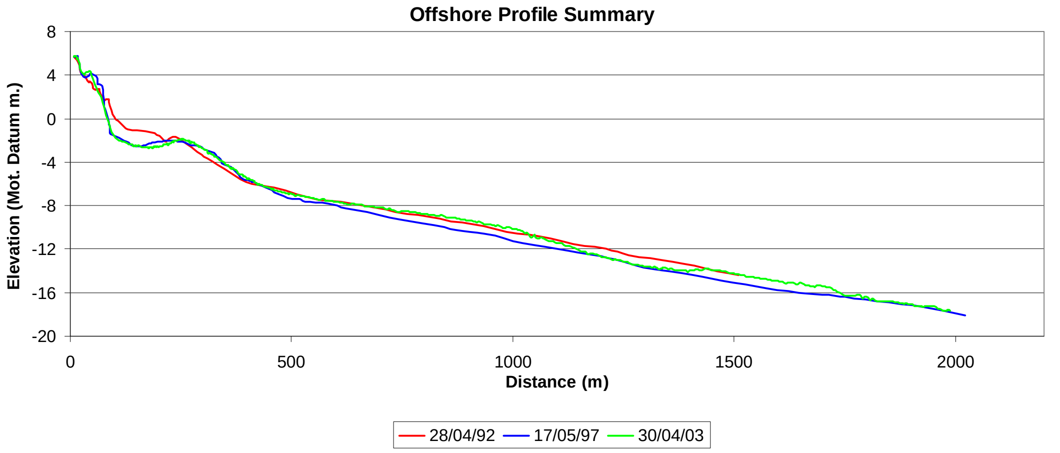
CCS 12 - Whakatane Spit

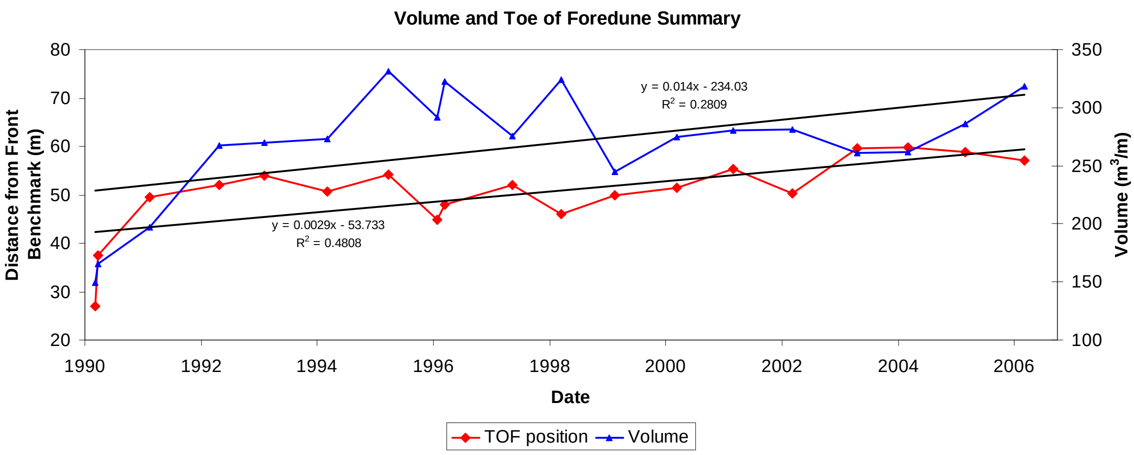


State: Stable

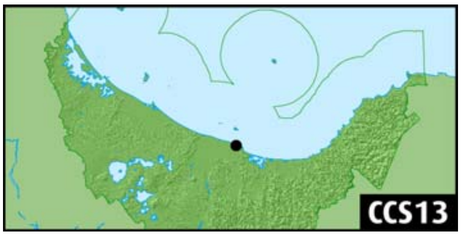
Location: NZMG 2861755E 6354371N
Period of record: 1990 – 2006
No. of profiles: 19
Morphodynamic type (Wright Short model): Transverse Bar and Rip
Volume p-level – 0.02 **TOF p-level –** 0.00







5.5.2 **Piripai (CCS 13)**



Discussion

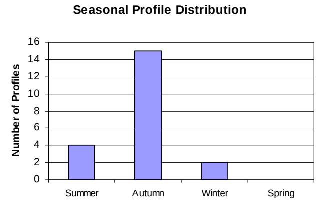
This site is located at the end of Ohuirehe Road, 2.8km to the west of the Whakatane River entrance. A rate of shoreline advance of 0.3m/yr since the Tarawera eruption in 1886 was reported by Pullar & Selby (1971). Gibb (1994) reported toe of foredune advance for the period 1944 to 1994. Healy (1976a) considered that progradation had ceased at Piripai and that the most dominant trend in the last 30 years was for net erosion with the greatest retreat occurring within minor embayment's that change their location along this section of beach (Tonkin & Taylor, 2002).

The profile summary shows the development of an incipient dune which is well vegetated (see Photograph 2006) with *spinifex*.

The offshore profiles show a variety of patterns. The 1992 profile has no offshore bar present, investigation of the onshore profile shows it to be in a eroded state. This lack of offshore bar is common to both adjacent sites signalling an erosion state for this section of beach pre 1992.

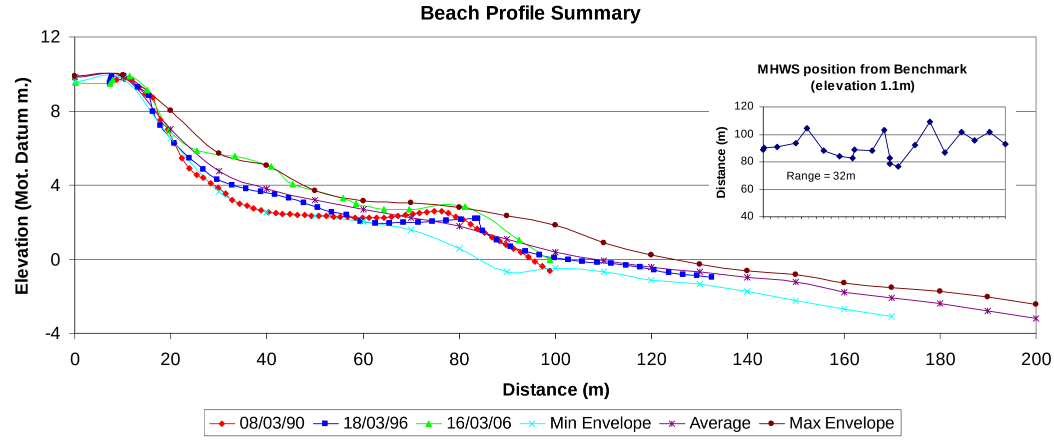
Statistical analysis shows a significant trend in the volume data set. The trend of the toe of foredune dataset is not as strong and hence a *trend towards accretion* has been proposed for this site for the period of record 1990 to 2006.

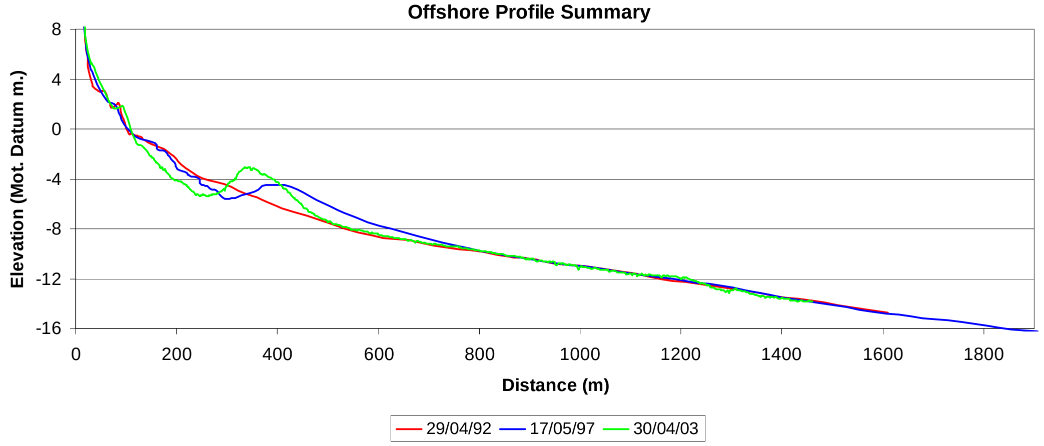
CCS 13 - Piripai

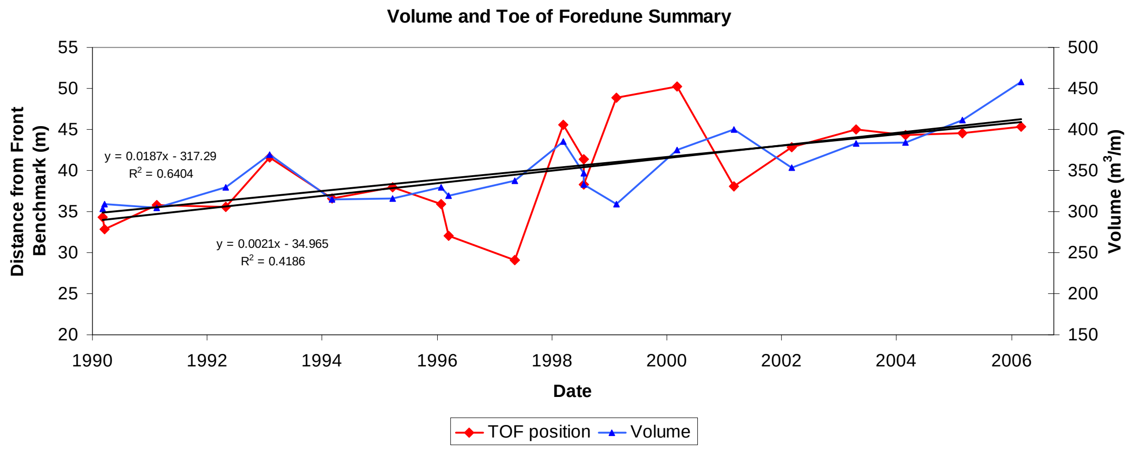


State: Accretion?

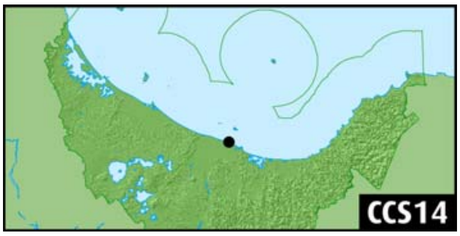
Location: NZMG 2859819E 6355350N
Period of record: 1990 – 2006
No.of profiles: 21
Morphodynamic type (Wright Short model): Transverse Bar and Rip
Volume p-level – 0.00 **TOF p-level –** 0.02







5.5.3 Golf Links Road (CCS 14)



Discussion

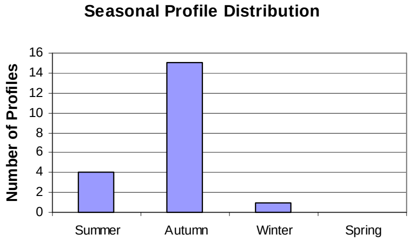
This site is located at the end of Golf Links Road, 700m east of the apex of the eastern cuspate foreland caused by wave refraction around Moutohora (Whale) Island (7km offshore). Aerial photography (2003) shows the back dune area is punctuated with a network of 4 wheel drive tracks. This dune system is approximately 50m wide. Both photographs exhibit a low frontal dune with a sparsely vegetated face. The 2006 photograph highlights a storm debri line at the base of the frontal dune.

The profile summary shows the latest profile exhibiting loss in the lower and mid beach areas when compared with the average. The accumulation in the 2006 profile on the crest of the dune is probably the result of the survey not undertaken on the benchmark orientated shore normal line.

The offshore profile shows a similar pattern to that exhibited at CCS13. A small poorly defined bar is present in 1992, contrasted by well developed bar/trough structures in 1996 and 2003.

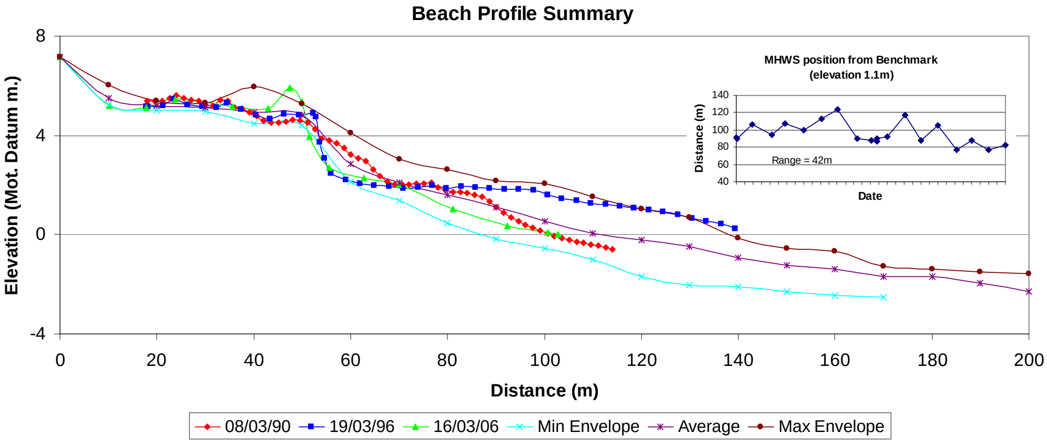
The volume and toe of foredune chart shows a seaward movement of the toe from 1992 to 1996 but since then the position of this feature has been moving landward (approximately 20m). The trend in the volume is not as strong which exhibits variation around a shallow sloping trend line. The proposed trend for this period of record is a *movement towards erosion*.

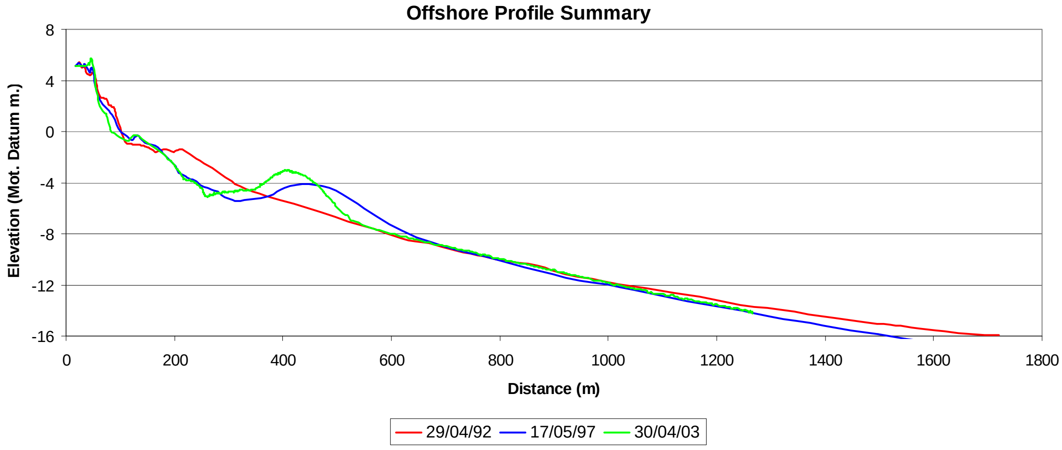
CCS 14 - Golf Links Road

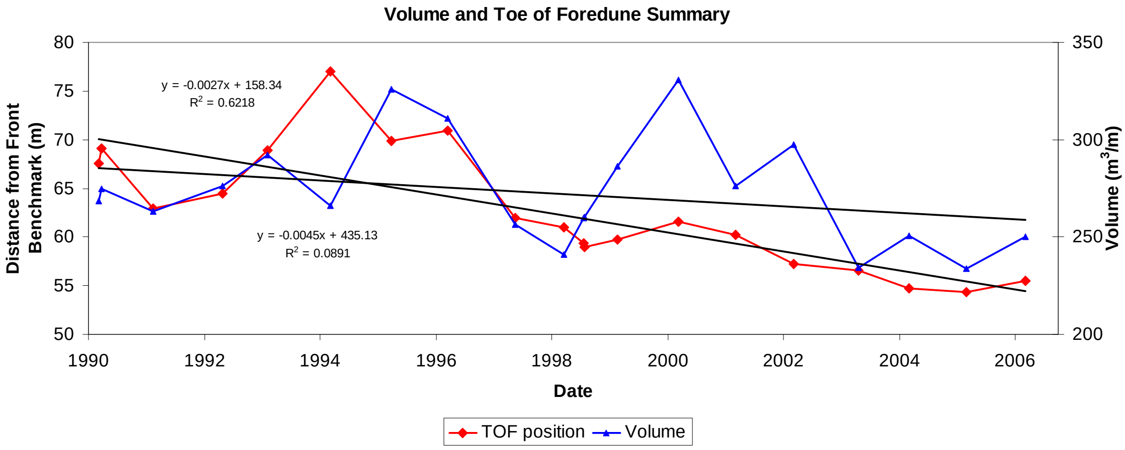


State: Erosion?

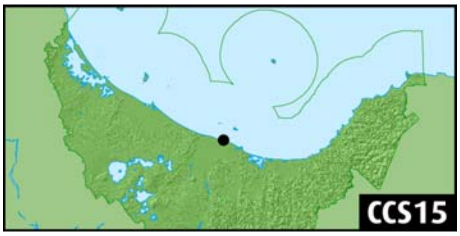
Location: NZMG 2856683E 6357038N
Period of record: 1990 – 2006
No. of profiles: 20
Morphodynamic type (Wright Short model): Low Tide Terrace
Volume p-level – 0.20 **TOF p-level –** 0.00







5.5.4 **Airport (CCS 15)**



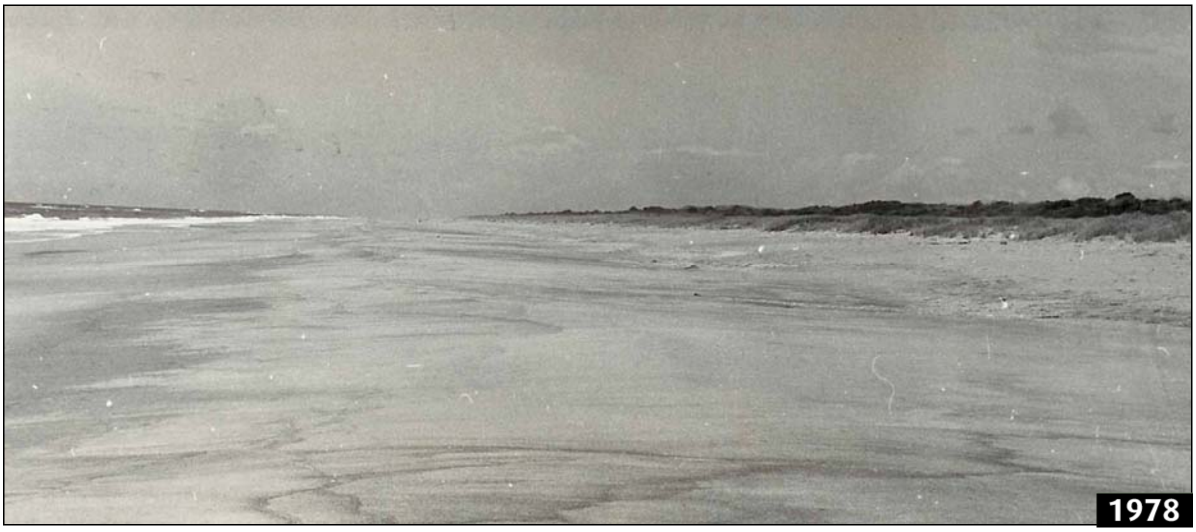
Discussion

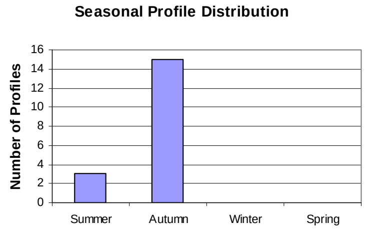
This site is located 2.3 km east of the Rangitaiki River entrance. This section of coast (which includes CCS14), located in the lee of Moutohora (Whale) Island, shows long term progradation due to the wave shadow effect from the island and sediment supply from both Whakatane and Rangitaiki rivers (note the Rangitaiki River sediment contribution has diminished since the construction of the mid catchment Matahina Dam, commissioned in the late 1960's).

The profile summary shows a landward retreat of the foredune for the period of record. The 2006 profile mimics the average for the mid and lower beach sections. The 1996 profile shows seaward development of the frontal dune. The MHWS position shows a horizontal variation of 26m during the period of monitoring.

The offshore profile record show offshore bar and trough features in the 1992 and 1997 profiles. These features have disappeared in the 2003 survey.

The statistical analysis shows no significant trend in the volume record. The toe of foredune position shows a significant negative trend for this site. The state for this site has been proposed as a *trend towards erosion* for the period of record. Gibb (1994) gave the following summary for this section of beach - long-term trend (1944-1994) of shoreline advance of approximately 55m, ranging from 33 to 77m, with short-term fluctuations of 30 to 40m.

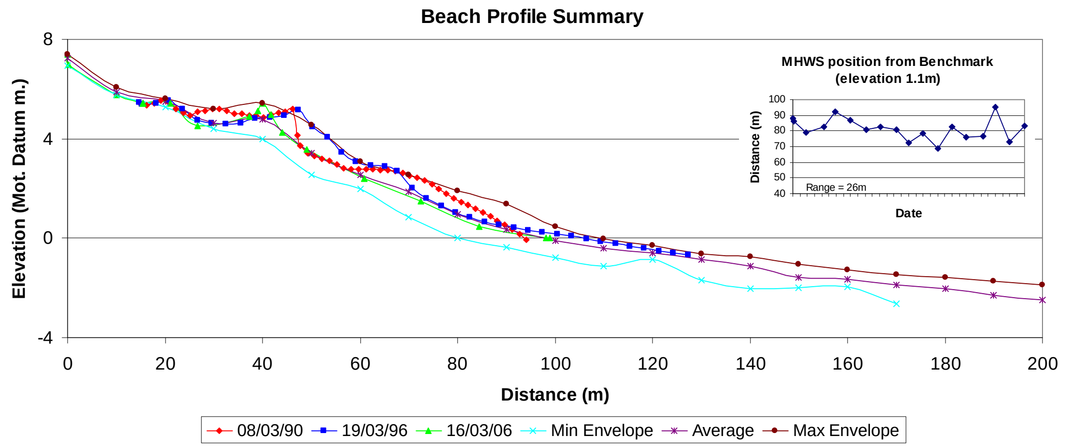


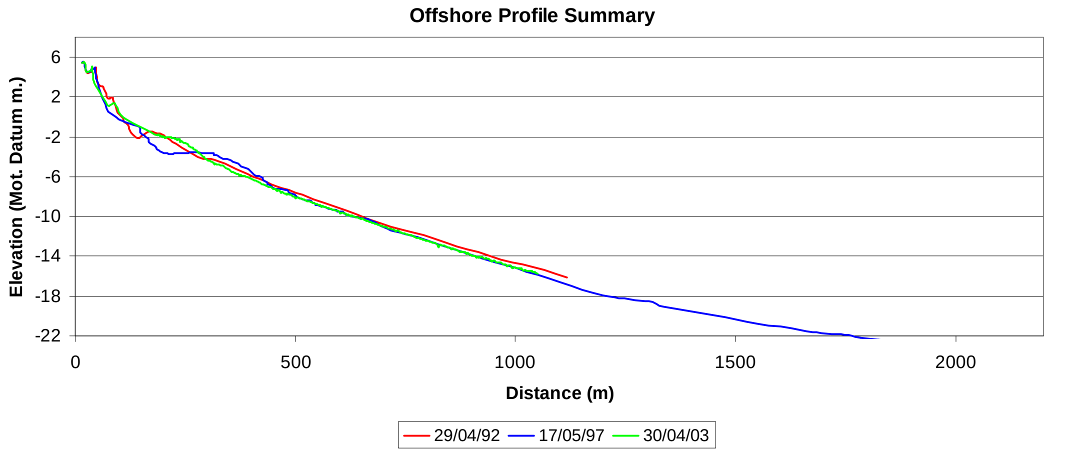


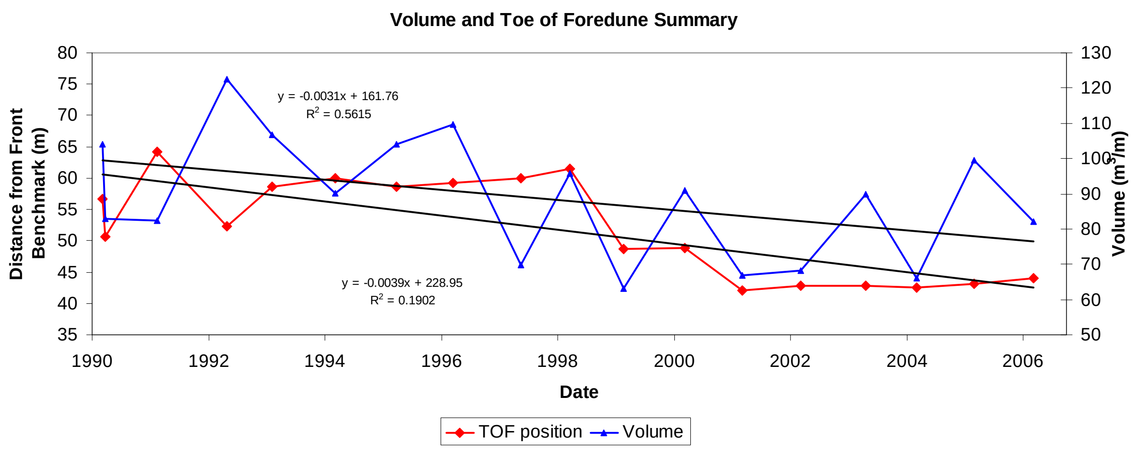
CCS 15 - Airport

State: Erosion?

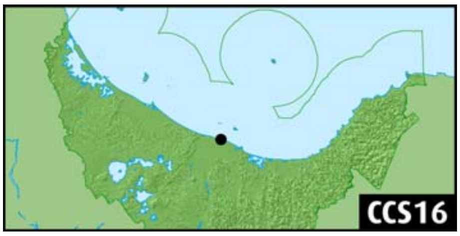
Location: NZMG 2853588E 6357978N
Period of record: 1990 – 2006
No.of profiles: 18
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.07 **TOF p-level –** 0.01







5.5.5 **Rangitaiki East (CCS 16)**



Discussion

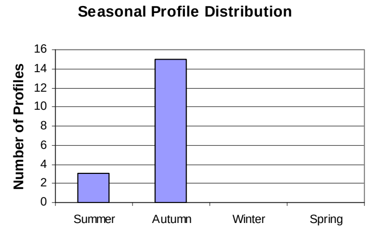
This site is located 850m to the east of the Rangitaiki River entrance. At this site the dune system width is approximately 100m wide and is backed by the Thornton Lagoon. A network of 4 wheel drive vehicle tracks is also present surrounding this site. Early photography shows a well developed berm and a moderately vegetated frontal dune (some areas of wind erosion is present). The 2006 photograph shows a similar vegetation state and a storm debris line at the base of the frontal dune.

The profile record shows a landward retreat of the steep faceted dune face between 1990 and 1996. This has reversed with the 2006 profile showing redevelopment of the frontal dune in a seaward position.

The offshore profiles all exhibit bar and trough structures. The position of landward edge of the offshore bar has varied by up to 200m. Initial convergence occurs at -8m.

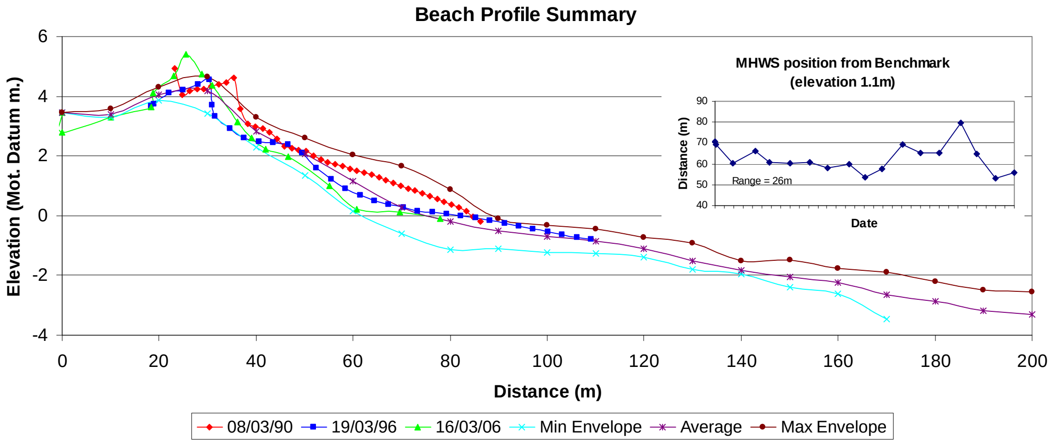
The statistical test shows no trend for either of the reported parameters. This site has determined *stable* for the period of record. Gibb (1994) stated a long-term trend (1922-1994) of shoreline advance of 45 to 120m, largely from training of the river mouth, with short-term fluctuations of 30 to 40m for this section of beach.

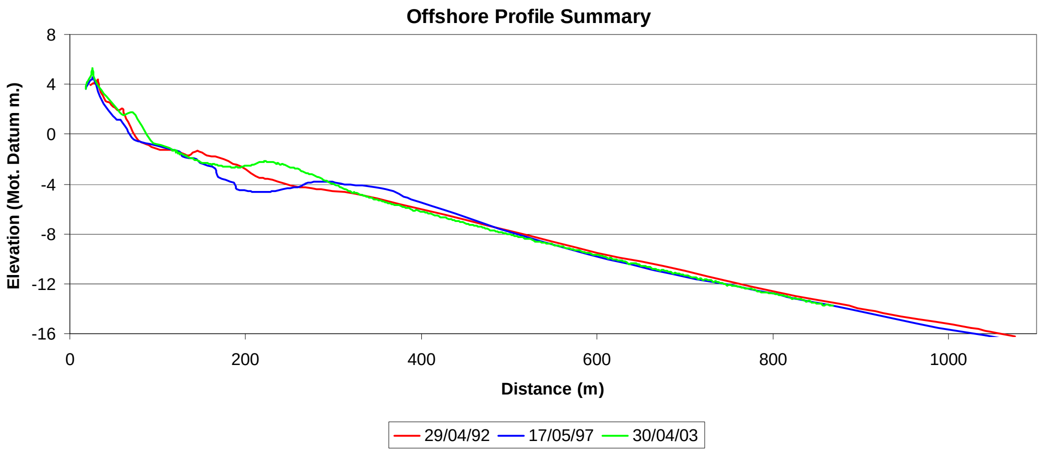
CCS 16 - Rangitaiki East

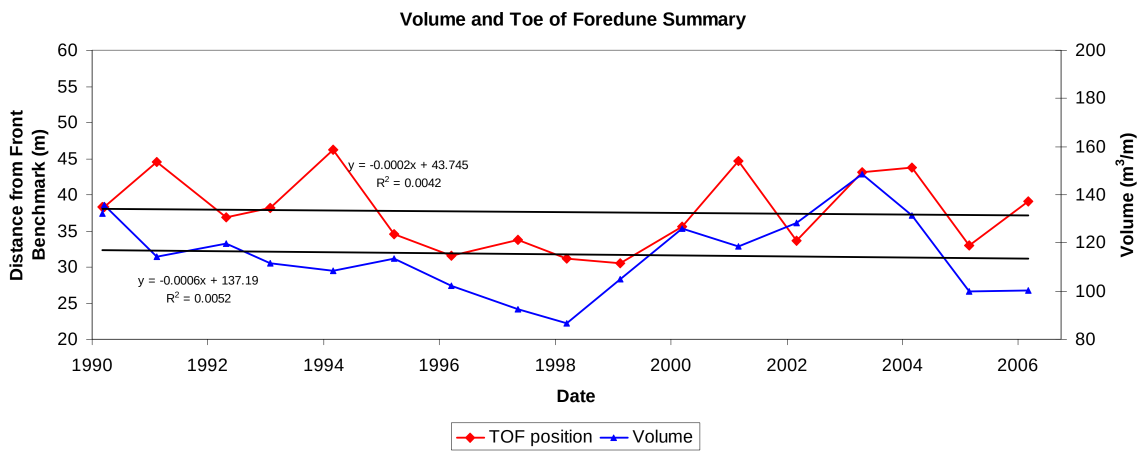


State: Stable

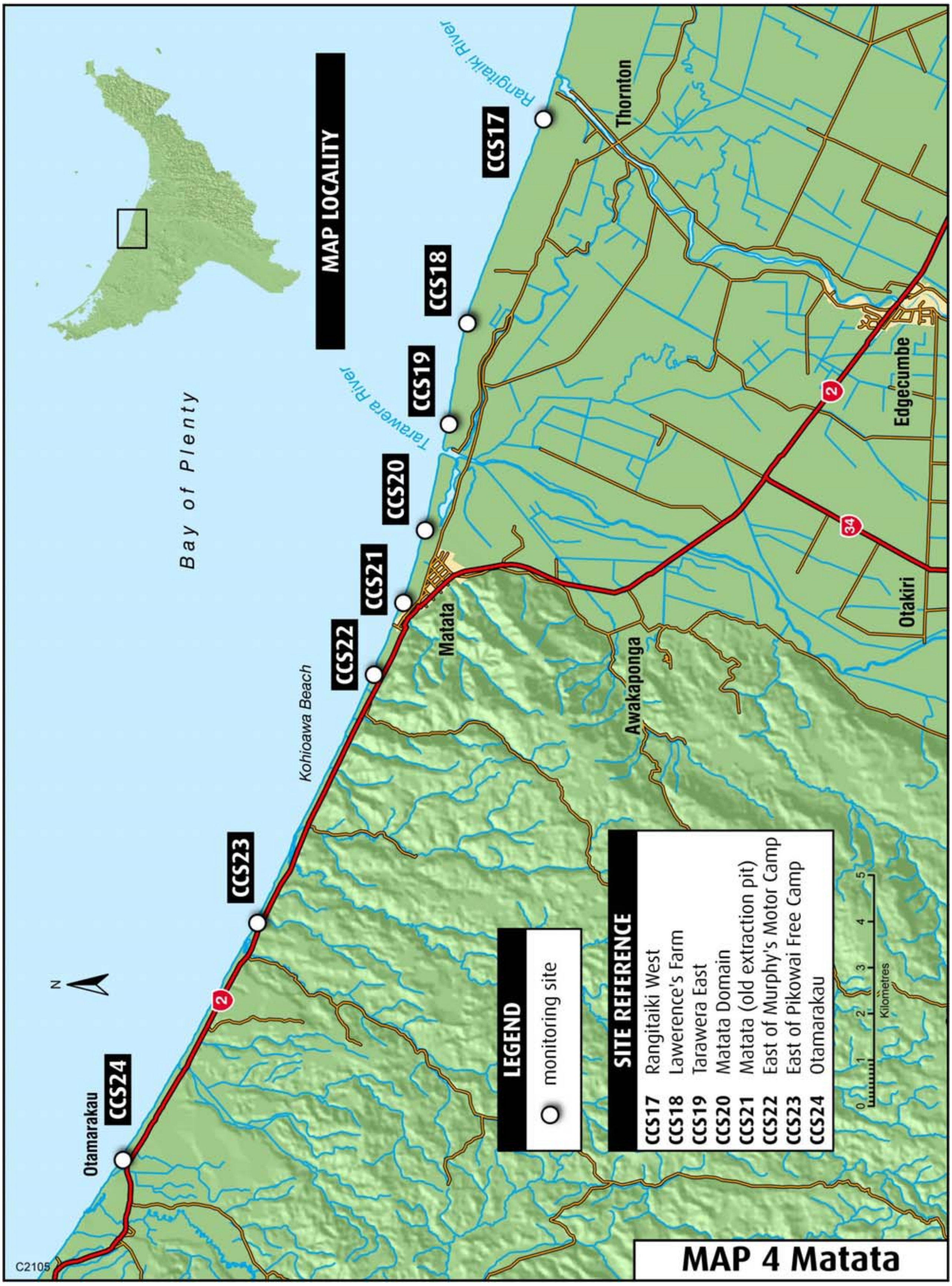
Location: NZMG 2852261E 6358320N
Period of record: 1990 – 2006
No. of profiles: 18
Morphodynamic type (Wright Short model): Transverse Bar and Rip
Volume p-level – 0.78 **TOF p-level –** 0.80



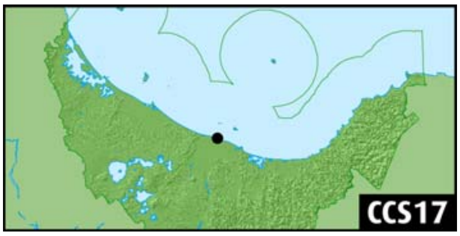




5.6 Matata Beach system



5.6.1 **Rangitaiki West (CCS 17)**



Discussion

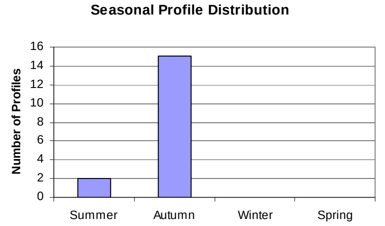
This site is located 900m to the west of the Rangitaiki River entrance. The early photography shows a well developed berm and wide upper beach area. The 2006 photograph shows profile with no prominent berm and a moderately vegetated fore dune.

The beach profile examples show the beach to be in an erosive state at the time of the 1990 profile with a significant loss of material from the entire profile. The vertical scarp is also present at this time. The later profiles (1996 and 2006) show a rejuvenated beach profile with both vertical and horizontal accumulation of sand. The 2006 profile shows the development of incipient dunes.

The offshore profile (1992) shows that during the early period of record the material that had been lost from the onshore beach profile was deposited in a zone 100 to 200m offshore in the form of several bars. The latter two profiles (1997 and 2003) show this material has moved (onshore) and is reflected in the healthier state of the profiles of the onshore section.

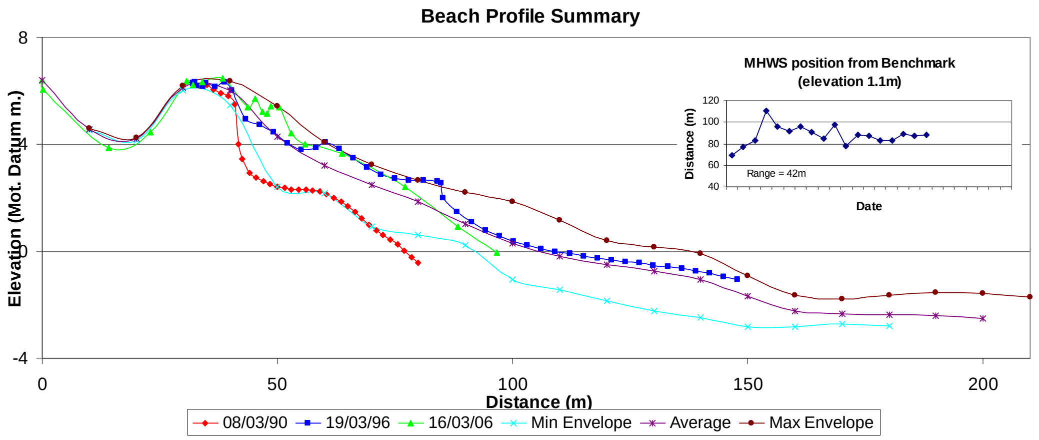
A beach state of *stable* has been determined for this site. Gibbs (1994) states that for this section of beach the long-term trend (1944-1994) of shoreline advance of approximately 50m, ranging from 40 to 62m, with short-term fluctuations of 20 to 30m was determined.

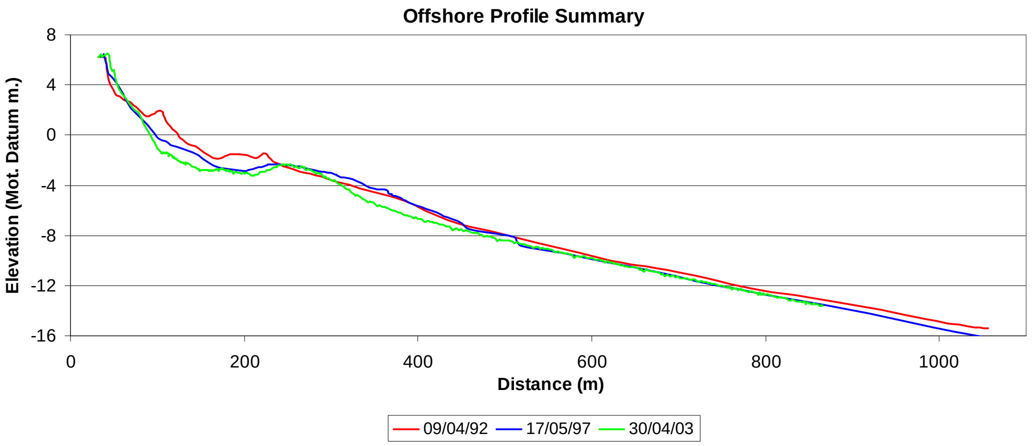
CCS 17 - Rangitaiki West

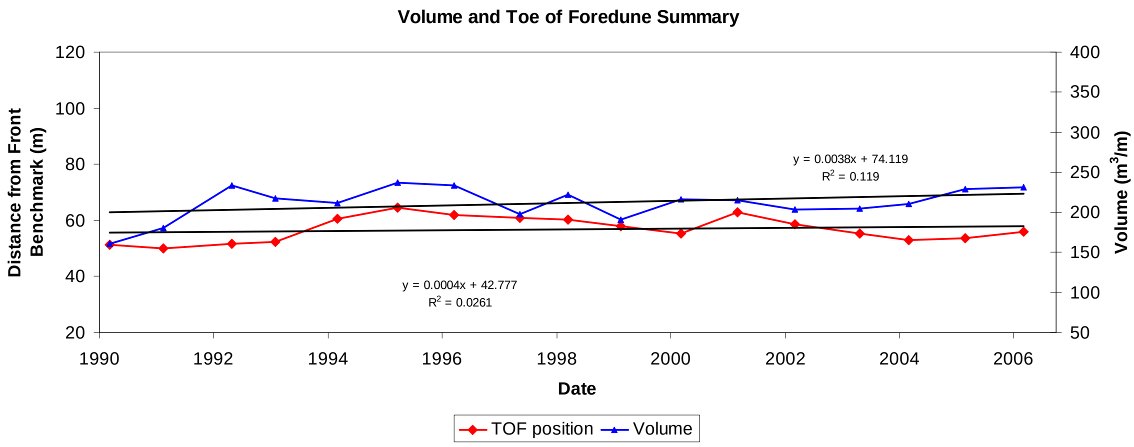


State: Stable

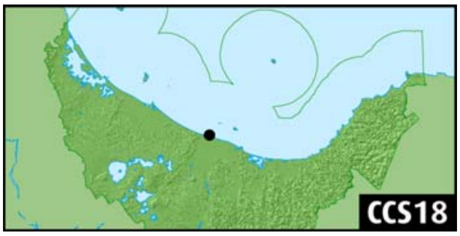
Location: NZMG 2850497E 6358840N
Period of record: 1990 – 2006
No. of profiles: 17
Morphodynamic type (Wright Short model): Transverse Bar and Rip
Volume p-level – 0.18 **TOF p-level –** 0.89







5.6.2 **Lawrences (CCS 18)**



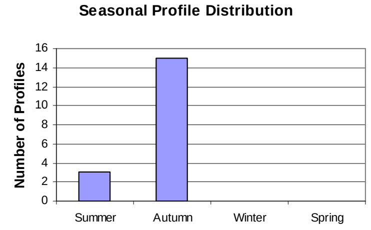
Discussion

This site is located 2.8km east of the Tarawara River entrance and on the crest of the western cuspate foreland feature. The 2006 photograph shows a well vegetated dune system, a developing (incipient) foredune has well developed *spinifex* vegetation. Aerial photography shows two well developed 4 wheel drive tracks through both the frontal and back dune system.

The profile dataset shows only slight variation in the profile shape for the period of monitoring. The MHWS shows a range of 17m of horizontal movement for this cross section. The offshore profiles show a well developed offshore bar in the zone 400-500m offshore. The point of convergence of the three measured profiles is determined at -7.5m.

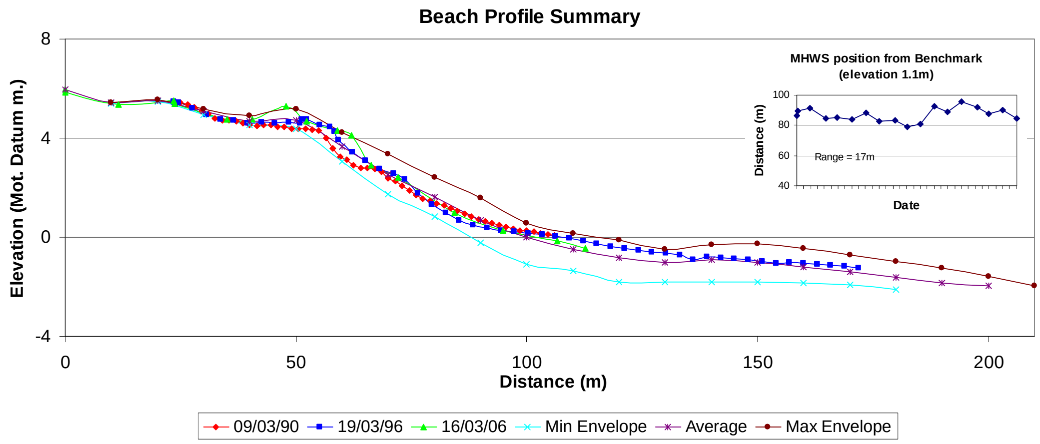
The toe of foredune and volume datasets show *stable* trends for this section. Tonkin and Taylor (2002) concluded that a conservative estimate of the current rate of shoreline advance is in the order of 1.2m/yr.

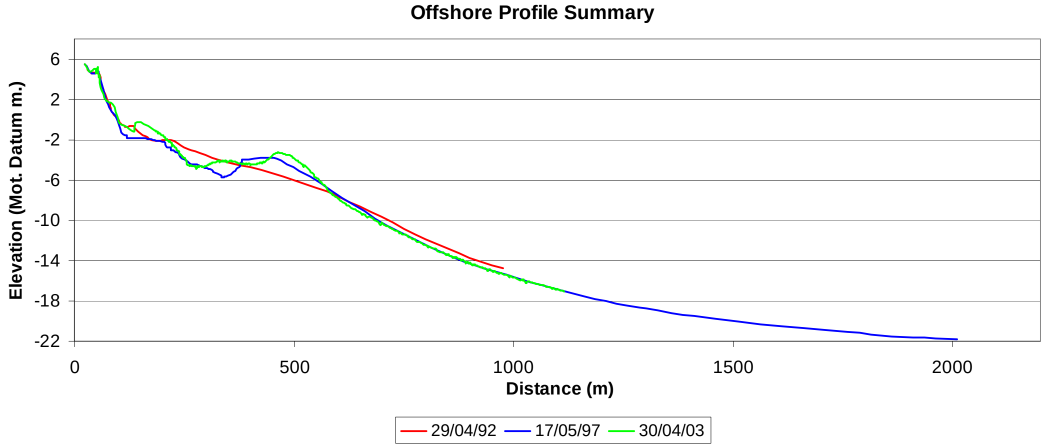
CCS 18 - Lawrences

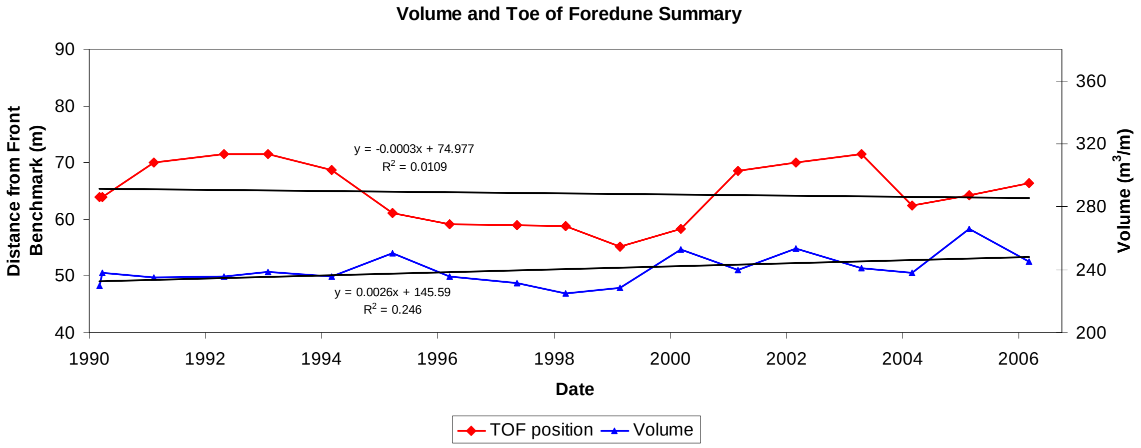


State: Stable

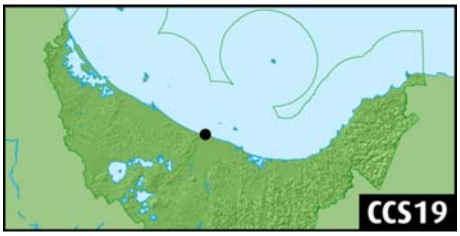
Location: NZMG 2846095E 6360481N
Period of record: 1990 – 2006
No. of profiles: 18
Morphodynamic type (Wright Short model): Transverse Bar and Rip
Volume p-level – 0.04 **TOF p-level –** 0.68







5.6.3 **Tarawera East (CCS 19)**



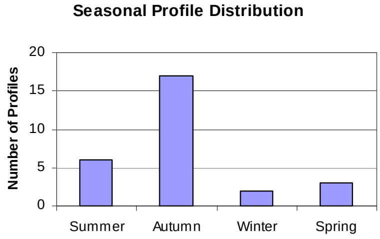
Discussion

The site is located 600m to the east of the Tarawera River entrance. This section of beach is influenced by the changing position of the river mouth. The foredune width ranges from 30 to 40m. The photography shows a well vegetated frontal dune system. This site is located at a section of beach where 4 wheel drive access is common.

The beach profile records shows strong vertical development from 1990 to 2006. Even in a depleted state the profile exhibits a berm feature. The two early offshore profiles show no significant offshore bar structure present. This pattern changes in the 2003 profile with two significant deposition areas. The profiles converge at -7m and flatten further at -15m (1200m offshore) probably as a result of the deposition fan (ebb delta) generated by sediment from the Tarawera River.

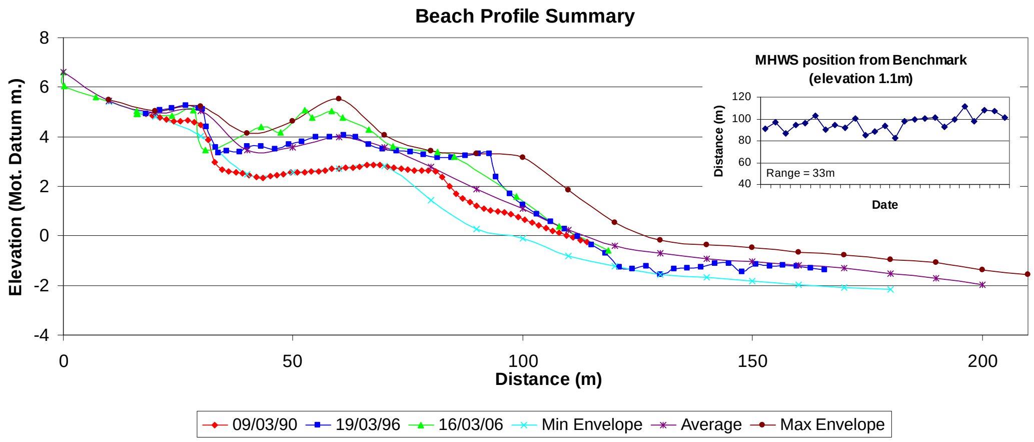
The linear regression analysis shows a significant trend in the volume record, so a state *tending towards accretion* has been defined for this period of record.

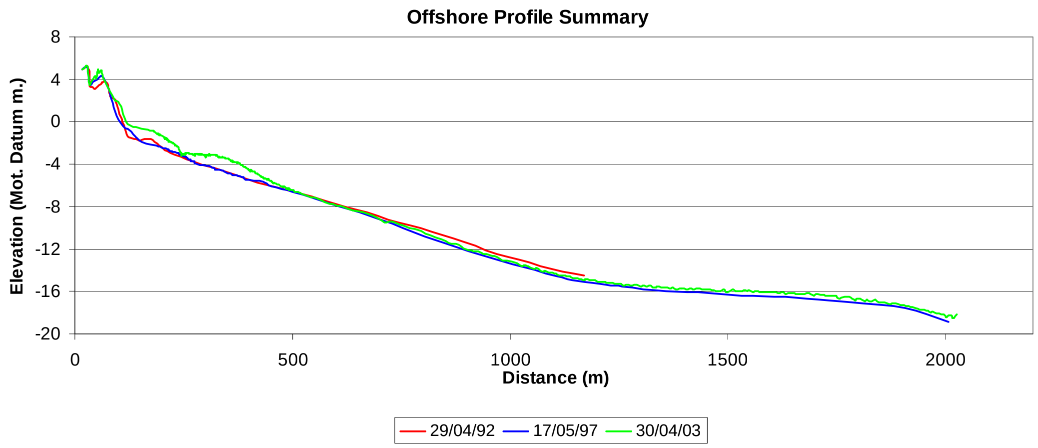
CCS 19 - Tarawera East

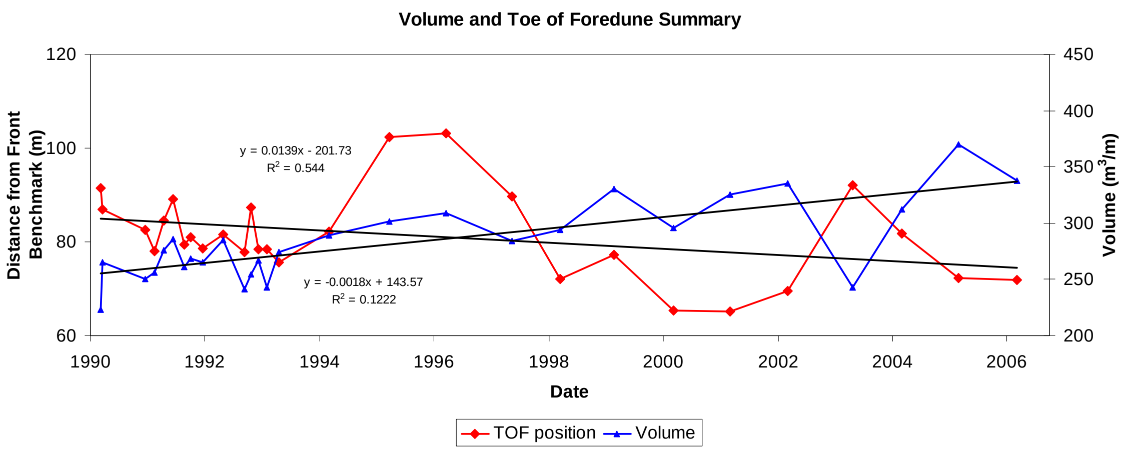


State: Accretion?

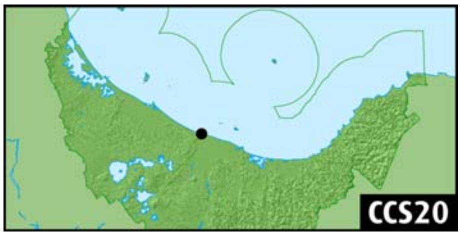
Location: NZMG 2843909E 6360878N
Period of record: 1990 – 2006
No. of profiles: 28
Morphodynamic type (Wright Short model): Low Tide Terrace
Volume p-level – 0.00 **TOF p-level –** 0.61







5.6.4 **Matata Domain (CCS 20)**

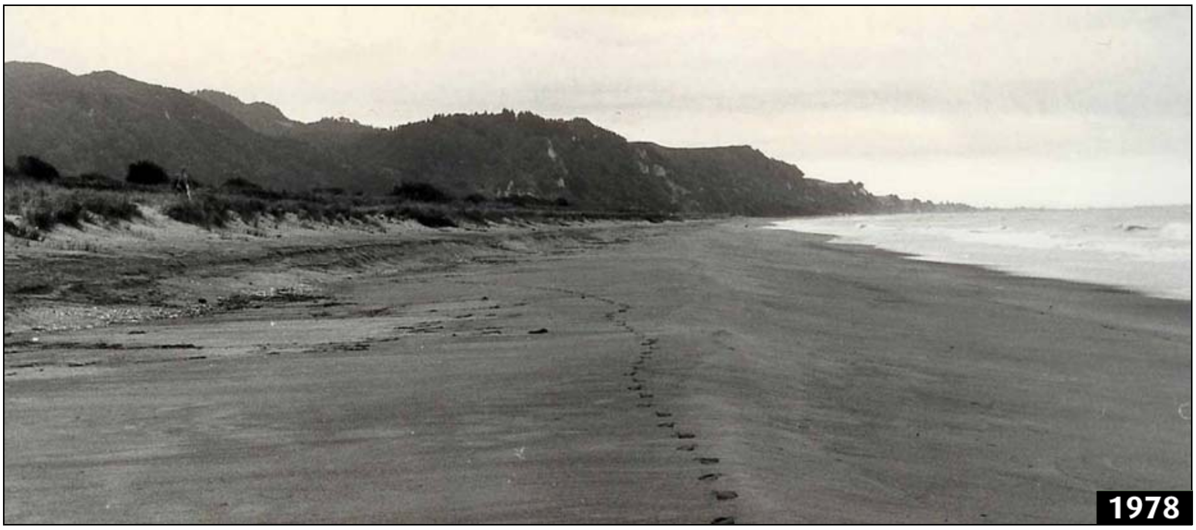


Discussion

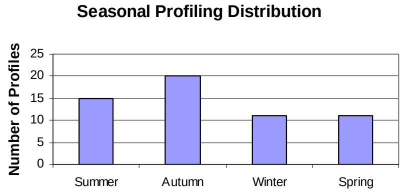
This site is located 600m to the east of the Matata Domain. The diversion of the Tarawera River mouth away from the Matata township in 1917 and the mining of approximately 6000m^3/yr of foreshore and dune sand for 20 years up to 1985 is likely to have influenced shoreline movements at Matata. The 1978 photograph shows a moderately vegetated dune with an erosional scarp in the upper beach area, a small berm feature is also present. The 2006 photograph shows similar amounts of vegetative cover and a storm debris line at the base of the frontal dune.

The profile dataset shows stability in the upper beach area. The lower beach (<3m elevation) has exhibited a wide vertical envelope (+4m) of sediment movement. The MWHS position shows a horizontal variation of 28m.

This site was profiled quarterly up to 2000 due to its inclusion in the sand mining monitoring programme. Analysis of the trends in the in the volume and toe of foredune analysis, shows that this profile site is in a *stable* state for the period on monitoring. Healy (1989) suggested that the pattern of alternating erosion and stability was due to localised wave refraction from offshore topography focusing longer period wave energy that has created a pattern of semi-permanent shallow embayments on the beach.

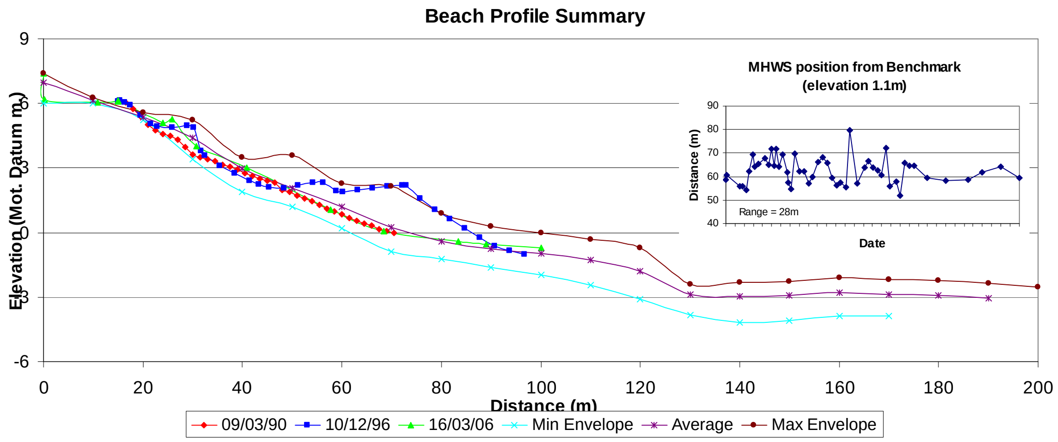


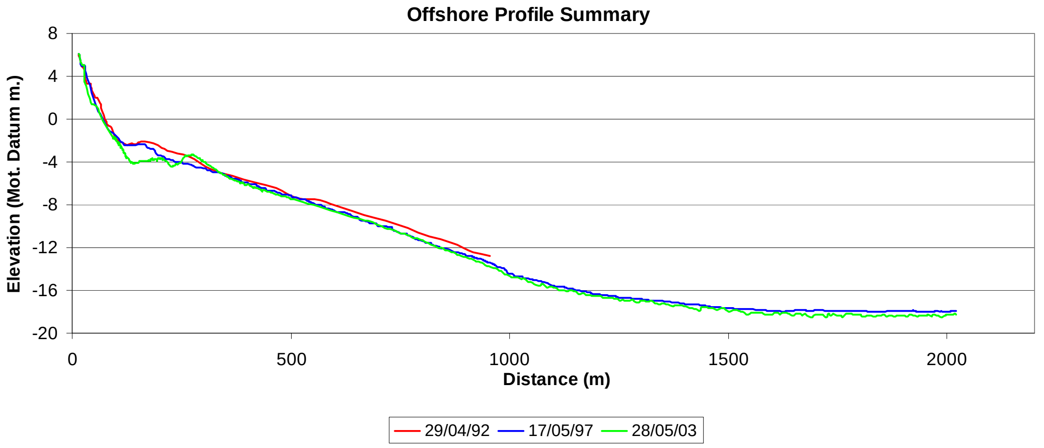
CCS 20 - Matata Domain

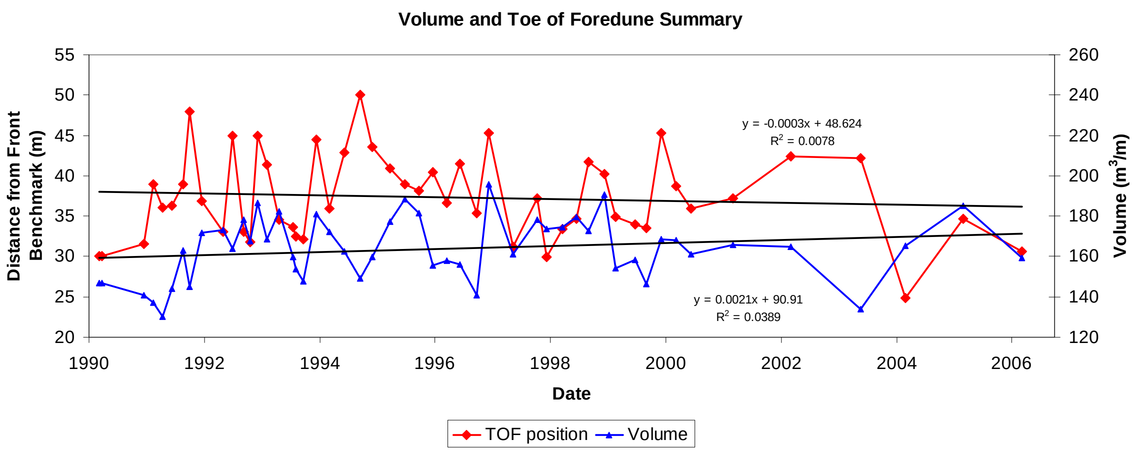


State: Stable

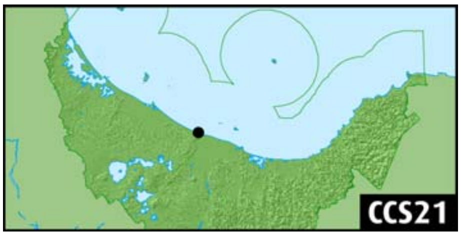
Location: NZMG 2841609E 6361400N
Period of record: 1990 – 2006
No.of profiles: 67
Morphodynamic type (Wright Short model): Low Tide Terrace
Volume p-level – 0.17 **TOF p-level –** 0.54







5.6.5 **Matata (old extraction pit) (CCS 21)**



Discussion

This site is located 1km to the west of the Matata Domain. This site fronts Clem Elliot Drive and the adjacent sand mining area. Healy (1977) gave the movement of 31m retreat for the period 1868 to 1977 (during this period there was a time of advance (1914-1949) which was attributed to the diversion of the Tarawera River).

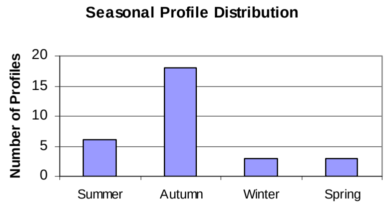
For 1978 photograph Healy states a dune description of spinifex runners encroaching onto areas of bare sand and slight dune accretion (isolated lumps). This vegetation trend is continued in the 2006 photograph with further establishment of the spinifex evident. The 2006 image also has signs of cusp development.

The beach profile record show seaward and vertical development of the upper beach area through to 2006. Below average volumes of sand are present in the three representative profiles displayed. The offshore profiles show the development of bar structures and a convergence occurring at -6m. Once again the earlier profile diverges from the more recent profiles once reaching -9m (possibly signalling an error with the sounding equipment).

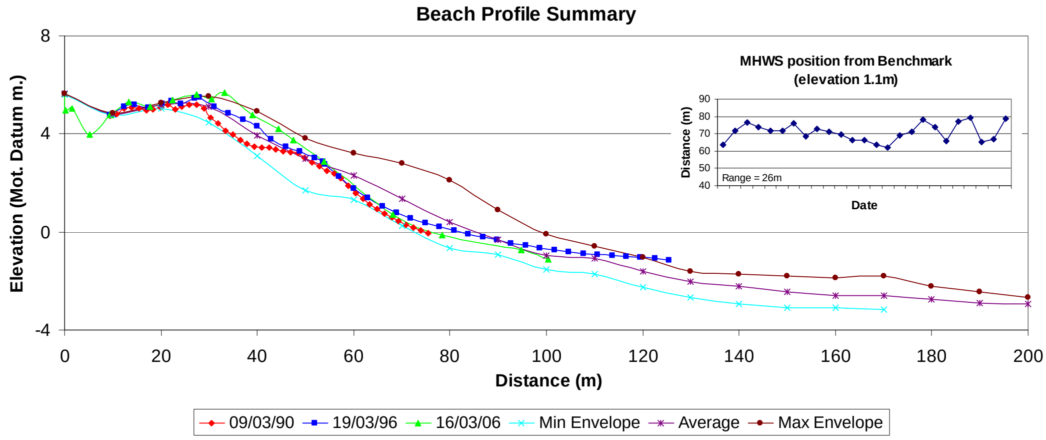
Only the volume dataset has registered a significant trend for this series of profiles hence a state condition *tending towards accretion* has been proposed for this section.

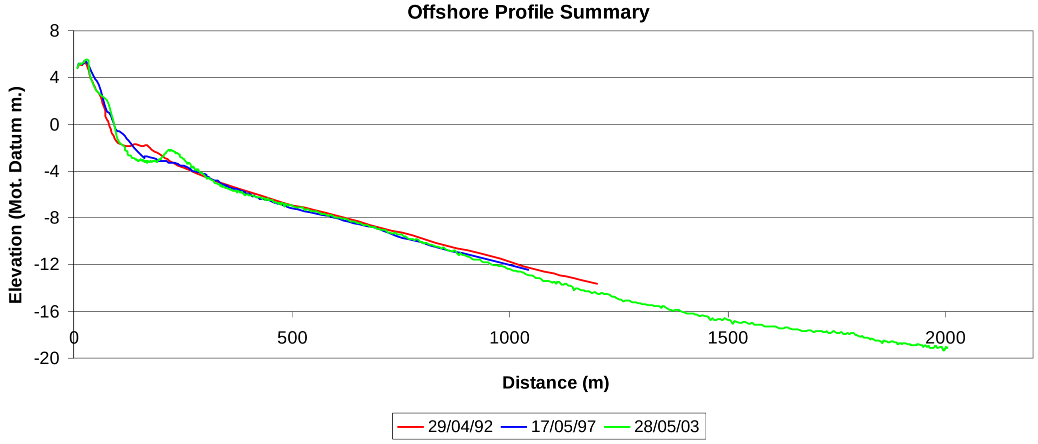
CCS 21 - Matata

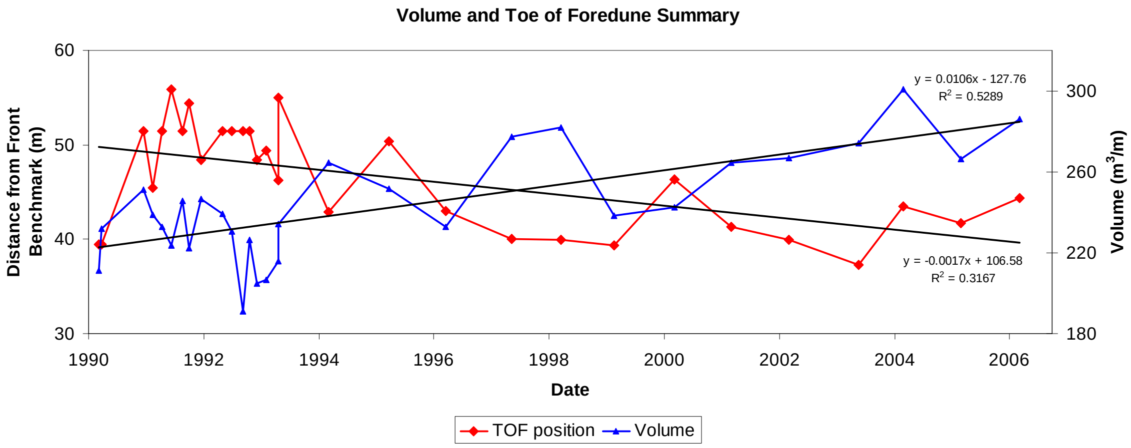
State: Accretion?



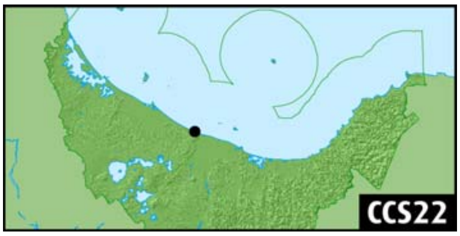
Location: NZMG 2840037E 6361867N
Period of record: 1990 – 2006
No. of profiles: 30
Morphodynamic type (Wright Short model): Low Tide Terrace
Volume p-level – 0.00 **TOF p-level –** 0.05







5.6.6 **East of Murphy's Motor Camp (CCS 22)**

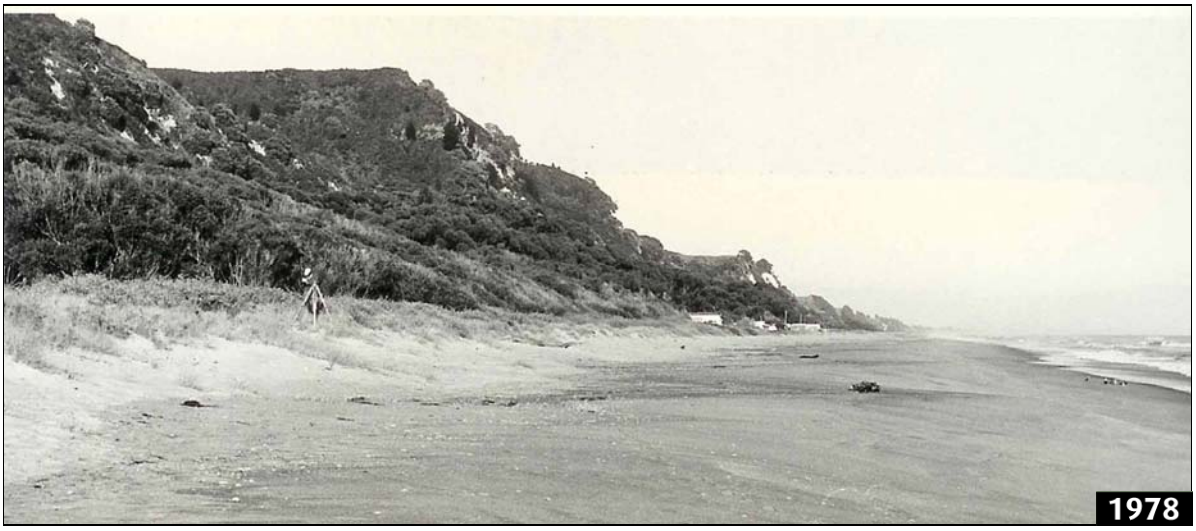


Discussion

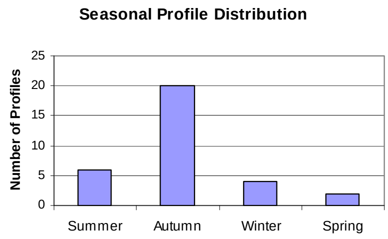
This site is situated 500m of the east Murphys Motor Camp. The beach borders a narrow Holocene coastal plain of sand barriers. Photography shows that in both cases *spinifex* is well developed on the frontal dune. *Spinifex* runners encroach down the front of the dune. A berm is present in both photographs with a varying position due to the development of beach cusps.

The beach profile record (1990-2006) shows a seaward movement of the frontal dune. The MHWS position fluctuates 32m horizontally. The offshore profiles exhibit offshore bar and trough development. At 2km offshore, reef structures are present, with elevation variations of several metres measured. The 1992 profile once again diverges from the other two later profiles.

The statistical analysis of both the volume and toe of foredune show no significant trends. This dynamic equilibrium pattern gives a *state of stable* for the period of record. Gibb (1994) states long-term trend (1918-1994) of dynamic equilibrium with short-term fluctuations of 15 to 20m for the stretch of beach from Matata to Mimiha Road.

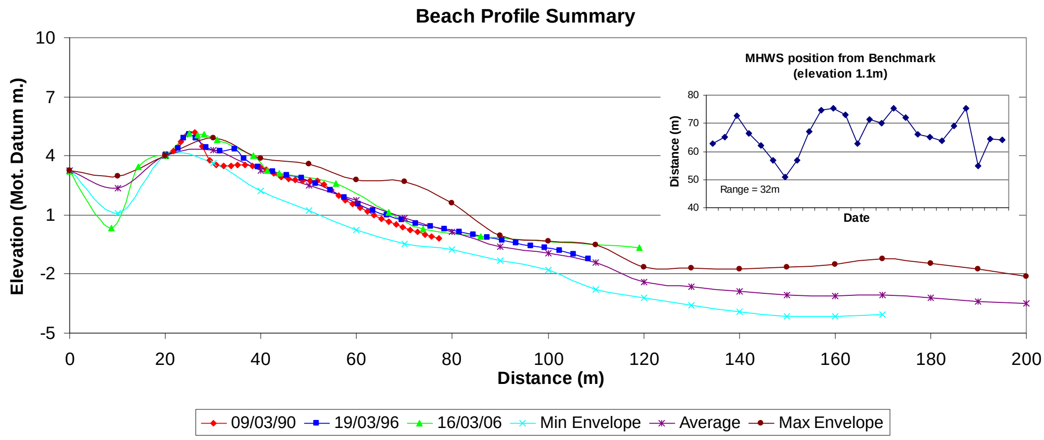


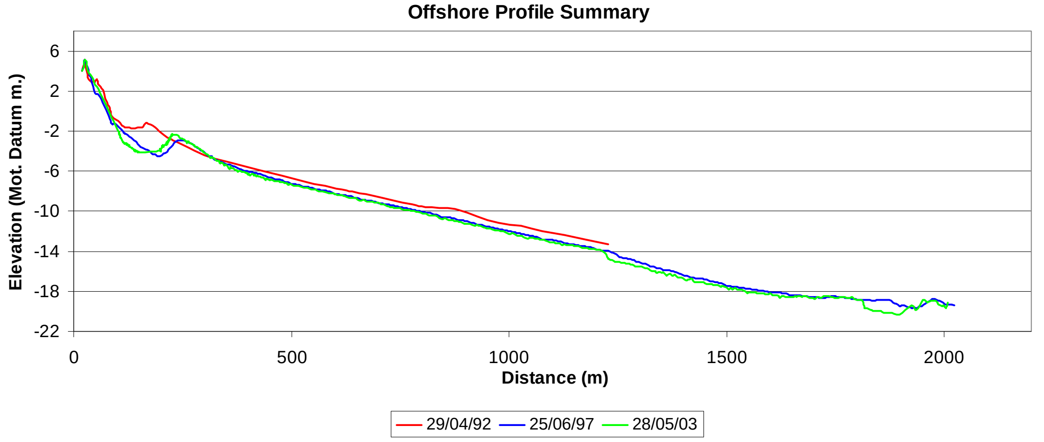
CCS 22 - East of Murphy's Motor Camp

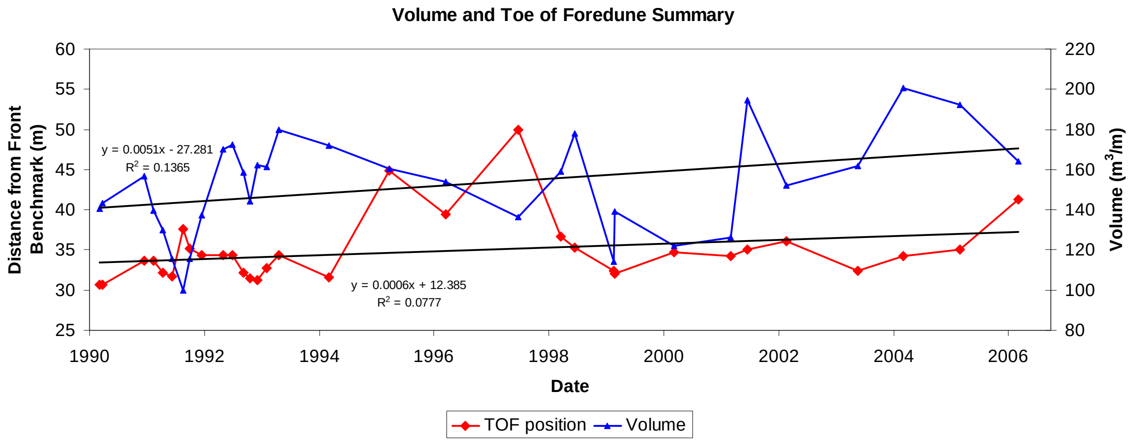


State: Stable

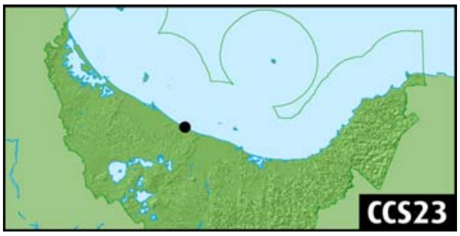
Location: NZMG 2838484E 6362506N
Period of record: 1990 – 2006
No. of profiles: 32
Morphodynamic type (Wright Short model): Low Tide Terrace
Volume p-level – 0.04 **TOF p-level –** 0.03







5.6.7 East of Pikowai Free Camp (CCS 23)

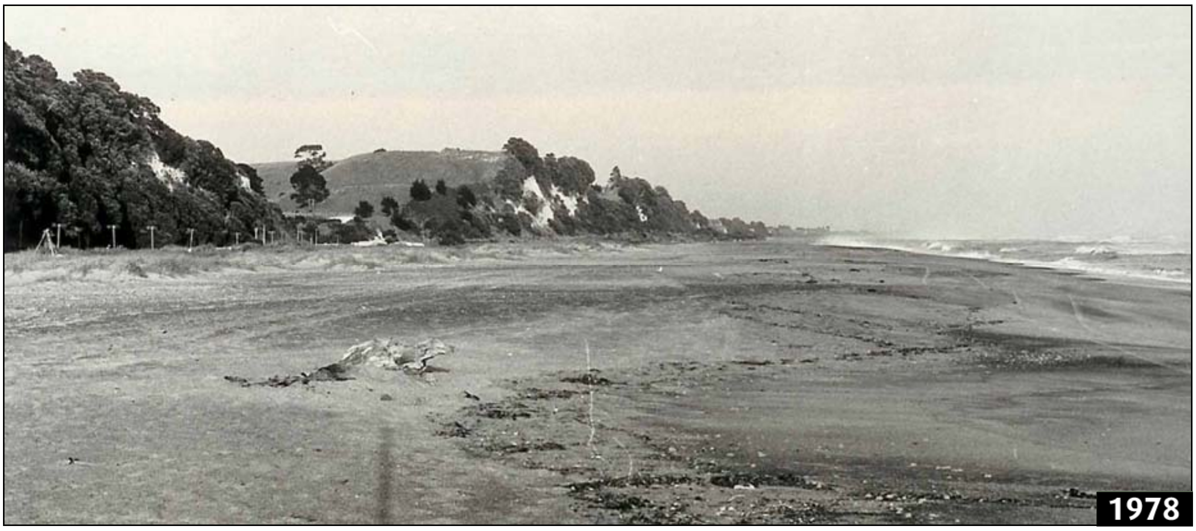


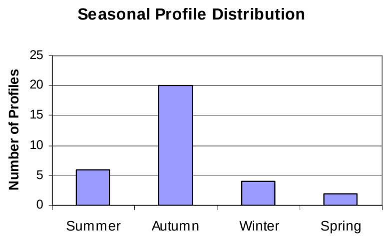
Discussion

This site is located 200m east of the Pikowai Camping Ground and 700m east of the Pikowai Stream. The 1978 photograph shows isolated dunes forming a frontal dune system. Blowout areas are present between spinifex vegetation colonising some bare areas and assisting dune accretion. The photography shows a change from a dissipative profile in 1978 to a low tide terrace configuration witnessed in 2006.

The beach profile dataset shows the formation of an incipient dune in the 1996 profile. The 2006 and 1990 profiles are aligned closely positioned slightly landward of the average for the 31 measured profiles. A berm is absent in the 2006 profile.

The toe of foredune dataset shows a significant negative trend. Thus giving a status tending towards erosion. A long-term trend (1918-1994) of shoreline retreat of approximately 20m ranging from 10 to 30m, with short-term fluctuations of 30 to 70m as a result of migrations of the Pikowai, Herepuru and Mimiha Streams. Advance from accretion followed cyclic stream migration and is temporary only (Gibb, 1994).

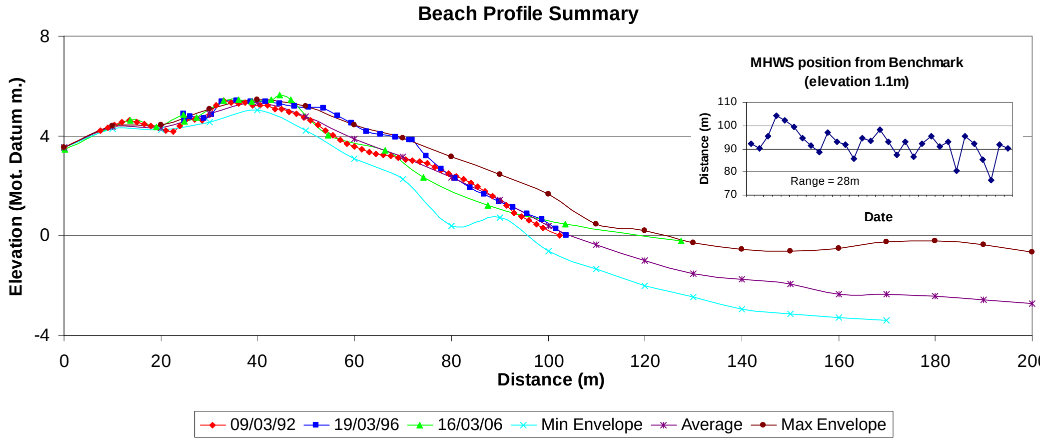


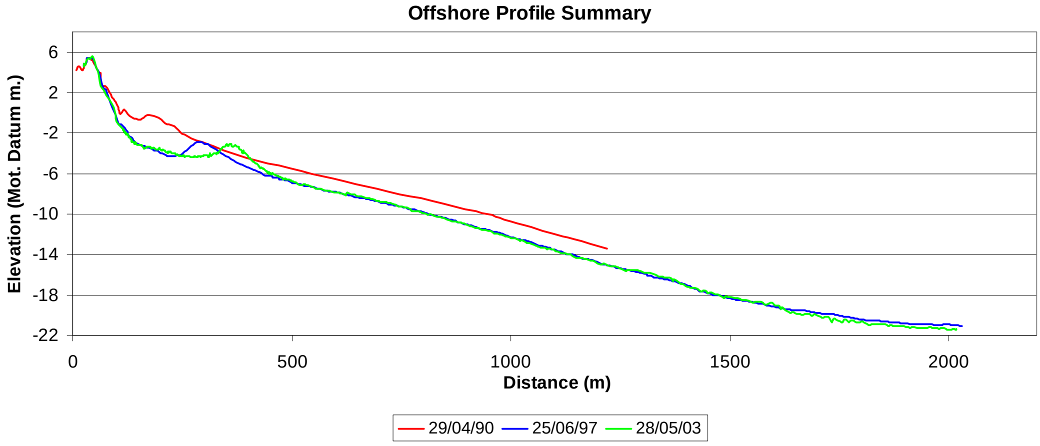


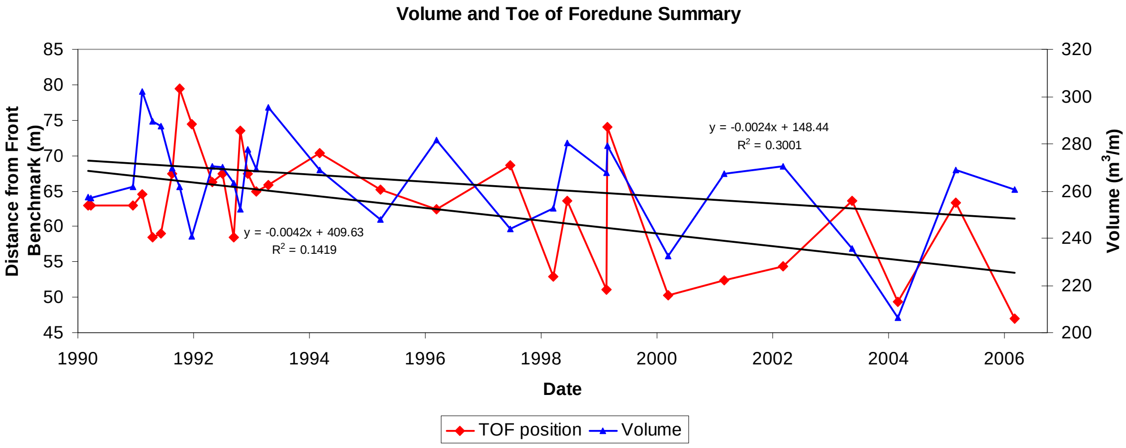
CCS 23 - East of Pikowai Free Camp

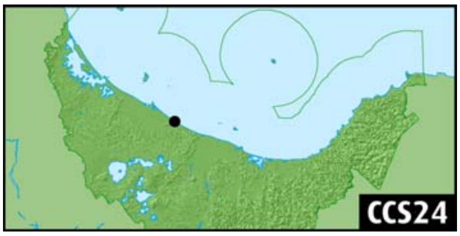
State: Erosion?

Location: NZMG 2833103E 6365020N
Period of record: 1990 – 2006
No. of profiles: 31
Morphodynamic type (Wright Short model): Low Tide Terrace
Volume p-level – 0.04 **TOF p-level –** 0.00









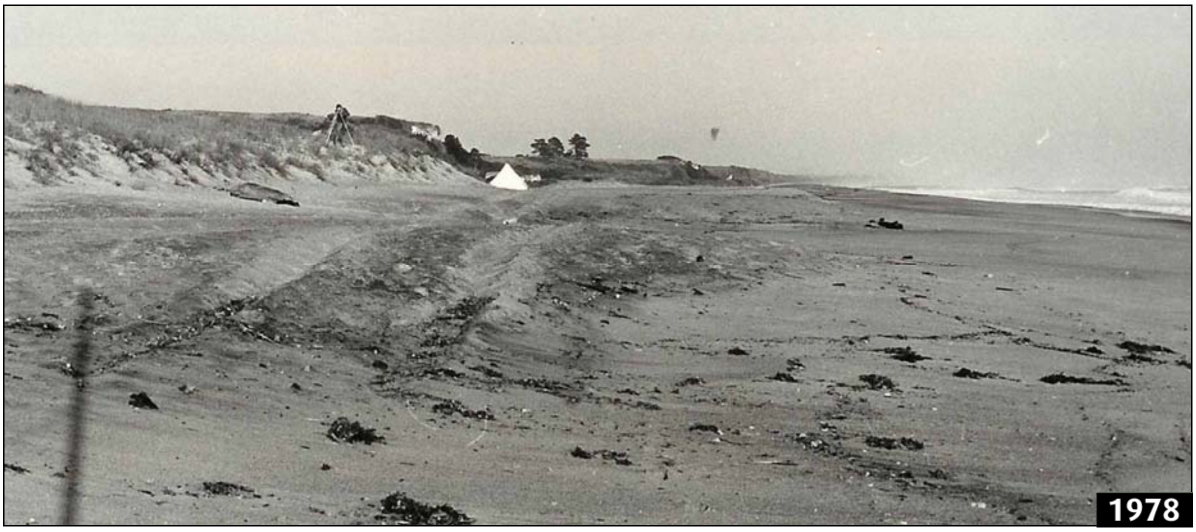
5.6.8 **Otamarakau (CCS 24)**

Discussion

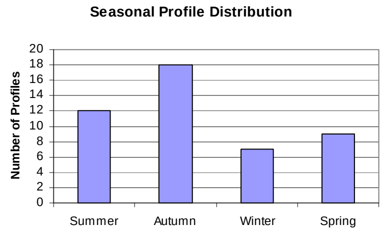
This site is located 1km to the east of where the Waitahanui Stream passes beneath the railway line. This is one of the most intensely monitored sites within the Matata beach system with 46 profiles collected. This interest is derived from the sand extraction operation undertaken by JW Paterson & Sons. Their consent (40052) for this extraction expired in 1998. This extraction occurred within 3 zones between the Waitahanui Stream and the Pikowai Stream (6km of beach) (Smith, 1997).

The beach profile record shows the loss of the frontal dune at this site. The 2006 profile shows a low dune with a slight crest present 40m from the benchmark. The 2006 photograph shows the remaining punctuated frontal dune system with some evidence of spinifex colonising the enduring mounds of sand. This area is also a beach access point for 4 wheel drive vehicles. For Pikowai to Otamarakau, Gibb (1994) stated a 6.4km-long sand beach bordering a narrow Holocene coastal plain comprising a primary sand barrier. Barrier is 30 to 50m wide and 5.4 to 6.6m above MHWS lowering to 2.25m near stream mouths. Subject to wind erosion, overtopping and inundation particularly near streams, from storm wave runup of 4 to 6m. Long-term trend (1918-1994) of shoreline retreat of approximately 25m, ranging from 10 to 35m, with short-term fluctuations of 10 to 30m increasing to 30 to 65m near stream mouths.

Analysis of the dataset shows statistically significant trends for both toe of foredune and volume highlighting a *state of erosion*.

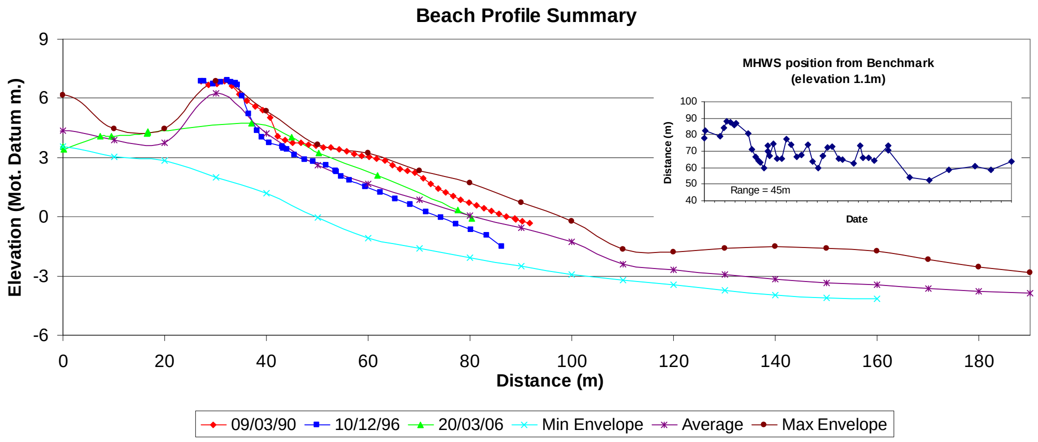


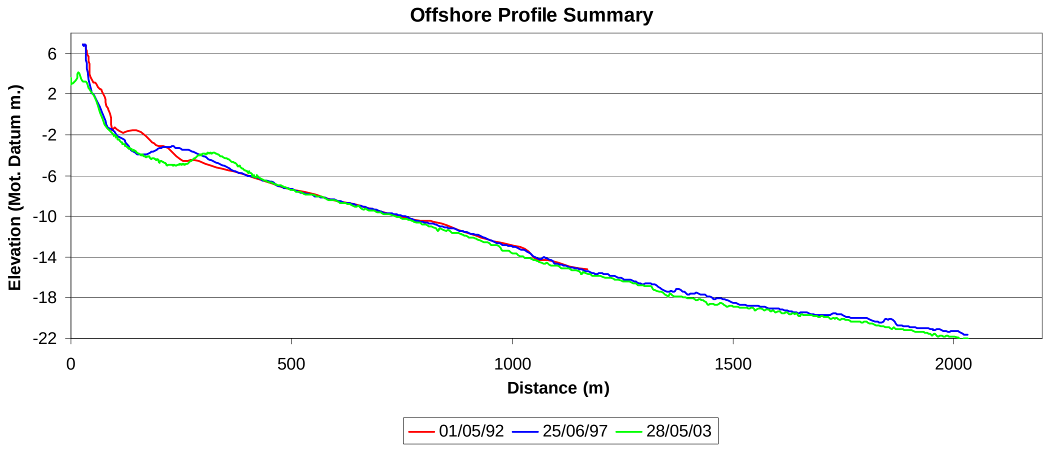
CCS 24 - Otamarakau

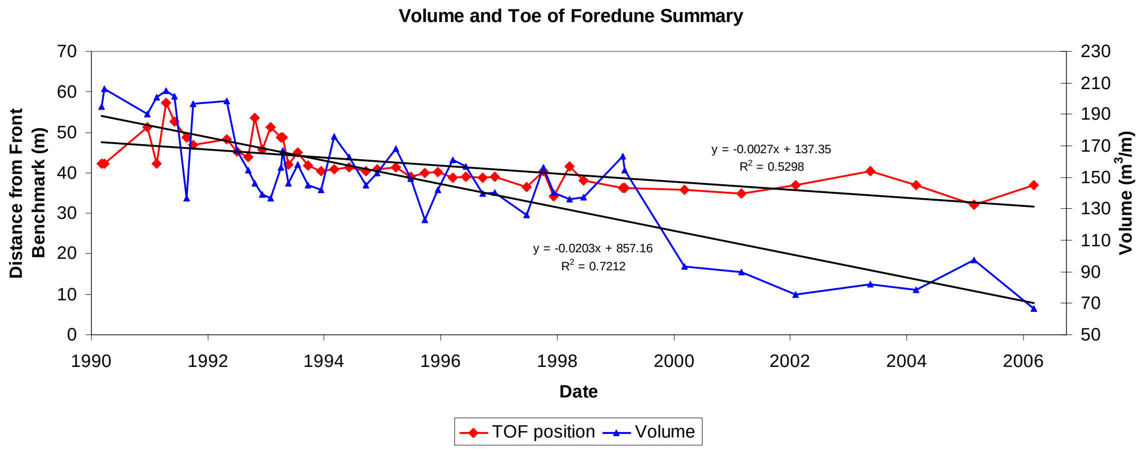


State: Erosion

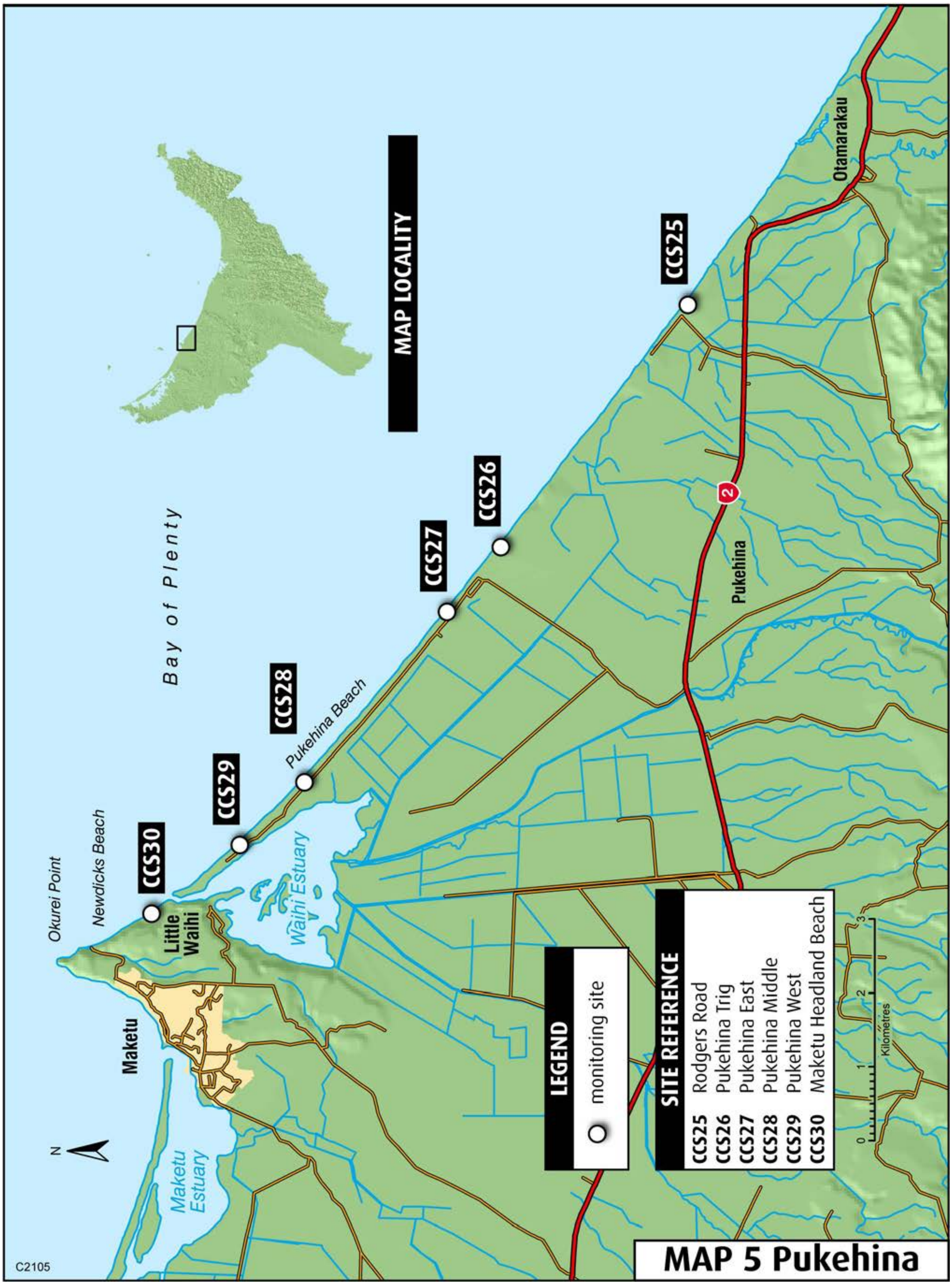
Location: NZMG 2827973E 6367928N
Period of record: 1990 – 2006
No. of profiles: 46
Morphodynamic type (Wright Short model): Low Tide Terrace
Volume p-level – 0.00 **TOF p-level –** 0.00



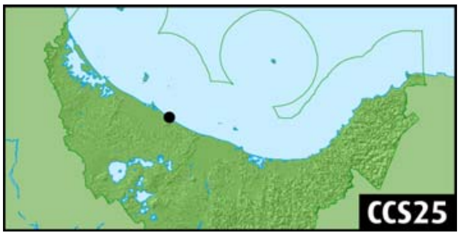




5.7 Pukehina Beach system



5.7.1 **Rodgers Road (CCS 25)**



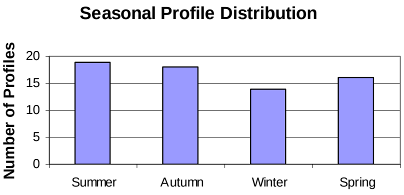
Discussion

This site is located 150m to the east of Rodgers Road. The site consists of a single steep foredune developed in front of Pleistocene cliffs some 20m in elevation (Phizacklea, 1993). The 1978 photograph shows a scarped frontal dune with limited spinifex cover, runners are also present at the base of the dune. A berm is also present although punctuated by beach cusps. The 2006 photograph shows a steeper sloping upper beach as a result of accumulated sand. The presence of a berm is not as prominent as in the earlier photograph.

The beach profile record shows a steep retreating frontal dune. The MHWS plot shows a general retreat of the 1.1m elevation position up until 1996 and some stability since then. The offshore profile show a well developed offshore bar accompanying a deep trough. The profile converge at -6m and from 650m to the extent of the profile reef structures are present (a significant reef is present at 1750m with a variation in depth of 4-5m when compared with surrounding seabed.

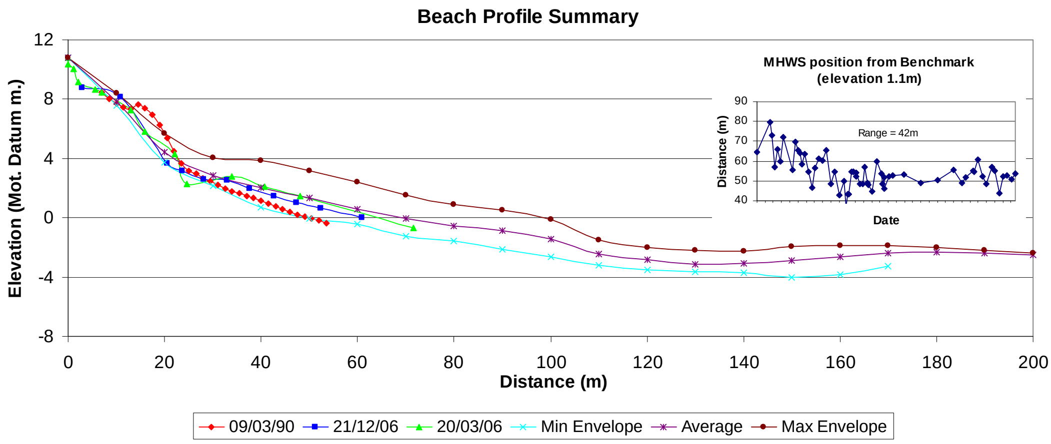
The analysis shows a significant trend in the volume dataset with a state tending towards *erosion* for the period of record. For the section of beach from Otamarakau to Rogers Road, Gibb (1994) states a long-term trend (1927-1994) of shoreline retreat of approximately 15m, ranging from 15 to 25m, with short term fluctuations of 10 to 15m.

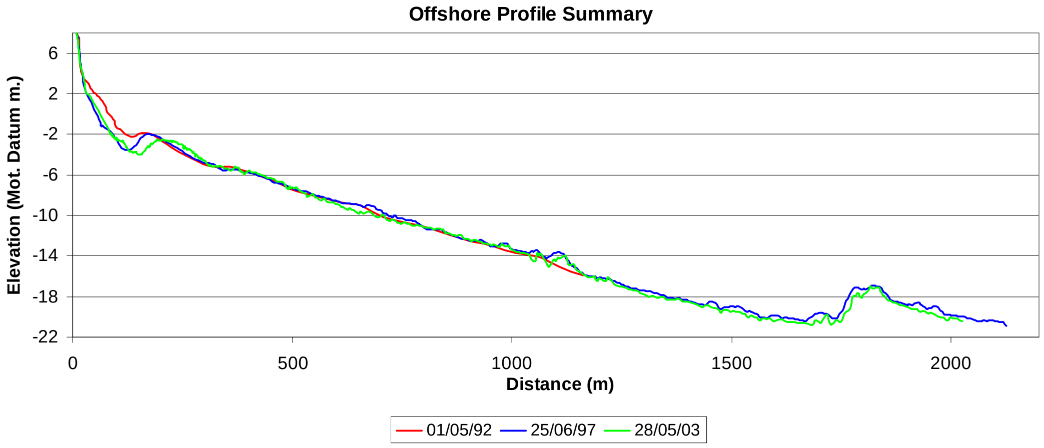
CCS 25 - Rodgers Road

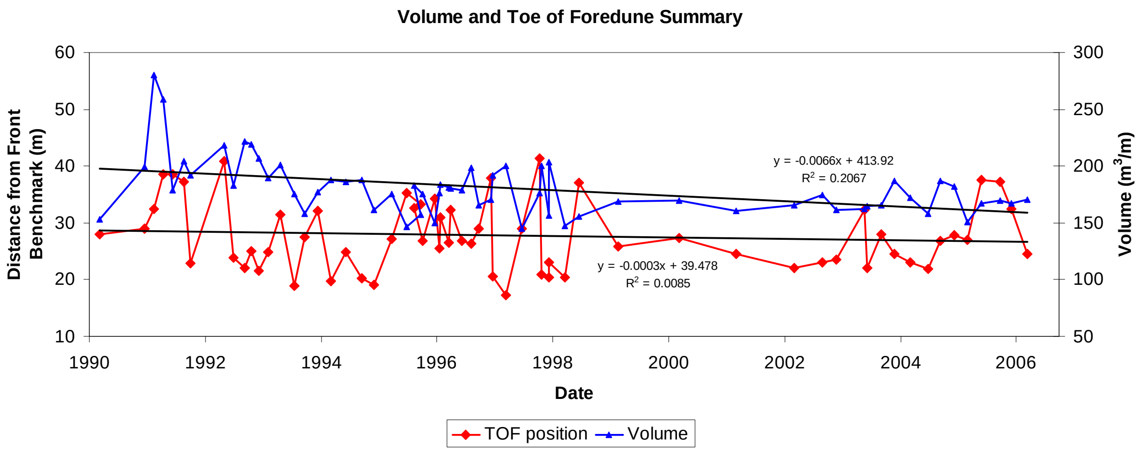


State: Erosion?

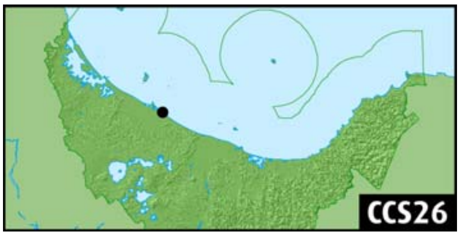
Location: NZMG 2824669E 6370219N
Period of record: 1990 – 2006
No.of profiles: 63
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.00 **TOF p-level –** 0.47







5.7.2 **Pukehina Trig (CCS 26)**



Discussion

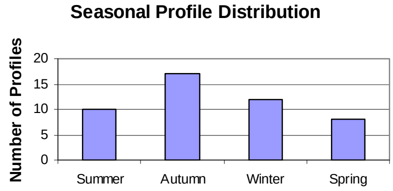
This site is located 6.5km to the east of the Waihi Estuary. This site has moved in a westward direction due to access issues at the 1978 site which is backed by 40m high vegetated Pleistocene cliffs. The current site shows (2006 photograph) long term erosion, with scarping along the base of the frontal dune caused by berm wash over and a predominant narrow high tide beach width.

The beach profile record shows a steep (near vertical in some cases) retreating frontal dune. The MHWS position is generally fluctuating within a 10m band, with extremes 5m either side of this band. The offshore profiles show a well developed offshore bar, with a position fluctuating between 150 and 300m offshore. At 1800m offshore a reef structure is present, raising ~6m from the surrounding seabed. The variation in shape of this structure is a reflection of varying survey paths. The extent of this feature (and others) is shown in Easton (2002).

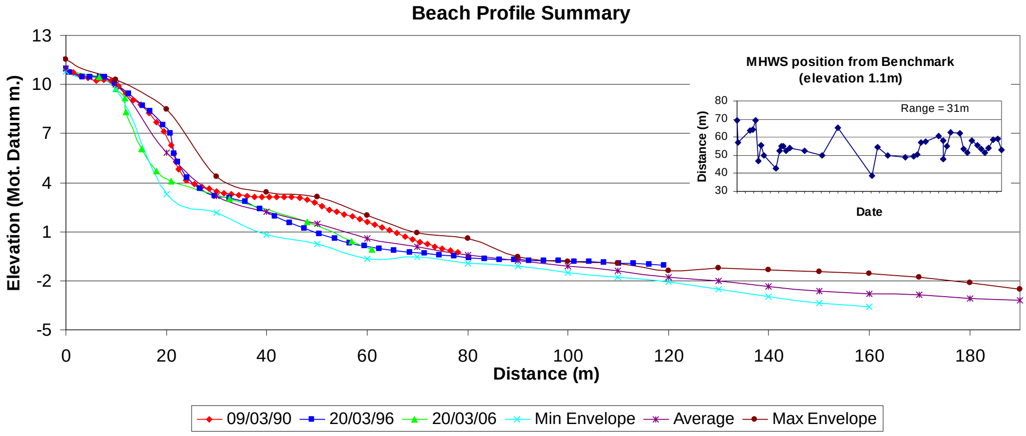
The analysis shows a significant trend in both the volume and toe of dune datasets with a state of erosion for the period of record. For Pukehina Beach to the Spit, Gibb (1994) states a long-term trend (1912-1994) of shoreline retreat of approximately 8m, ranging from 2 to 14m, with short-term fluctuations of 10 to 30m increasing to 30 to 60m at the spit tip.

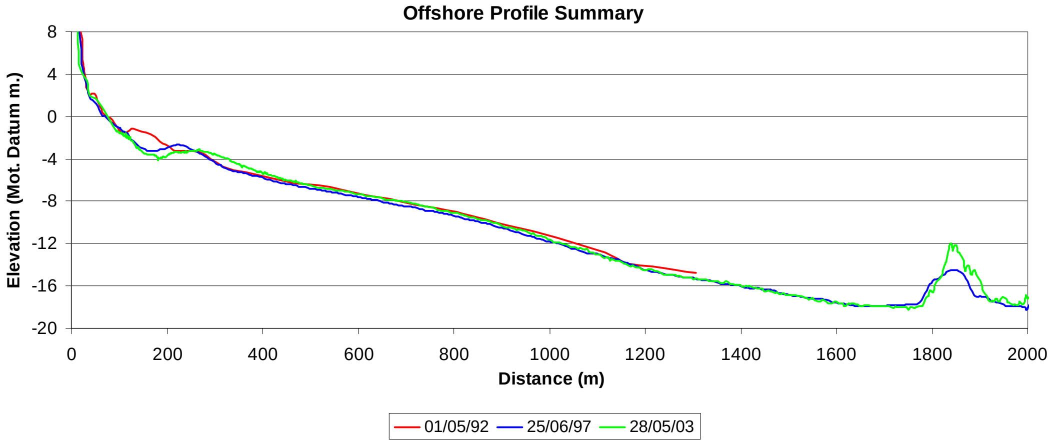
CCS 26 - Pukehina Trig

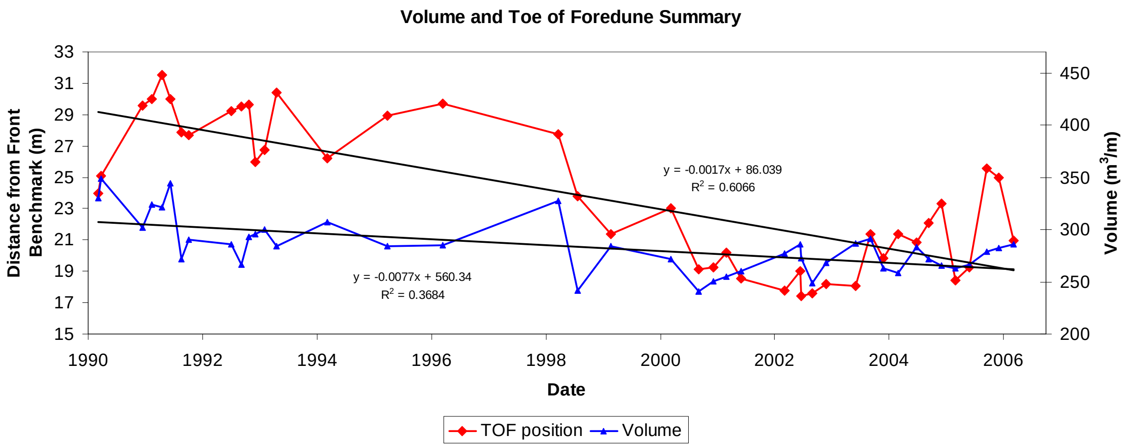
State: Erosion



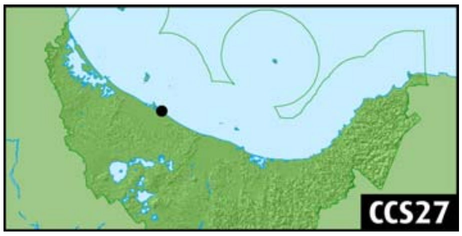
Location: NZMG 2821394E 6372745N
Period of record: 1990 – 2006
No. of profiles: 43
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.00 **TOF p-level –** 0.00







5.7.3 Pukehina East (CCS 27)



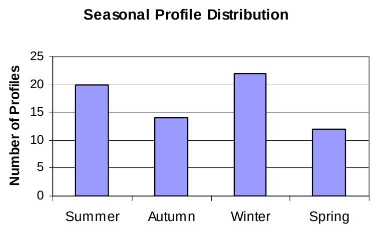
Discussion

This site is located 5.3km to the east of the Waihi Estuary. The 1978 photography shows the large frontal dune present at this site (and present in many location along Pukehina Beach), with an elevation of 10m. It is vegetated with *spinifex* and *mulenbeckia*. Zones of faceted dune are present as a result of human and wind influences. The 2006 photograph shows a retreat in the position of the frontal dune. A steep dune face is evident with overhanging vegetation present. Staircases have been installed to help with access to the beach.

The profile record shows the retreat of the frontal dune and also a lowering of the upper and mid beach face. The MHWS position fluctuates between 10m, with a more landward position in the early 1990's. The offshore profiles show the presence of an offshore bar. The volume of sediment in the inner zone (0 – 250m) shows a marked loss. As with CCS26 there is a reef structure present 1700m offshore.

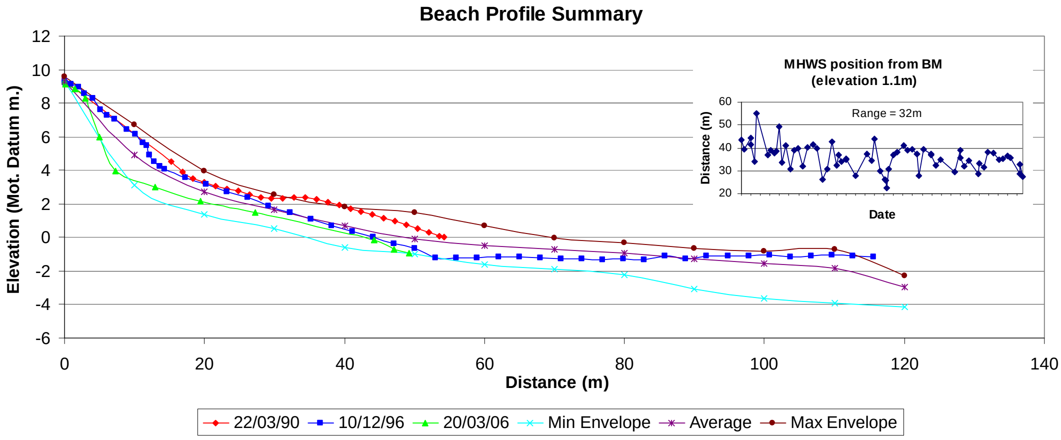
Profile analysis shows a state of *erosion*. Strong negative trends are present for both toe of foredune position and beach volume for the period of record 1990 to present. For Pukehina Beach to the Spit, Gibb (1994) states a long-term trend (1912-1994) of shoreline retreat of approximately 8m, ranging from 2 to 14m, with short-term fluctuations of 10 to 30m.

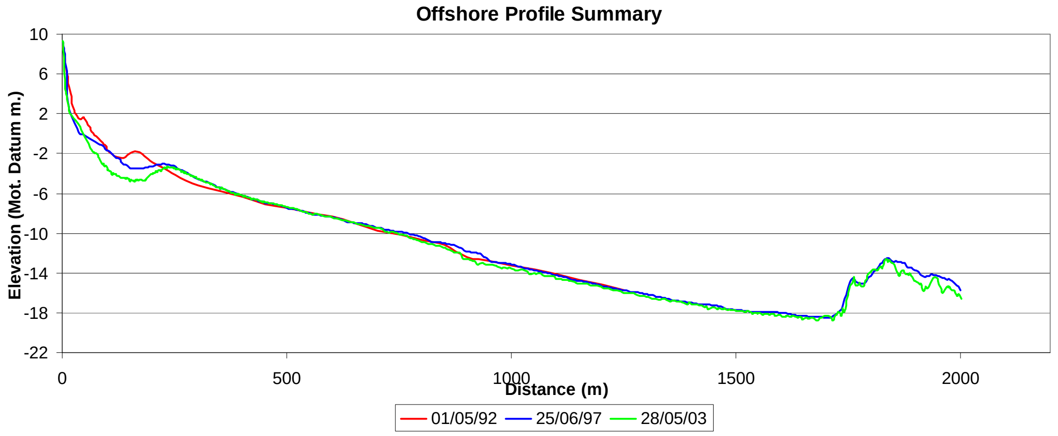
CCS 27 - Pukehina East

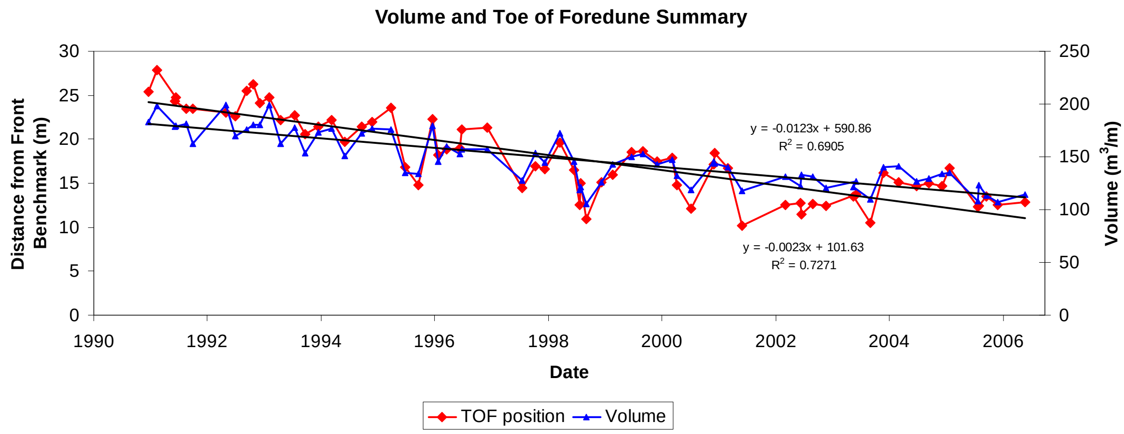


State: Erosion

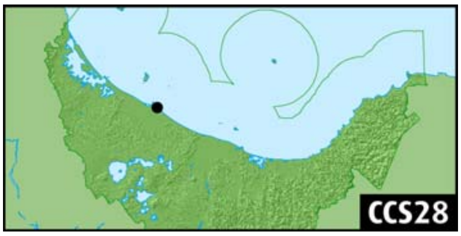
Location: NZMG 2820517E 6373465N
Period of record: 1990 – 2006
No. of profiles: 68
Morphodynamic type (Wright Short model): Transverse Bar and Rip
Volume p-level – 0.00 **TOF p-level –** 0.00







5.7.4 **Pukehina Middle (CCS 28)**



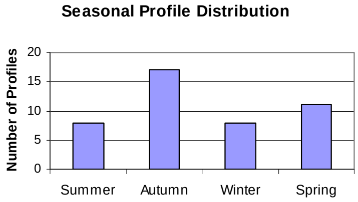
Discussion

This site is located 2.3km to the east of the Waihi Estuary inlet. The 1978 photograph shows the presence of high (10m+) frontal dunes. Spinifex runners are present along the face of the scarped dune. The 2006 photograph shows spinifex present in the foreground of the dune with muelenbeckia covering the upper back slope. Access points have been defined to confine human traffic across the lower dune section, as the photograph suggests this section is still suffering from an erosional pattern.

The profile history shows dynamic movement in the mid beach section, berm development and elimination is a common pattern at this site as sediment supply permits. The offshore profile record shows active offshore bar development and fluctuation. No offshore reef is present at this site as measured at the 3 sites to the west. Easton (2002) records fine featureless sand morphology offshore for this site.

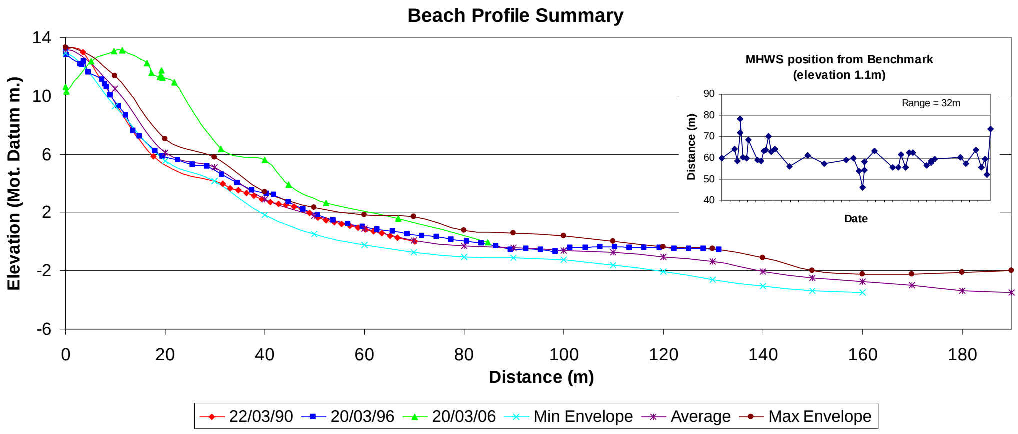
Profile analysis shows a state of erosion. Strong negative trends are present for both toe of foredune position and beach volume for the period of record 1990 to present. For Pukehina Beach to the Spit, Gibb (1994) states a long-term trend (1912-1994) of shoreline retreat of approximately 8m, ranging from 2 to 14m, with short-term fluctuations of 10 to 30m.

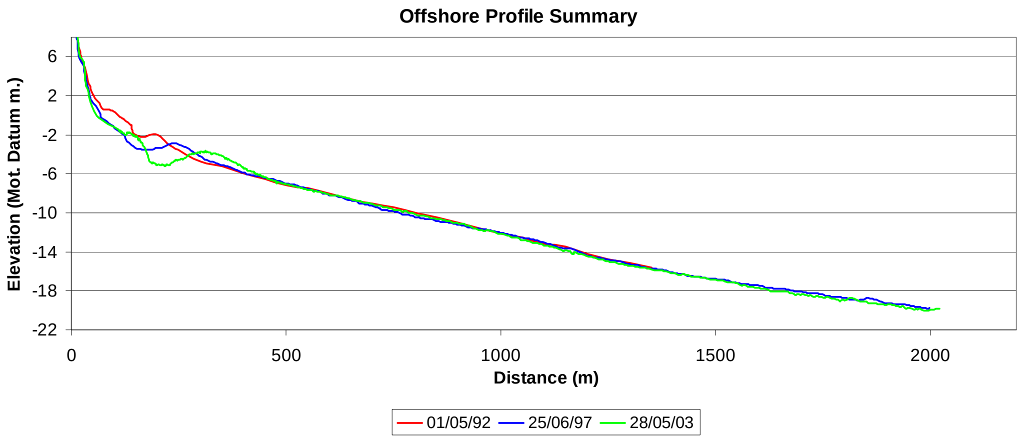
CCS 28 - Pukehina Middle

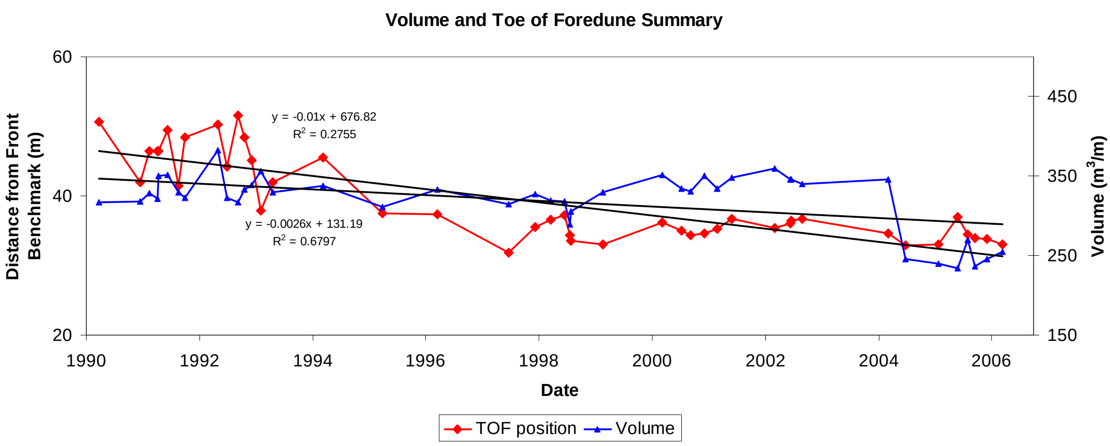


State: Erosion

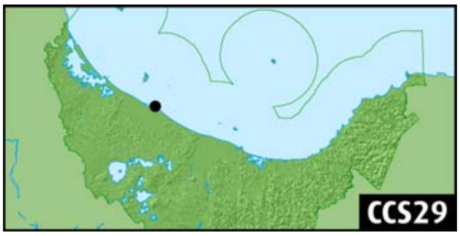
Location: NZMG 2818211E 6375393N
Period of record: 1990 – 2006
No. of profiles: 43
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.00 **TOF p-level –** 0.00







5.7.5 **Pukehina West (CCS 29)**



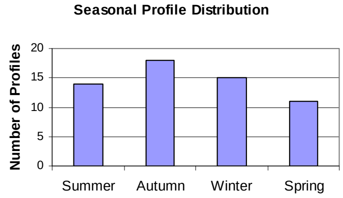
Discussion

This site is located 1.3km from the Waihi Estuary entrance, and 250m east from the end of residential development at Pukehina Beach. The 1978 photograph shows the dune in an eroded state with a developed scarp and spinifex occupying this face. A narrow high tide beach is present. The 2006 photograph shows a small incipient dune forming which is densely populated with spinifex. No berm is present in either photograph. At this distal end of the spit the beach flattens in profile and a low tide terrace morphodynamic type is predominant.

The profile record shows a general retreat and lowering of the profile at this site. The MHWS position is more landward when compared with the position at the start of the investigation period (early 1990's). The offshore data shows a variety of offshore bar forms. In the 1997 profile no bar is present, the 1990 profile shows a slight bar formation at 200m offshore, in 2003 a significant trough has developed 250m offshore. This variability suggests the influence and interaction of the Waihi Estuary ebb tidal delta interacting with the nearshore beach system along this spit section of Pukehina Beach.

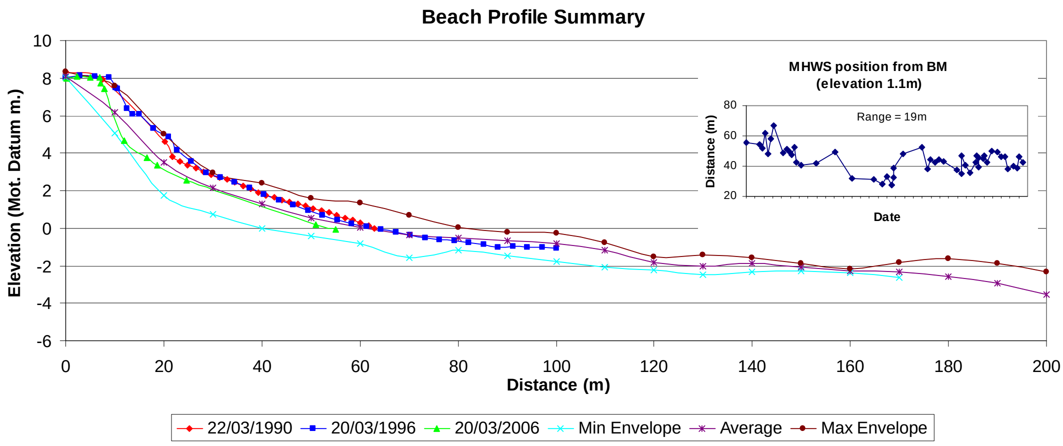
For the period of record analysed a state of *erosion* is shown in the toe of foredune and beach volume records. Gibb (1994) states a long-term trend (1912-1994) of shoreline retreat ranging from 2 to 14m, with short-term fluctuations of 10 to 30m increasing to 30 to 60m at the spit tip.

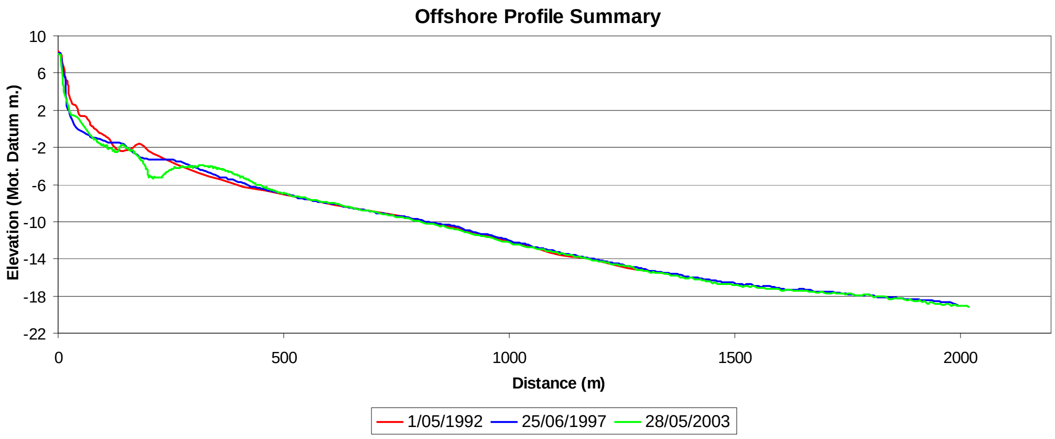
CCS 29 - Pukehina West

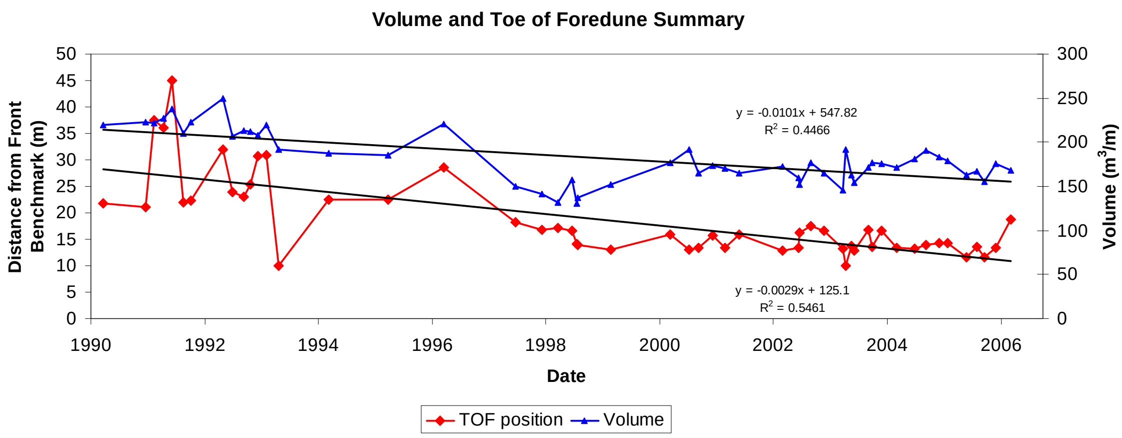


State: Erosion

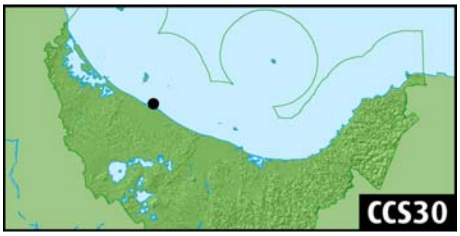
Location: NZMG 2817361E 6376269N
Period of record: 1990 – 2006
No. of profiles: 51
Morphodynamic type (Wright Short model): Low Tide Terrace
Volume p-level – 0.00 **TOF p-level –** 0.00







5.7.6 **Maketu Headland Beach (CCS 30)**



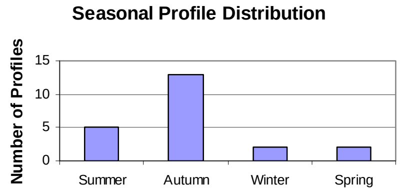
Discussion

This site is located on the western side of the Waihi Estuary entrance, 330m from the inlet. The beach is commonly known as Newdicks Beach (1.2km long), situated on the eastern flank of Okurei Point. The 1978 photograph shows the dune to be in a prograding state with a well colonised (spinifex) face. The 2006 photograph is taken further seaward but shows a depleted lower profile frontal dune still colonised with spinifex but exhibiting a reduced volume.

The profile record shows a frontal dune retreat with an associated reduction in beach elevation. The horizontal position of this beach has varied markedly over time evidenced by up to 3m separation between the minimum and maximum beach envelope positions. The offshore profile show that as with CCS 29 profile the 1997 measurements show an absence of predominant offshore bar. The MHWS position has shown stability since 2002.

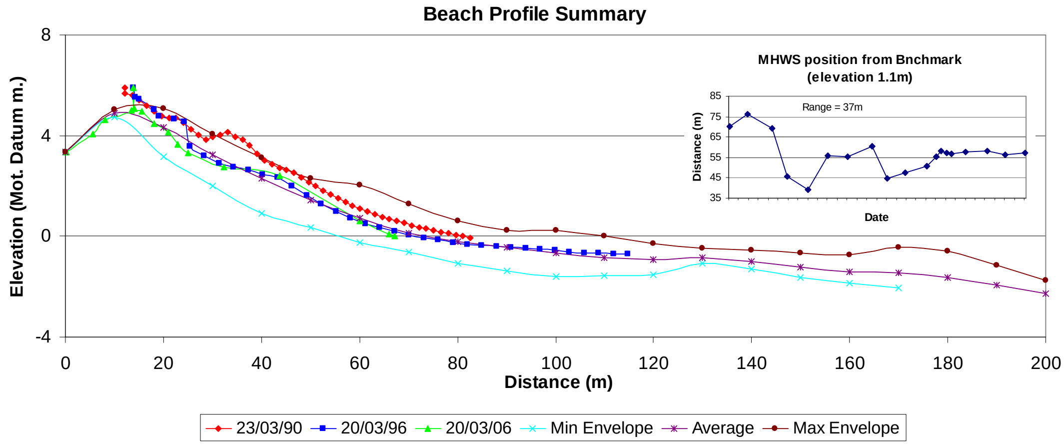
For the period of record analysed a state tending towards erosion for the period of record is shown in the toe of foredune and beach volume records. A long-term trend (1931-1981) of shoreline retreat of approximately 3m, ranging from 12 to 15m with unstable slopes extending about 25m inland from MHWS.

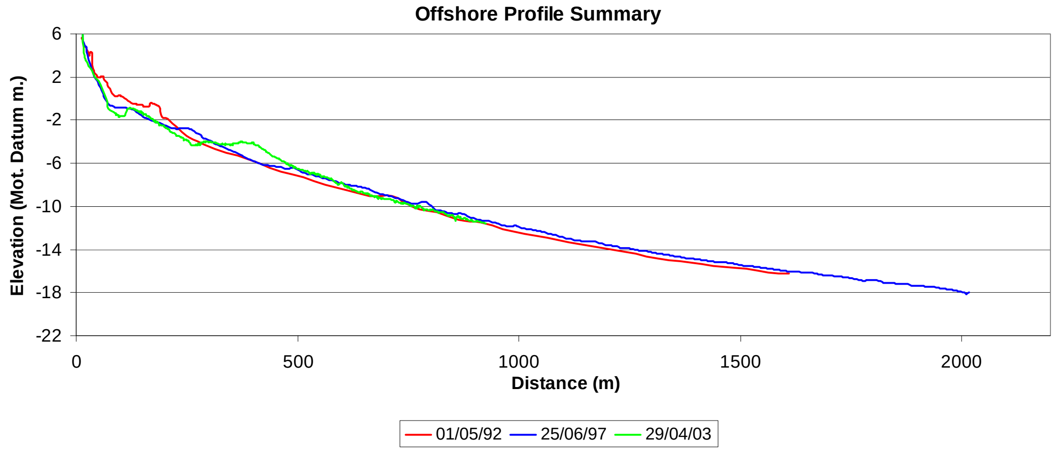
CCS 30 - Maketu Headland Beach

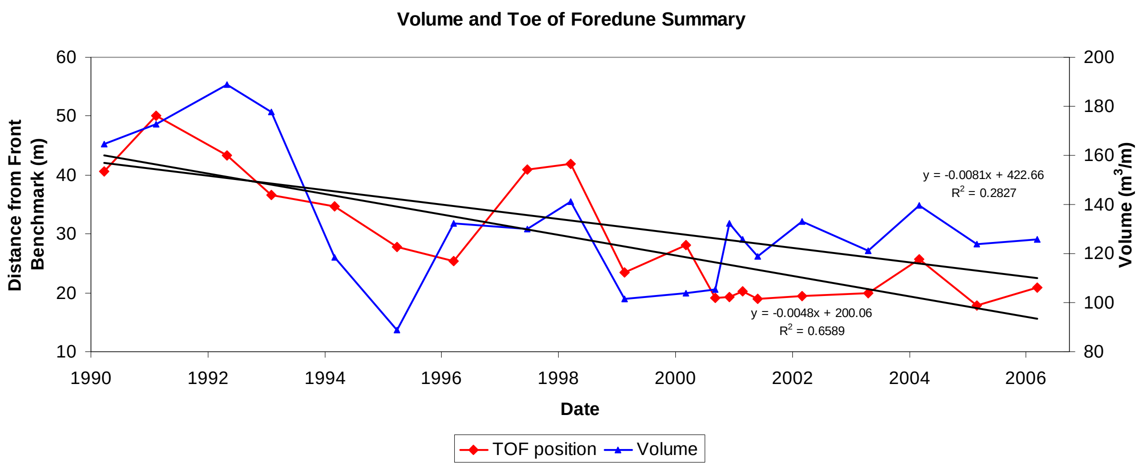


State: Erosion?

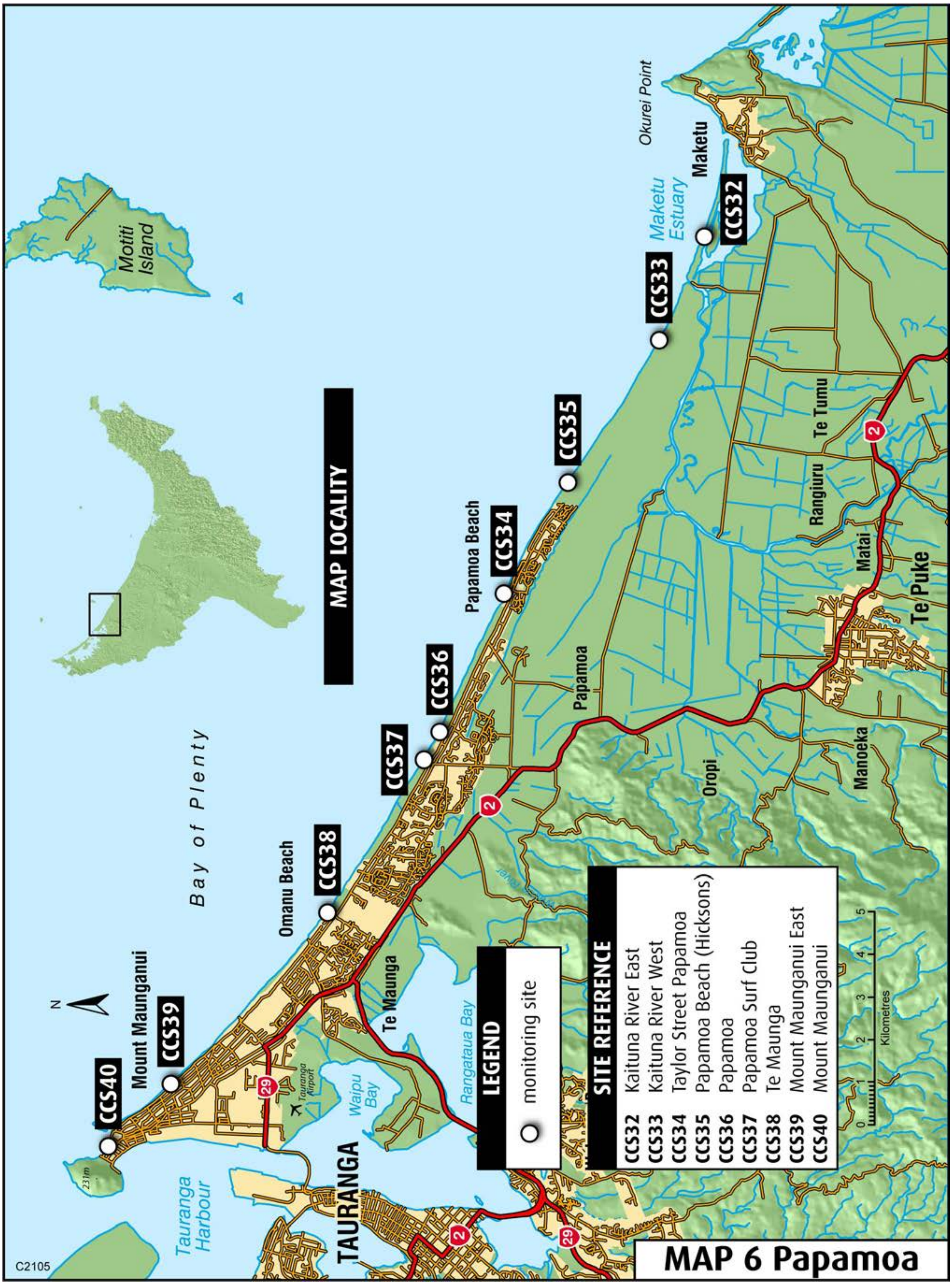
Location: NZMG 2816434E 6377453N
Period of record: 1990 – 2006
No. of profiles: 20
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.02 **TOF p-level –** 0.00





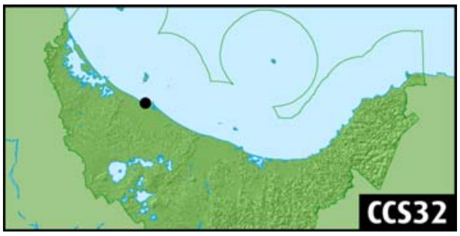


5.8 Papamoa Beach system



5.8.1 **Kaituna River East (CCS 32)**

Discussion

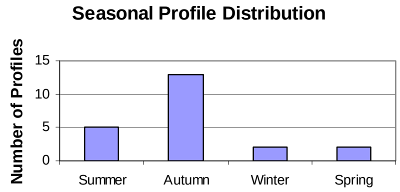


This site is located on the Maketu Spit (2.3km to the west of the Maketu Estuary and 1.1km to the east of the Kaituna Cut). The Spit is a 3.45km-long sand beach bordering a 75 to 150m-wide free form Holocene sand spit that has grown from northwest to southeast to partially enclose Maketu Estuary (Gibb, 1994). The 1978 photograph shows an accreting frontal dune with Spinifex occupying the frontal dune and runners colonising the leading face. The 2006 photograph show a similar pattern to that exhibited in 1978. Site 31, previously located to the east was lost in 1978 when the Maketu Spit was breached.

The profile history shows a seaward movement of the frontal dune, accompanying this seaward movement is a marked positive vertical translation. The MHWS record shows a maximum vertical fluctuation of 17m. The offshore profiles show the presence of a dynamic bar system. Convergence occurs at -7m.

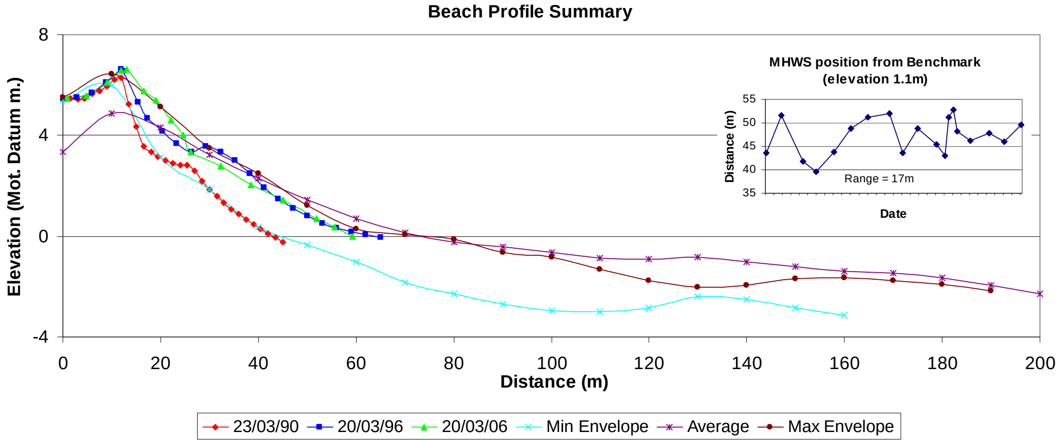
The trend analysis shows a state *tending towards accretion*. . The long-term trend (1943-1994) of dynamic equilibrium with short-term shoreline fluctuations of 10 to 20m increasing to 20 to 30m near the Kaituna River mouth and 50 to 70m near the inlet to Maketu Estuary (Gibb,1994).

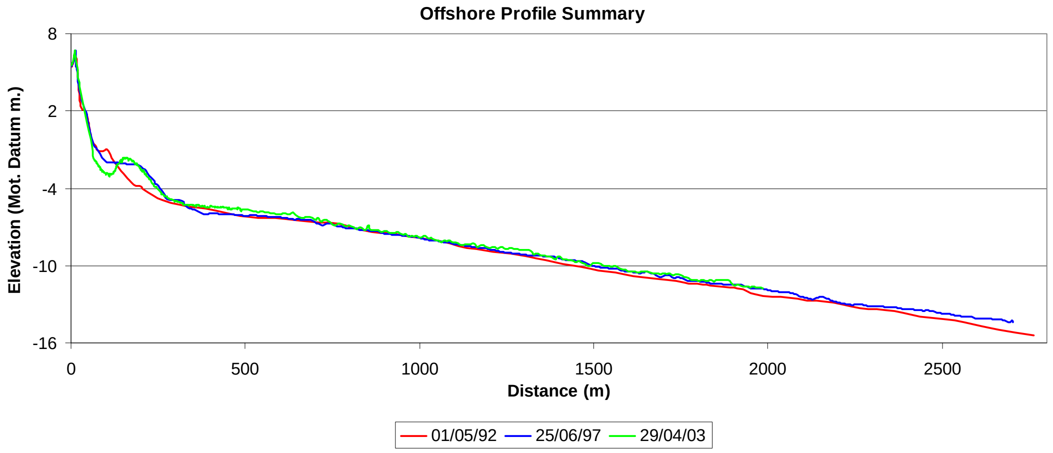
CCS 32 - Kaituna River East

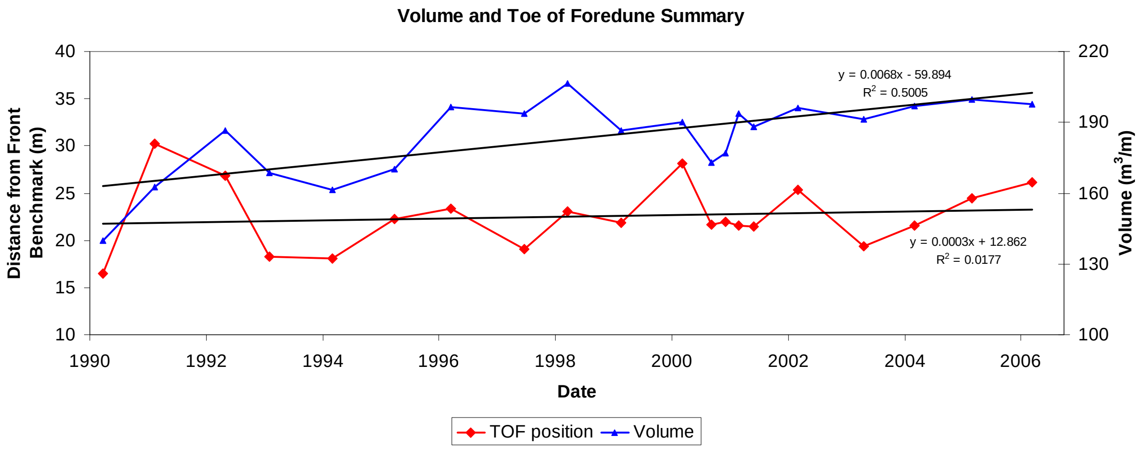


State: Accretion?

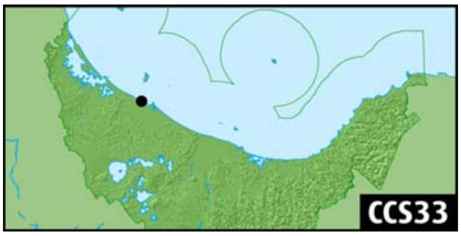
Location: NZMG 2812197E 6377739N
Period of record: 1990 – 2006
No. of profiles: 20
Morphodynamic type (Wright Short model): Rhythmic Bar and Beach
Volume p-level – 0.00 **TOF p-level –** 0.58







5.8.2 **Kaituna River West (CCS 33)**



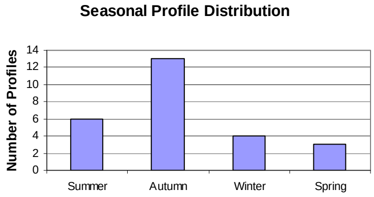
Discussion

The site is located 1.5km to the west of the Kaituna Cut. The 1978 photograph shows a heavily scarped frontal dune which is sparsely colonised by *spinifex*. The 2006 photograph shows a similar pattern of dune state. In the back dune area an exotic forest block has been developed, over hanging and slumped vegetation occupy the frontal dune face.

The profile history shows a significant retreat of the frontal dune position. There is approximately 6m of landward movement between 2002 and 2004 (evidenced by mid dune vegetation (*muelenbeckia*) having slumped onto the face of the frontal dune. The MWHS position chart also shows this beach translation. The 1992 profile shows no evidence of an offshore bar, the 1997 and 2003 profiles show a well developed offshore bar.

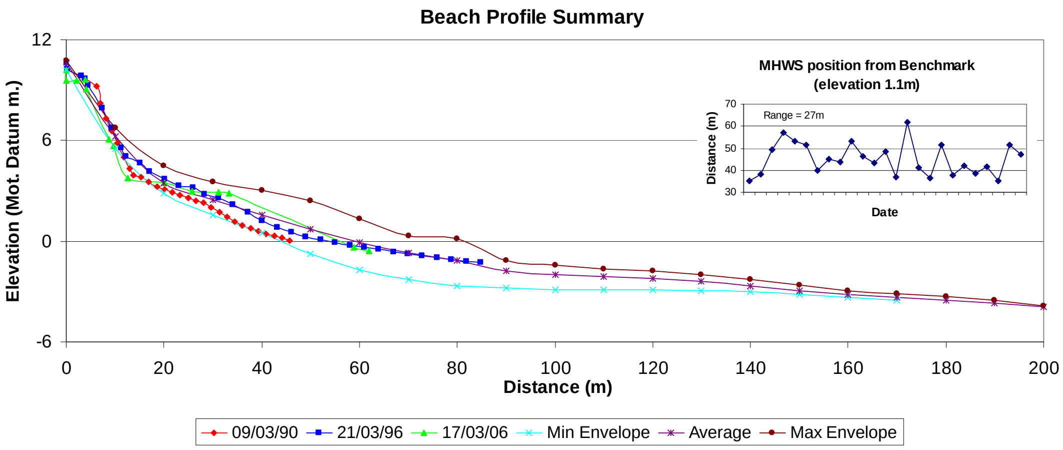
For the period of record analysed a state of *erosion* for the period of record is shown in the toe of foredune and beach volume records. For the section of beach from the Kaituna Cut to Papamoa Gibb (1994), a long-term trend (1903-1994) of shoreline retreat of approximately 14m, ranging from 6 to 22m, with short-term fluctuations of 10 to 20m increasing to 30 to 50m near the Kaituna River mouth.

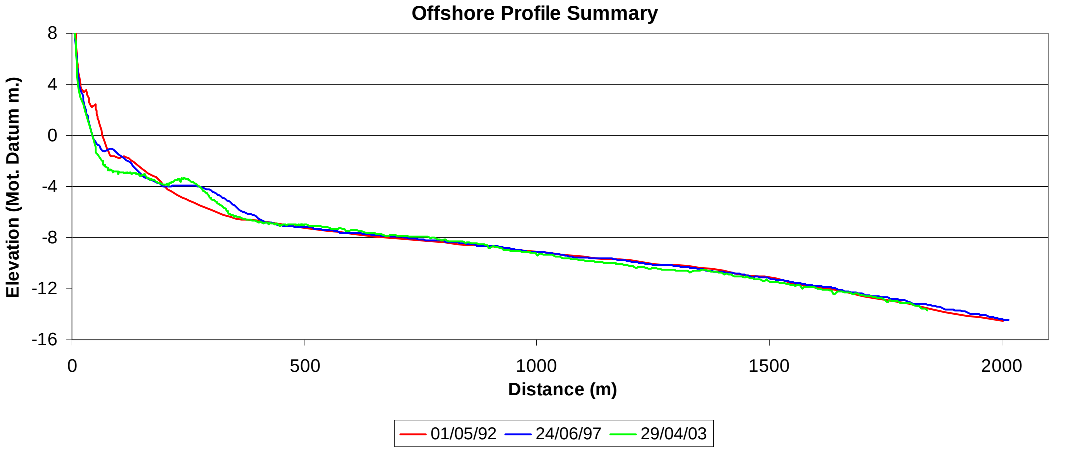
CCS 33 - Kaituna River West

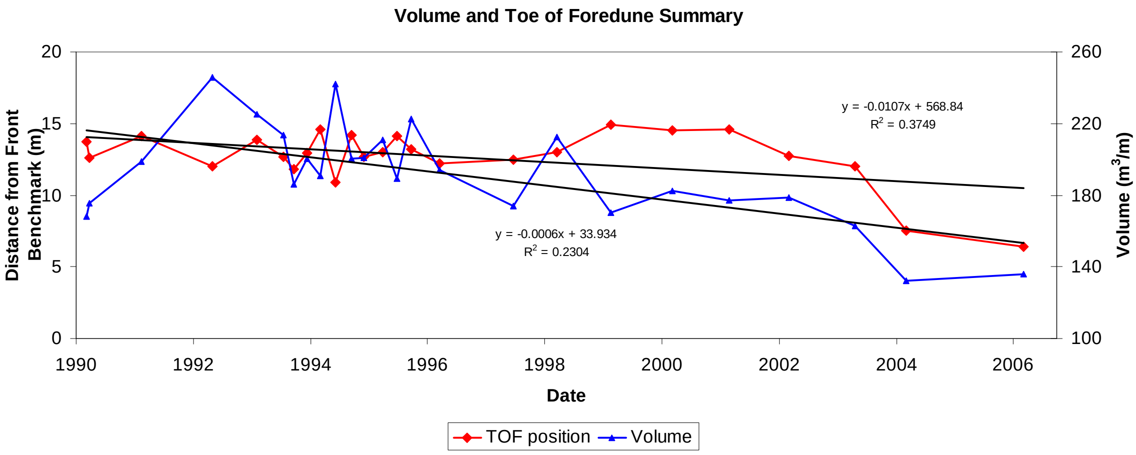


State: Erosion

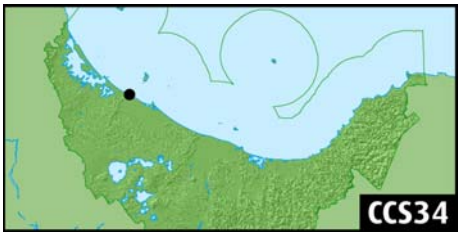
Location: NZMG 2809761E 6378789N
Period of record: 1990 – 2006
No.of profiles: 25
Morphodynamic type (Wright Short model): Transverse Bar and Rip
Volume p-level – 0.00 **TOF p-level –** 0.01







5.8.3 Taylor Street Papamoa (CCS 34)



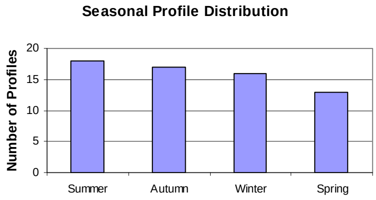
Discussion

This site is located at the western end of Taylor Street, which is at the eastern end of the Papamoa development. The Papamoa Beach system is an 8.8km-long sand beach bordering Holocene coastal plain of sand dunes. The foredune ranges from 30 to 50m in width and 4.7 to 13.0m above MHWS (Gibb, 1994). Analysis by Healy et al. (1977), Gibb (1994) and Hodges and Dealy (1997) indicate that the beaches are subject to cyclical erosion events with the frontal dune complex periodically exhibiting a strongly faceted foredune that is subject to blowouts. This pattern is seen in the photographs below. The 1978 image shows a poorly vegetated frontal dune with evidence of human and wind induced erosion. This has been reversed in the 2006 image with a well vegetated incipient frontal dune.

The profile dataset shows the dynamic nature of this section of beach. The offshore dataset shows a well developed offshore bar in the 1997 and 2003 profiles. In 1992 this feature was absent. Convergence occurs at -7m.

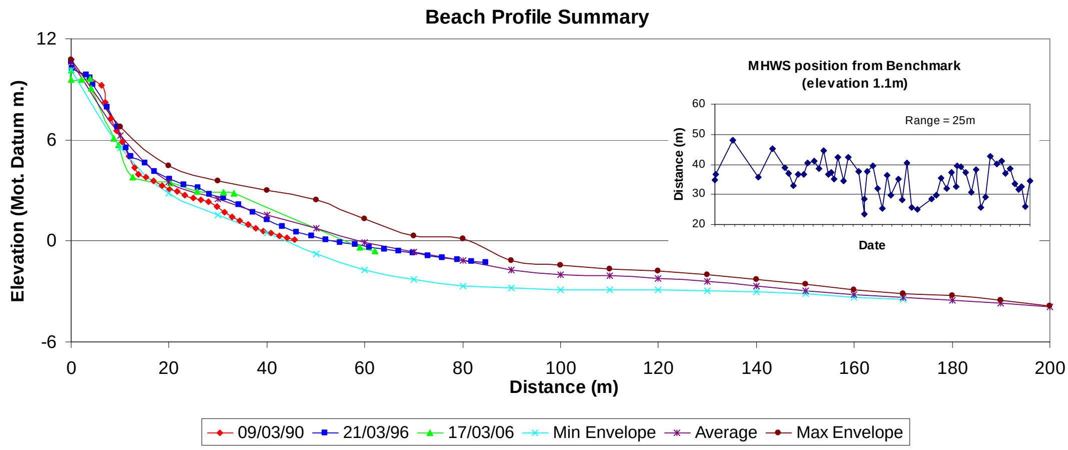
The trend analysis shows strong negative trends (erosion) in both the toe of foredune and volume datasets. For the section of beach from the Kaituna Cut to Papamoa Gibb (1994), a long-term trend (1903-1994) of shoreline retreat of approximately 14m, ranging from 6 to 22m, with short-term fluctuations of 10 to 20m.

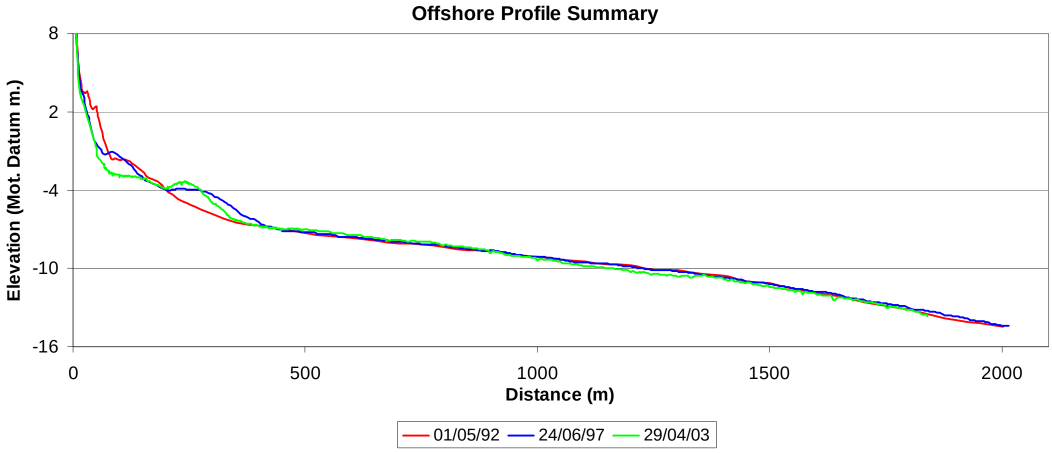
CCS 34 - Taylor Street Papamoa

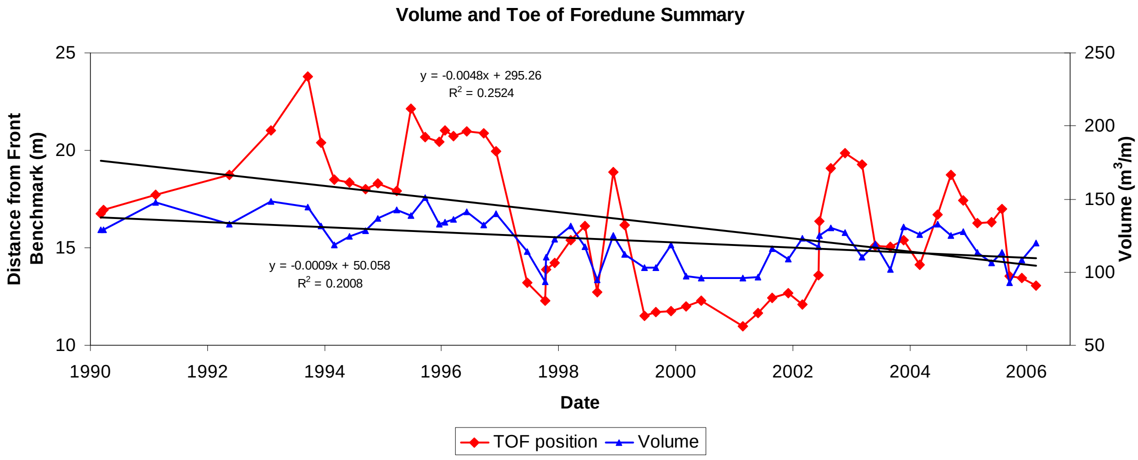


State: Erosion

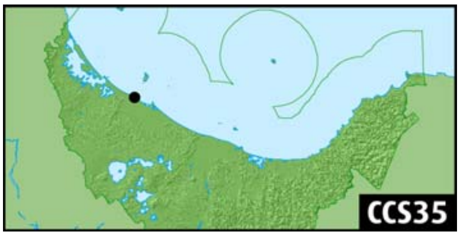
Location: NZMG 2803813E 6382419N
Period of record: 1990 – 2006
No. of profiles: 57
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.00 **TOF p-level –** 0.00







5.8.4 **Papamoa Beach (Hicksons) (CCS 35)**



Discussion

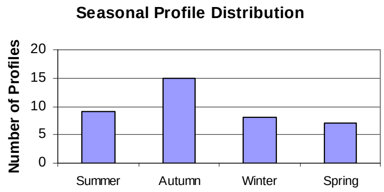
This site is located 600m east of the Papamoa development. This section is located in the lee of Motiti Island and as with the similar situation on the Rangitaiki Plains a cuspate foreland has formed as a result of long wave refraction around Motiti Island. For the 1978 photograph a generally prograding frontal dune is present, which is vegetated with Spinifex. Healy (1978) comments that at this time it was being grazed by cattle. The 2006 photograph also shows a prograding frontal dune which is well vegetated. The area behind the dune is currently undeveloped, hence human foot traffic through the frontal dune area is minimal, however the photograph highlights the popularity of vehicular traffic on this section of beach.

The beach profile record shows stability in the upper beach section. Berm development is episodic with the area of beach around 4m elevation showing marked changes in the selected profiles. The 1992 offshore profile appears erroneous as it diverges strongly from the 1997 and 2003 profile at depth. The convergence point for the later two profiles is at -7m.

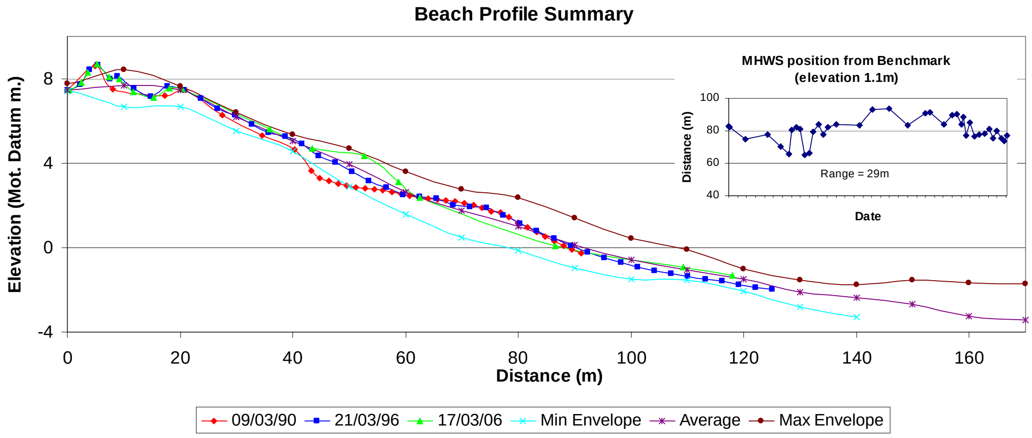
The trend analysis for this site shows a pattern *tending towards erosion* for the period of record. For the section of beach from the Kaituna Cut to Papamoa Gibb (1994), a long-term trend (1903-1994) of shoreline retreat of approximately 14m, ranging from 6 to 22m, with short-term fluctuations of 10 to 20m increasing to 30 to 50m near the Kaituna River mouth.

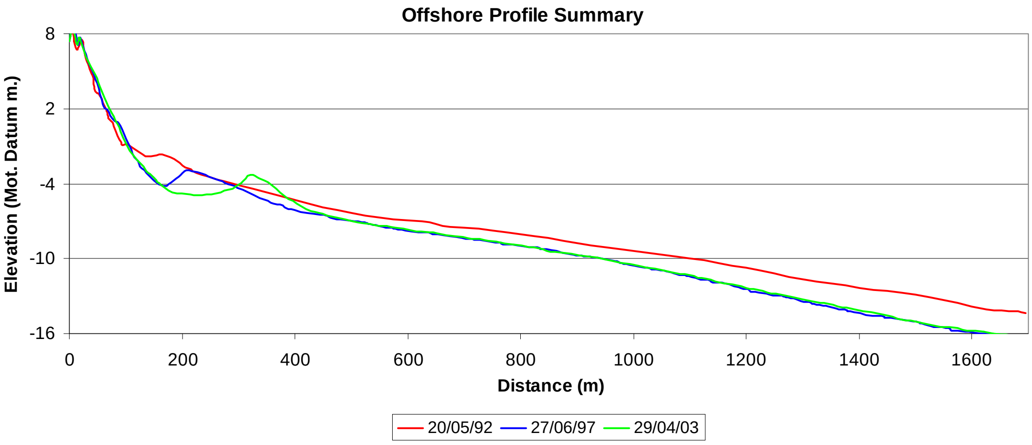
CCS 35- Papamoa Beach (Hicksons)

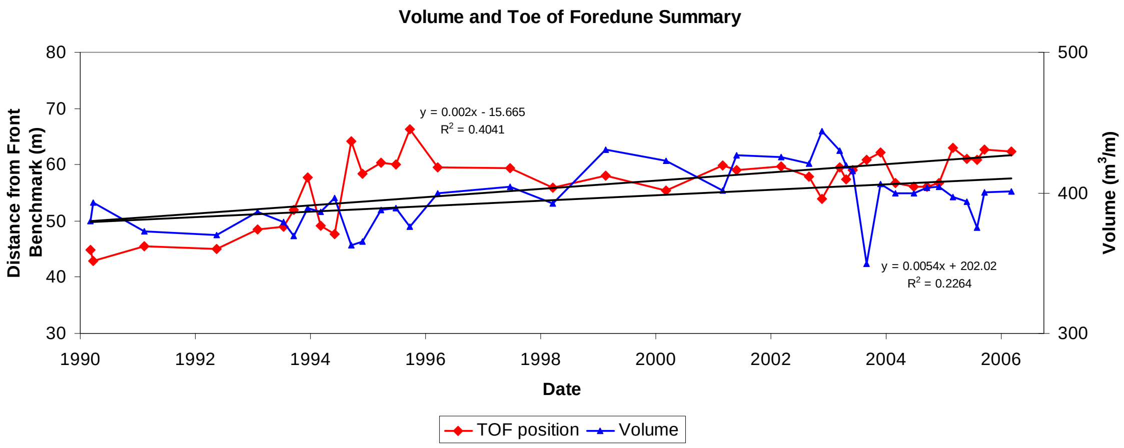
State: Accretion?



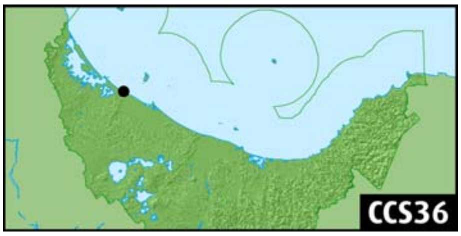
Location: NZMG 2806427E 6380928N
Period of record: 1990 – 2006
No. of profiles: 39
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.00 **TOF p-level** – 0.05







5.8.5 **Papamoa (CCS 36)**

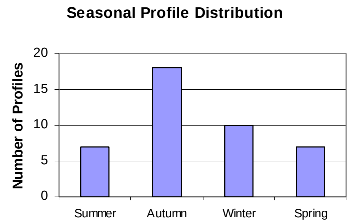


Discussion

This site is located centrally between Omanu and Papamoa beaches. A high (10m) frontal dune system is present. The site is approximately several hundred metres east of an old sand extraction site. The 1978 photograph shows the effect of pedestrian traffic through and across the frontal dune at this site. Wind erosion is also present. The 2006 photograph shows the development of a low incipient dune which is well covered with Spinifex. This site is located on the eastern edge of Papamoa Domain; Gibb (1996) stated that over the last 51 to 72 years the duneline has advanced at 0.10 to 0.33m/year.

The profile history shows a well developed berm profile in 1990. In 2006 the incipient dune is present but no berm development is measured. The MHWS position generally varies 10-15m showing the dynamic nature of the beach around 1m elevation. The maximum range of horizontal movement is 26m. The offshore profiles show only moderate to slight bar development. The 1992 profile diverges at depth suggesting questionable data beyond 400m offshore. The remaining two offshore profiles converge at approximately -6m.

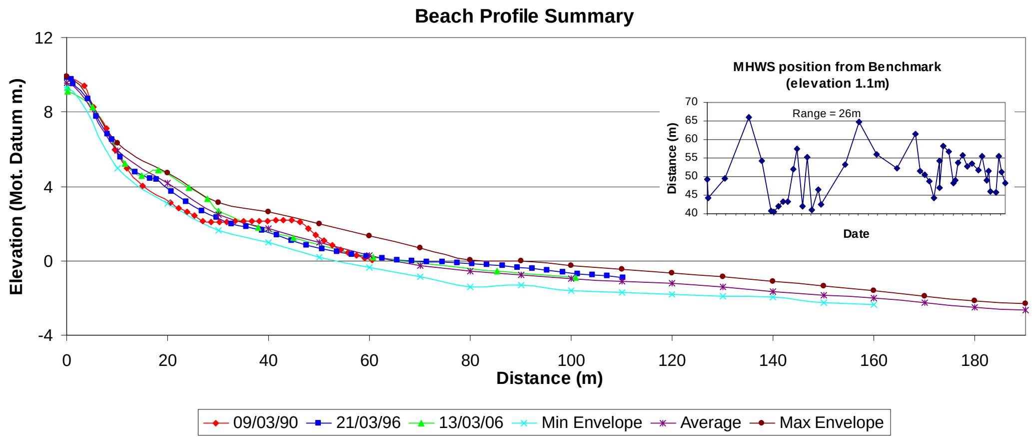
The statistical analysis shows an accumulation in beach volume for the period of record. The toe of foredune shows no trend, but fluctuates about and average position 26m from the benchmark. The state of the beach at this site is *tending towards accretion*.

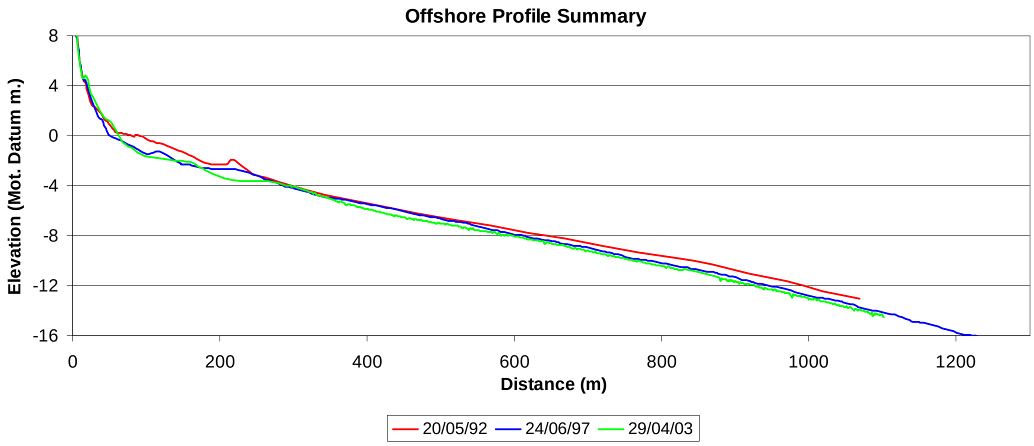


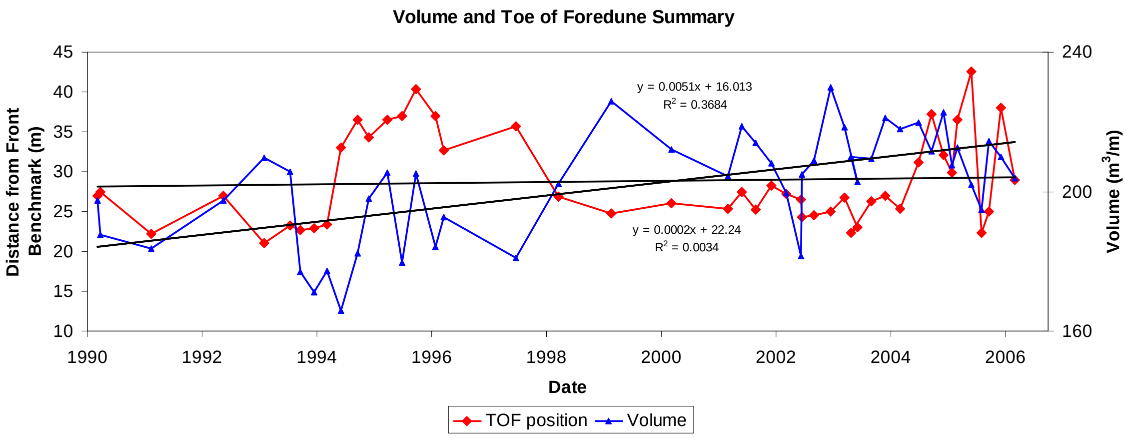
CCS 36 Papamoa

State: Accretion?

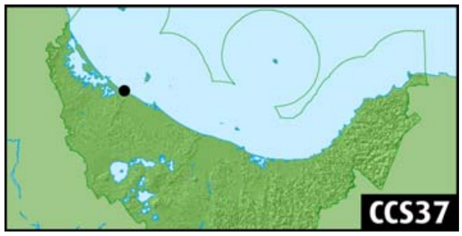
Location: NZMG 2800576E 6383931N
Period of record: 1990 – 2006
No.of profiles: 44
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.00 **TOF p-level –** 0.29







5.8.6 **Papamoa Surf Club (CCS 37)**

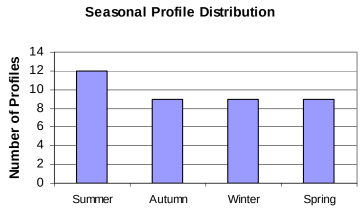


Discussion

This site is located in front of the Papamoa Surf Club at the Papamoa Domain, 100m east of the beach front carpark. It is one of the Dune Care programme sites. The 1978 photograph shows that this section of beach is popular for recreational activities, and the foredune reflects the effects of human traffic with large areas exhibiting loss of vegetation and resulting blowouts caused by wind erosion. The 2006 photograph shows the development that has taken place in the bach dune area. Portions of the frontal dune have also been retired from human traffic and exhibit thriving populations of *spinifex* and *pingao*.

This site was installed in 1996 when the dune care work was initiated. The profile history shows a stable dune and upper beach area. Moderate berm development can be seen in the 2006 profile. The envelope plots show a tight band for the measured record, with only 1-2 m of vertical movement measured above the MSL position.

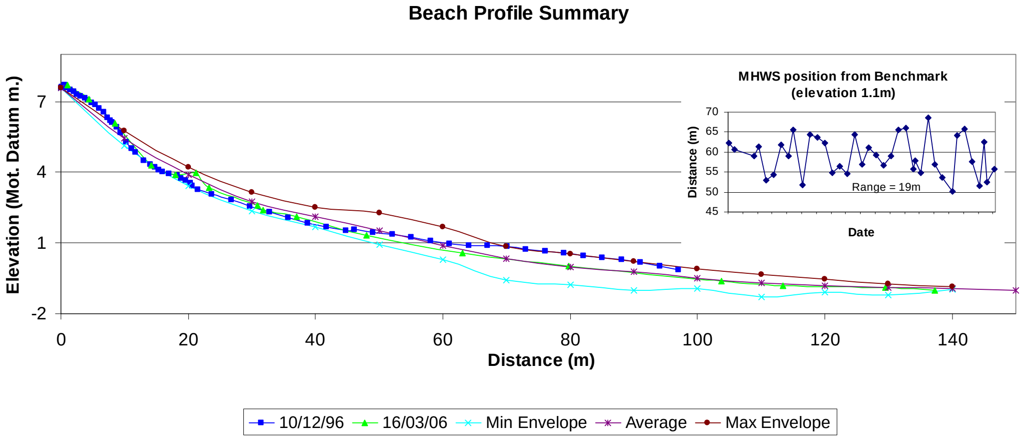
The analysis of the volume shows no strong trend and points to the beach at this section being in a stable state. The toe of foredune analysis shows a seaward movement of this position by up to 5m, signalling an *accretionary trend*. This site is located in the central region of the Papamoa Domain. In 1996, Gibb stated that over the last 51 to 72 years the Domain duneline has advanced at 0.10 to 0.33m/year.

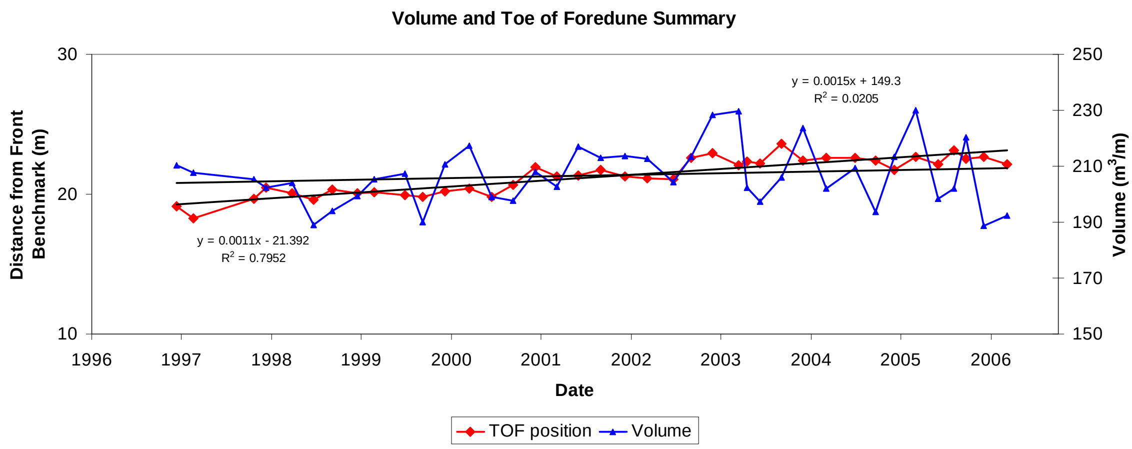


CCS 37 Papamoa Surf Club

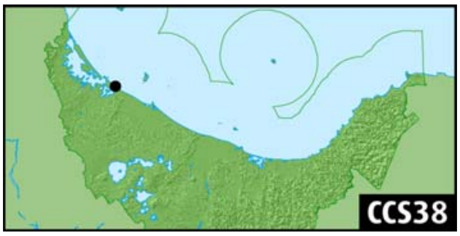
State: Accretion?

Location: NZMG 279990E 638430N
Period of record: 1996 – 2006
No. of profiles: 39
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.38 **TOF p-level –** 0.00





5.8.7 **Te Maunga (CCS 38)**



Discussion

This site is situated 100m to the east of Sunbrae Grove, 8km from Mt Maunganui. This site is within the 11.9km section of sand beach bordering the Holocene coastal plain of sand dunes between Papamoa and Omanu. The foredune is typically 30 to 50m wide and 4.7 to 9.7m above MHWS. The 1978 photograph shows a frontal dune faceted with slumped and accumulated sand being vegetated by colonising spinifex runners. There is no berm development present (Healy, 1978). The 2006 photograph shows a steeply angled eroded dune face with overhanging vegetation.

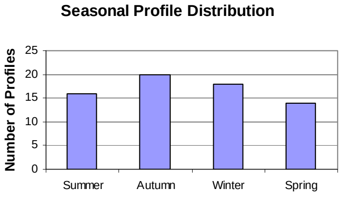
The profile history shows a variable lower beach profile. The 1990 profile shows evidence of a berm with a crest at 2m. This feature is absent in the other two representative profiles. The 2006 profile shows a dune face retreat of up to 5m when compared with the 1996 position. The MHWS position has reduced in variability, for the last 10 years it has fluctuated approximately 5m around an average position 70m from the benchmark.

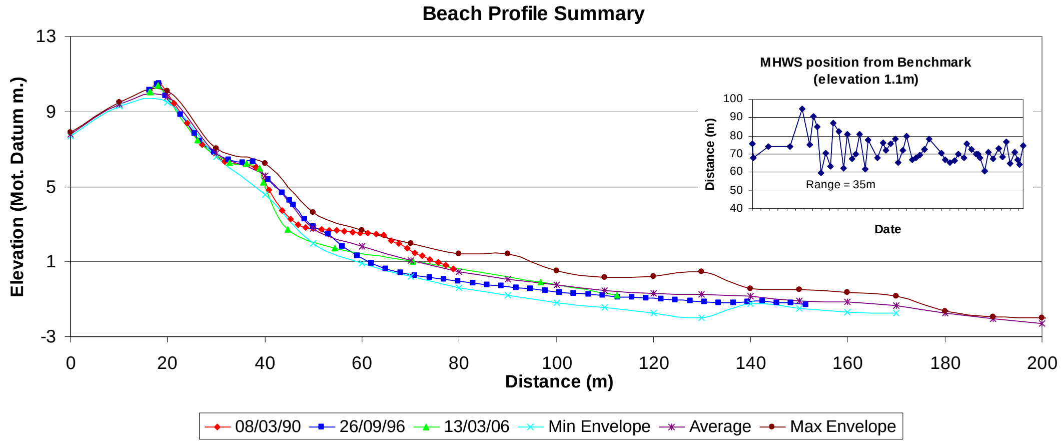
The statistical trend analysis shows this profile site is in a state moving towards erosion. The toe of foredune record shows a significant retreating pattern. The beach volume trend is not a strong as material removed from the upper beach is deposited in the lower beach area (around MSL) hence showing only a slight negative net change in the overall profile.

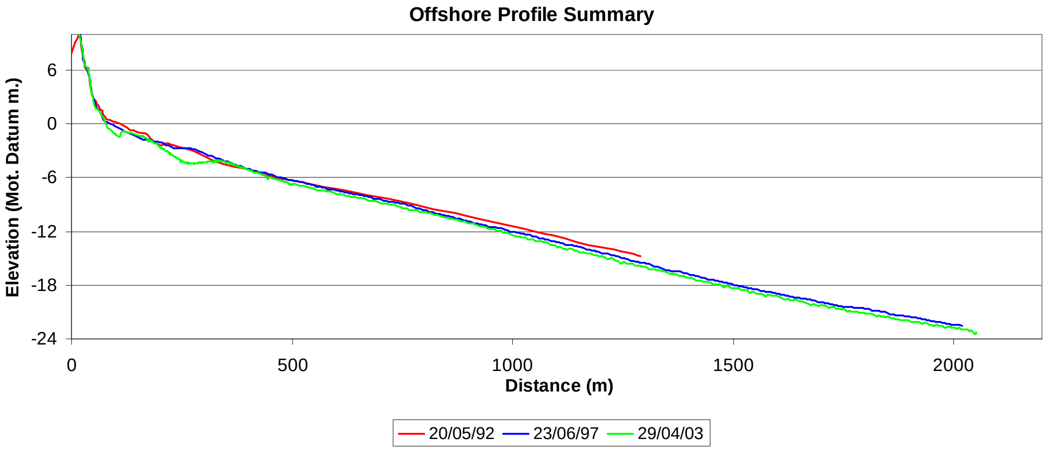
CCS 38 Te Maunga

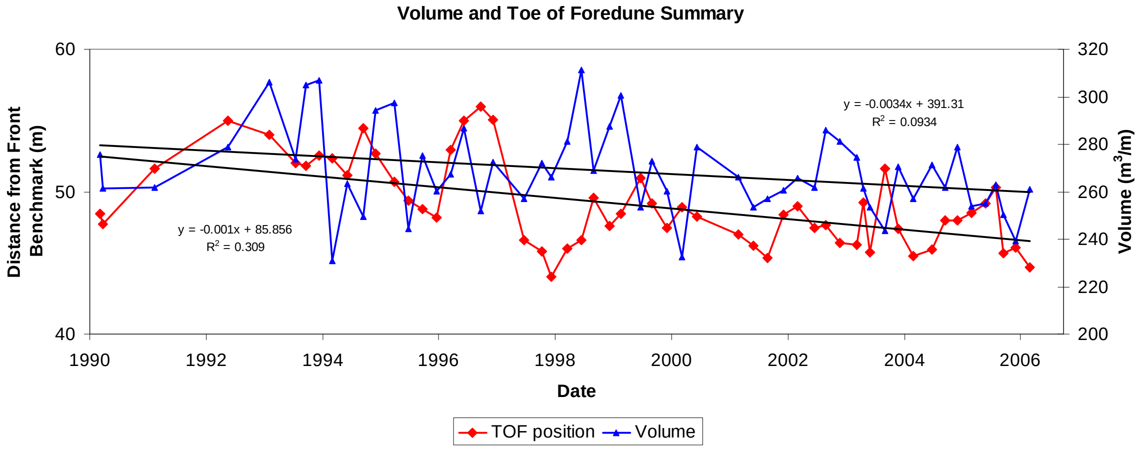
State: Erosion?

Location: NZMG 2796350E 6386548N
Period of record: 1990 – 2006
No. of profiles: 65
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.02 **TOF p-level** – 0.00









5.8.8 **Mt Maunganui East (CCS 39)**

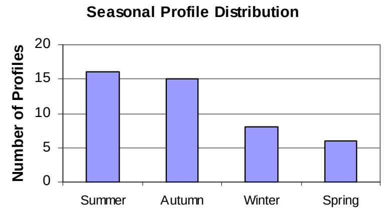
Discussion

This site is located 200m to the west of the recently installed Tay Street artificial reef, 2.7km from Mt Maunganui. This section is described as 4.6km-long sand beach bordering Holocene sand dunes forming the Mount Maunganui tombolo (Gibb, 1994). The 1978 photograph shows a gently sloping prograding frontal dune with a spinifex vegetative cover. The 2006 photograph shows a similar profile, with a higher density of spinifex coverage. Both photographs show a wide high tide beach with evidence of wind blown sand deposits.

The profile history shows a retreat of the frontal dune toe. The 2006 profile show a more gently sloping frontal dune when compared with the 1990 and 1996 profiles. The minimum envelope positions show that during certain times the beach can retreat vertically (up to 2m in some mid beach parts of the profile). The offshore profile record a zone within 500m of the shore that dynamic bar development. The 1992 profile diverges from the latter two which suggest an erroneous dataset. The remaining two profiles converge at -12m.

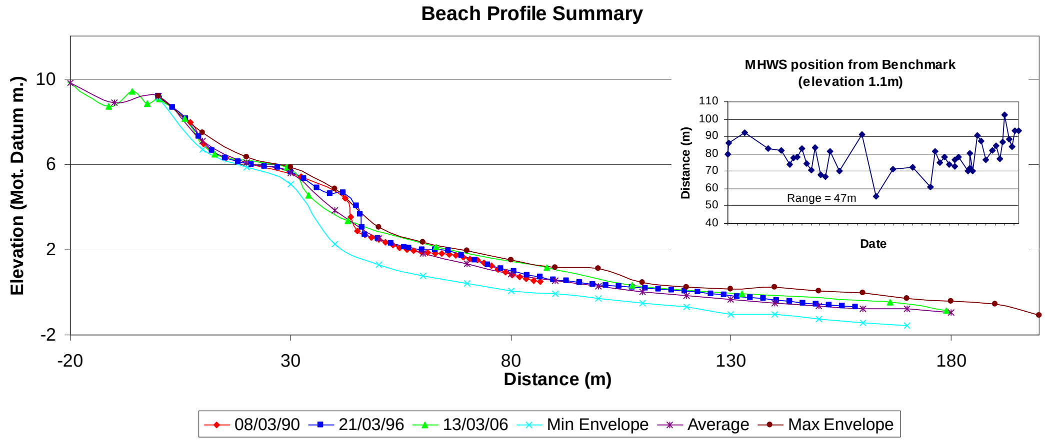
The toe of foredune position dataset statistically shows a retreat. The volume time series trend is less dominant. This combination gives a *state tending towards erosion* for the last 16 years of recorded profiles. This site is adjacent to the newly erected artificial reef and thus will be a key site for monitoring the effect this structure has on the surrounding coastline.

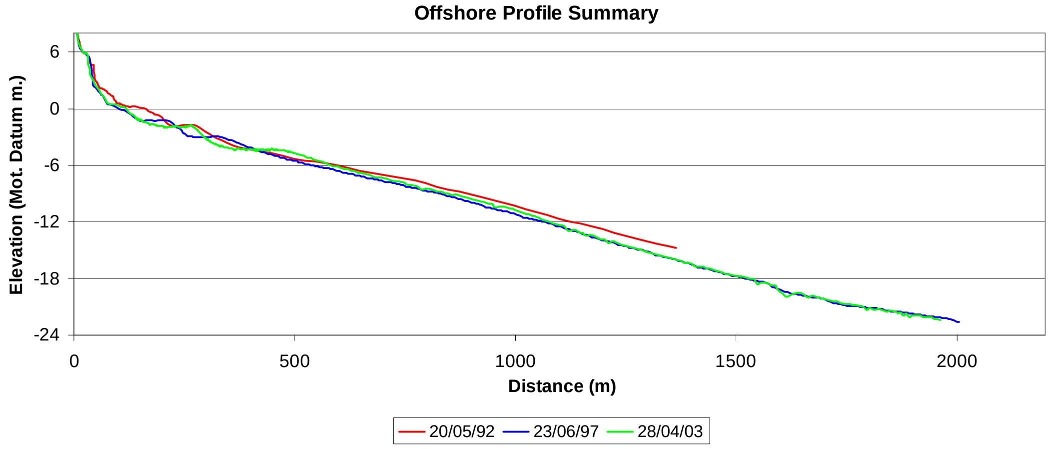
CCS 39 Mt Maunganui East

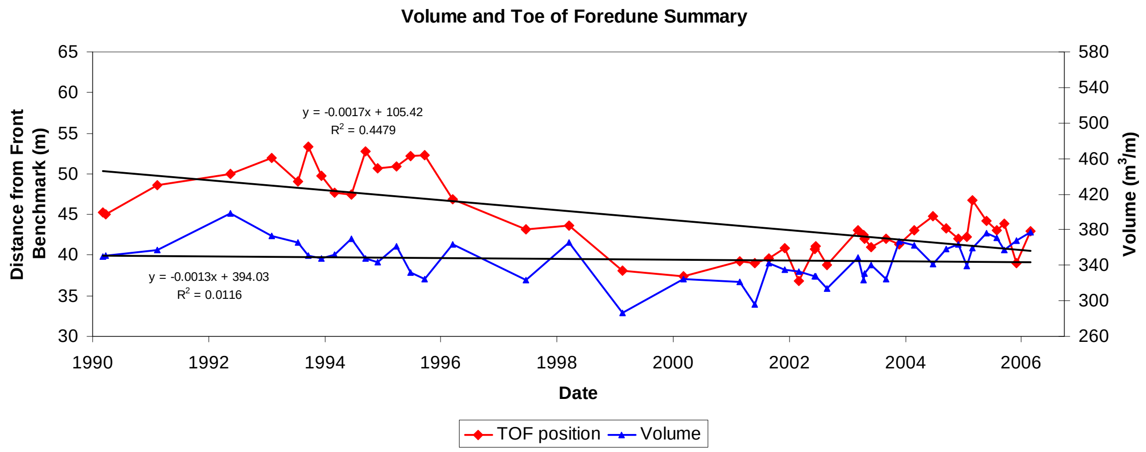


State: Erosion?

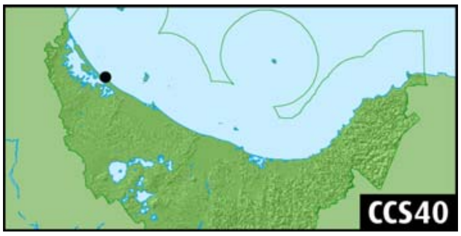
Location: NZMG 2792312E 6390219N
Period of record: 1990 – 2006
No. of profiles: 46
Morphodynamic type (Wright Short model): Rhythmic Bar and Beach
Volume p-level – 0.43 **TOF p-level –** 0.00







5.8.9 **Mt Maunganui (CCS 40)**

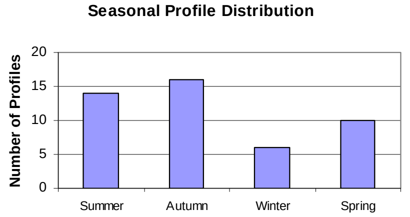


Discussion

This site is located at the base of Mt Maunganui and is arguably one of the most popular and well recognised sections of open coast beach in New Zealand. Recently this section of beach is regularly groomed (see patterns in 2006 photograph) and is replenished by material moving onshore from the harbour dredge spoil dumping sites located several kilometres offshore.

The profile record shows the development of the "frontal dune". Recently this feature has undergone extensive re-vegetation with native species as part of the local Dune Care programme. This dataset shows the strong vertical development of the mid to lower section of the nearshore beach profile. This trend is also reflected in the MHWS plot showing a seaward movement in this commonly referred to position. The offshore profile record converges at -9m. The earlier 1992 profile shows a marked change in slope at -14m.

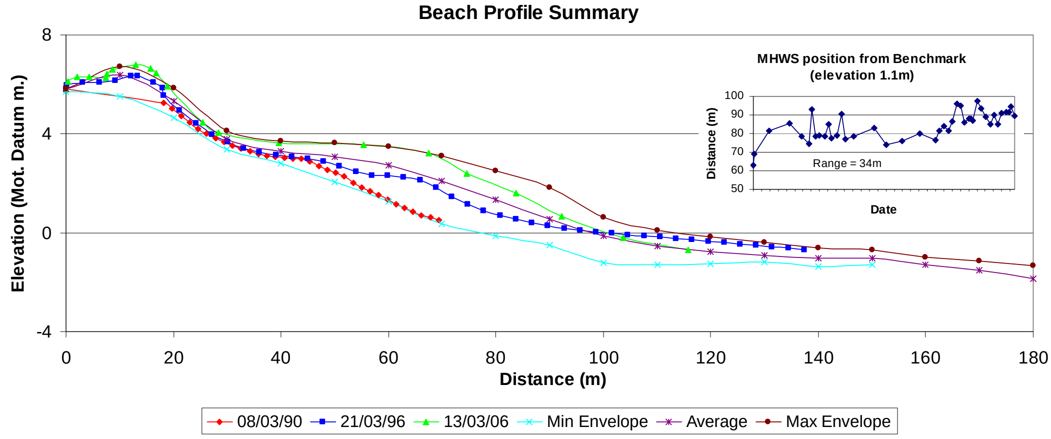
The calculated volume record shows a strong positive timeseries which would be a reflection of the positive onshore sediment supply as a result of spoil dumping ground. This process has been further investigated and explained by the MSc thesis undertaken by Foster (1991). The toe of foredune position shows a very slight negative trend, which reflects the high levels of human traffic and occupation during the summer months. This trend should now change to one similar to that of the volume with the re-vegatation and the retiring of this area from public access.

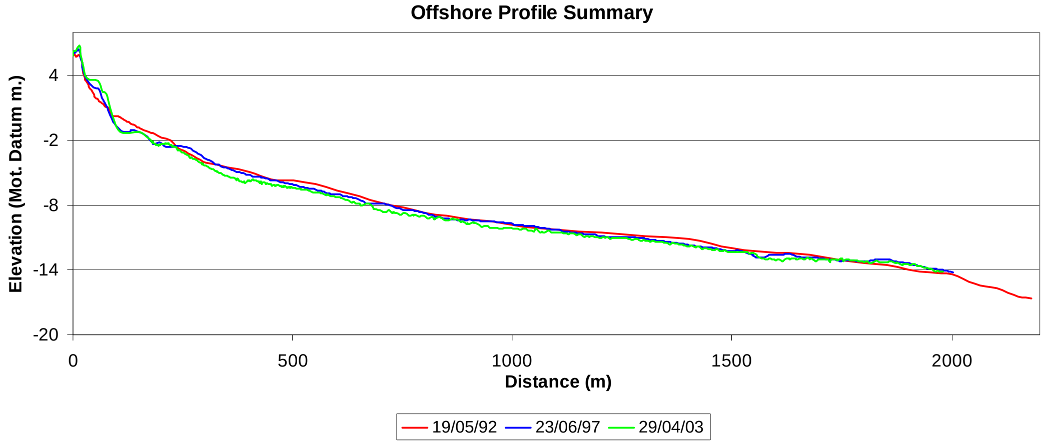


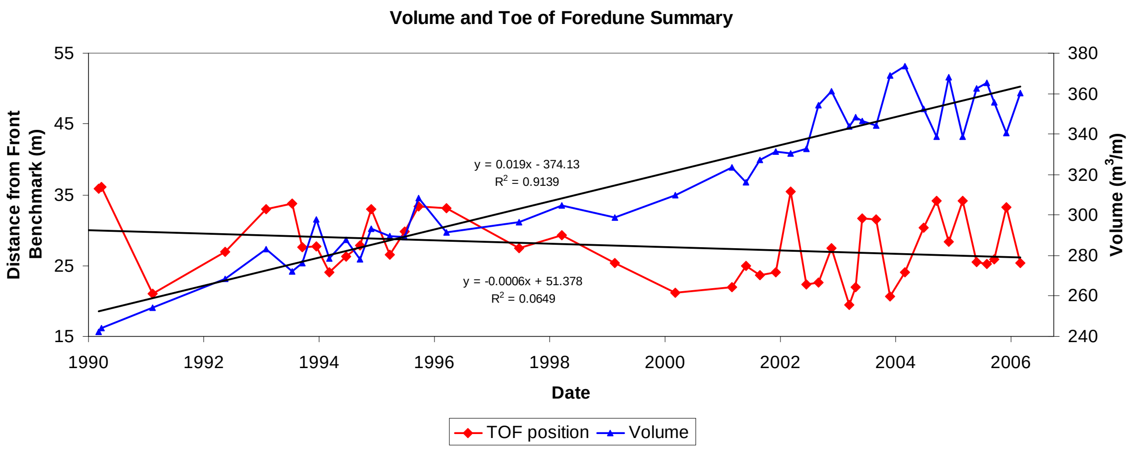
CCS 40 Mt Maunganui

State: Accretion?

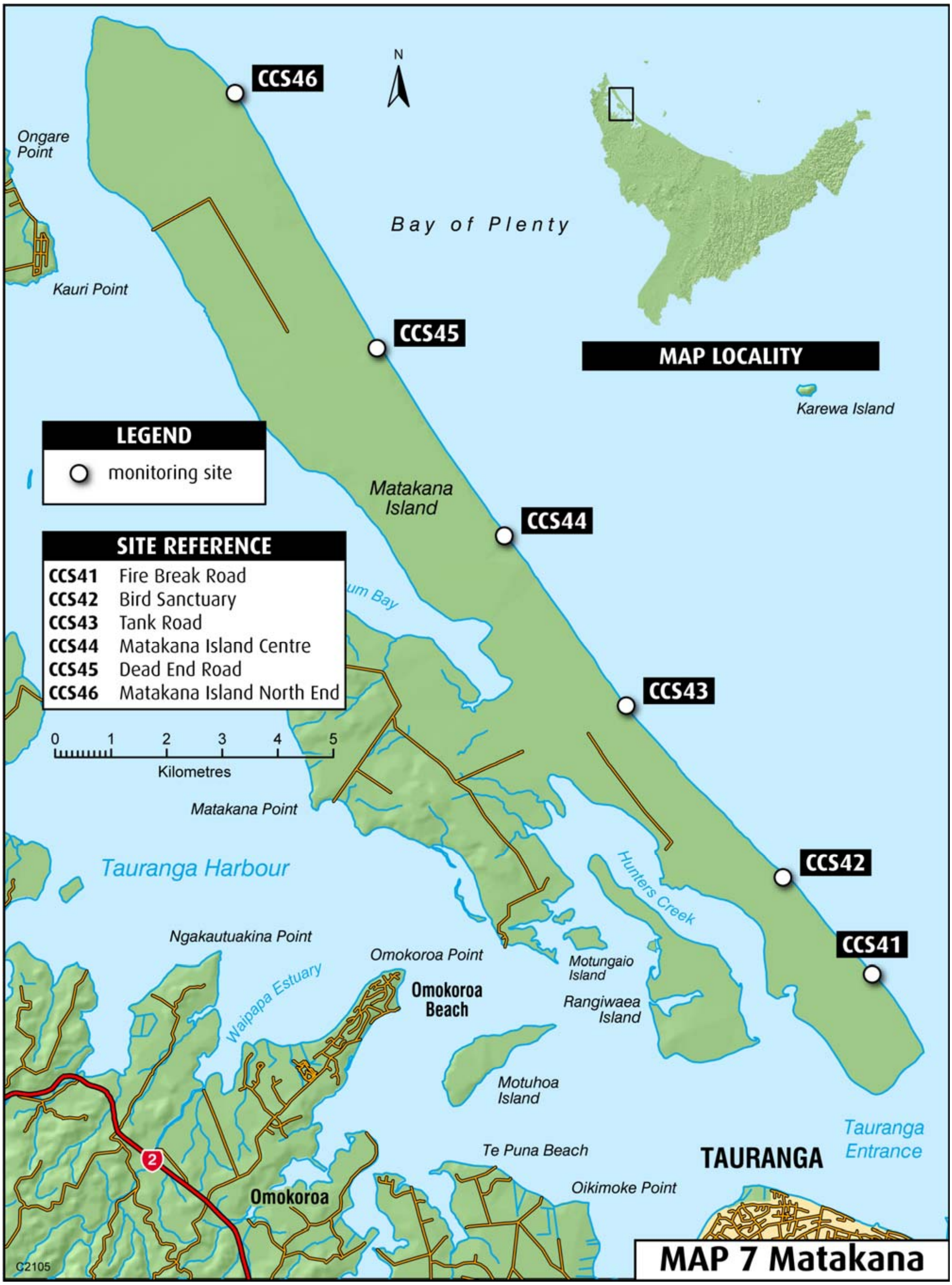
Location: NZMG 2790869E 6391677N
Period of record: 1990 – 2006
No.of profiles: 43
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.00 **TOF p-level –** 0.10



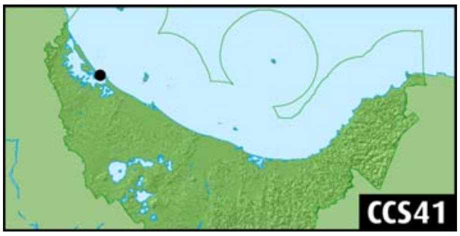




5.9 Matakana Beach system



5.9.1 **Fire Break Road (CCS 41)**



Discussion

This site is located 2km from the Tauranga Harbour tidal inlet at the southern end of the barrier island. The physical characteristics of this site are dominated by the ebb tidal delta and the sediment transfer between this delta and the adjacent open coast beach. The island is dominated by exotic forestry on the open coast side. This forestry occupies land right to the seaward edge of the frontal dune. In many places the foredune has been altered by trees falling onto the upper beach section.

Due to access issues and the lack of residential development on the open coast side of the barrier this site has only been profiled annually (typically in March).

The nearshore beach profile record shows a low tide terrace form. The early 1992 profile shows a very well developed berm which becomes absent in the later two representative profiles (1996 and 2006). These later profiles show a stable upper beach but a marked loss in the swash zone for the 1996 profile, with a steepening in this zone. The 2006 profile shows a recovery although the profile stops short of the MSL position. The MHWS position plot shows a variation on elevation of 31m over the 16 year period. These trends show that sediment supply at this site is dynamic and a result of exchanges with the nearby ebb delta.

This pattern of sediment flux is further reinforced by the offshore profile record with striking changes occurring to the seaward extent of each of these profiles. The 1992 profile shows an abrupt elevation decrease at 1600m. Variations in the profiles occurs all the way to 2500m (elevation -12m) unlike other sites along the coast where changes are less detectable once an elevation -8m is reached.

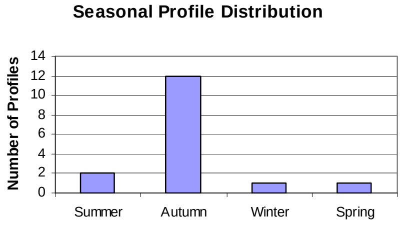
The trends in the toe of foredune position and beach volume are not statistically significant leading to a stable beach state. The toe of foredune position exhibited a strong seaward movement from 2000 to 2003 with a positional change of approximately +15m.

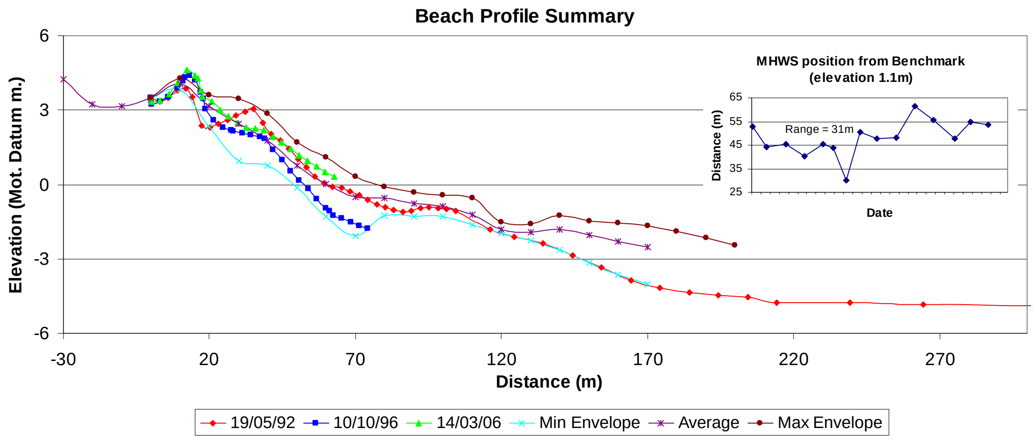
No photography is available for this site.

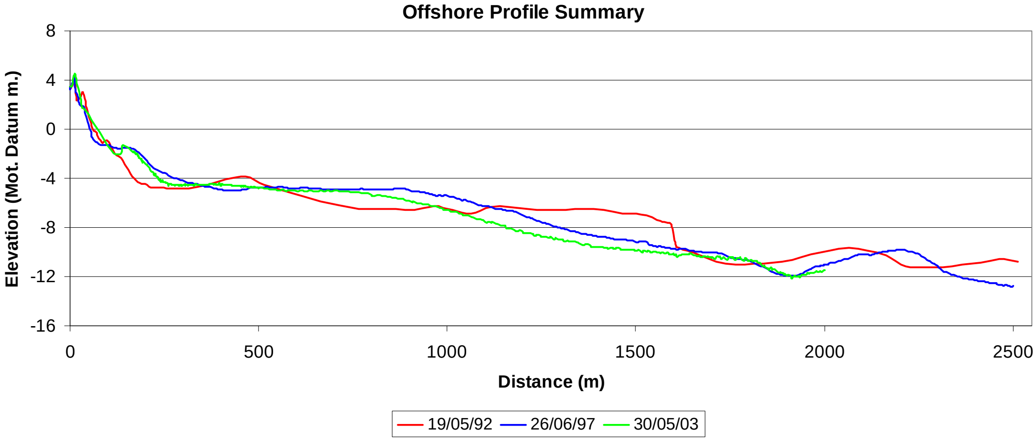
CCS41 Fire Break Road

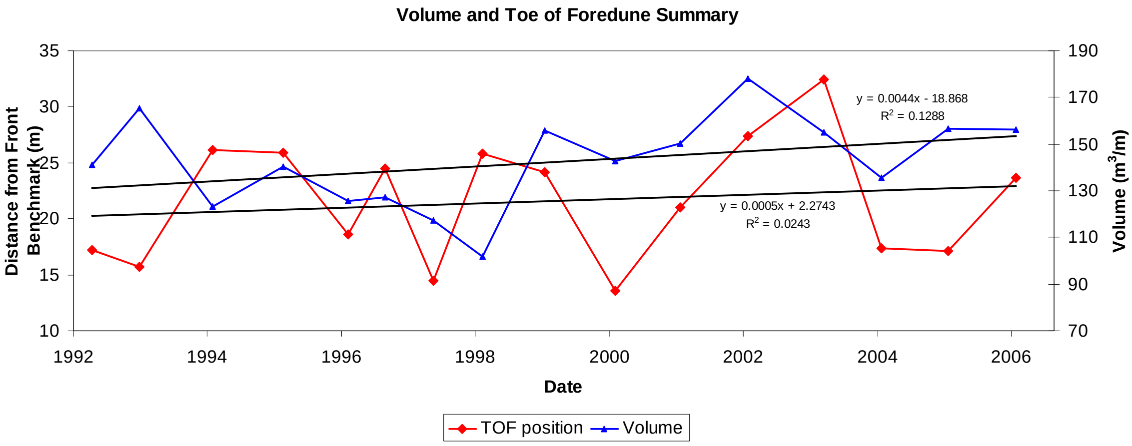
State: Stable

Location: NZMG 2788155E 6392681N
Period of record: 1992 – 2006
No. of profiles: 16
Morphodynamic type (Wright Short model): Low Tide Terrace
Volume p-level – 0.17 **TOF p-level –** 0.57

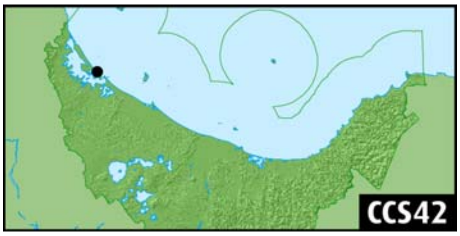








5.9.2 Bird Sanctuary (CCS 42)



Discussion

This site is located 4km from the Tauranga Harbour tidal inlet. Like CCS41 and the other four sites on the barrier, this site is backed by exotic pine forestry.

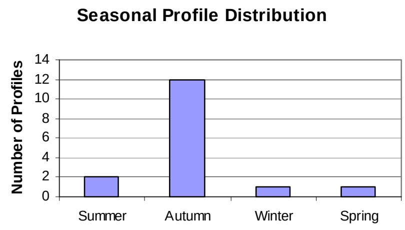
The profile history plot shows a pattern of erosion, with 40m of landward movement of the foredune. The MHWS position shows a range of 49m of movement. The envelope plots show this section of beach to be in its most landward position for the 14 years of measured record.

The offshore profiles show a large dominant offshore bar structure which varies in position by several hundred metres. The size of this bar is a reflection of the state of the upper beach (erosional) and would be partially affected by sediment supply for the tidal delta. The 1992 profile diverges at depth suggest erroneous data for the seaward section. The 1997 and 2003 profiles converge at a depth of -8m, 800m offshore.

The statistical analysis shows strong test results for both beach volume and toe of foredune position, coupled with negative slopes; the resulting trend for this profile section is one of erosion.

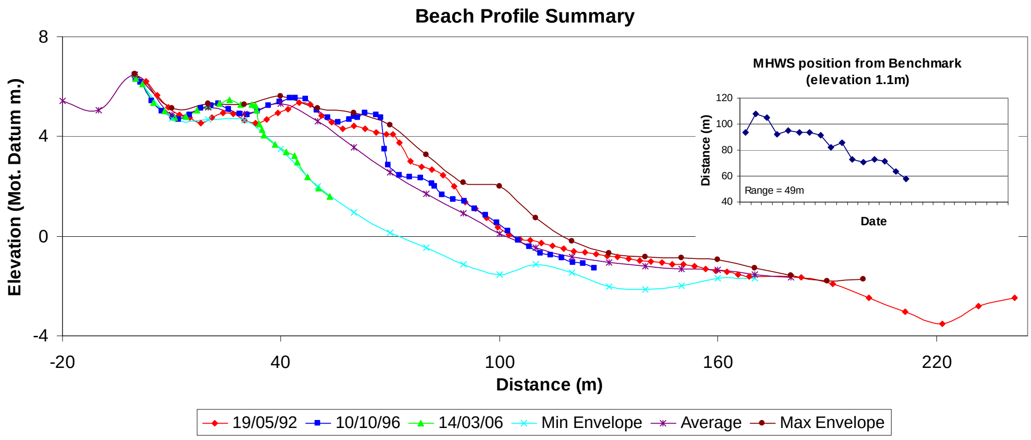
No photography is available for this site.

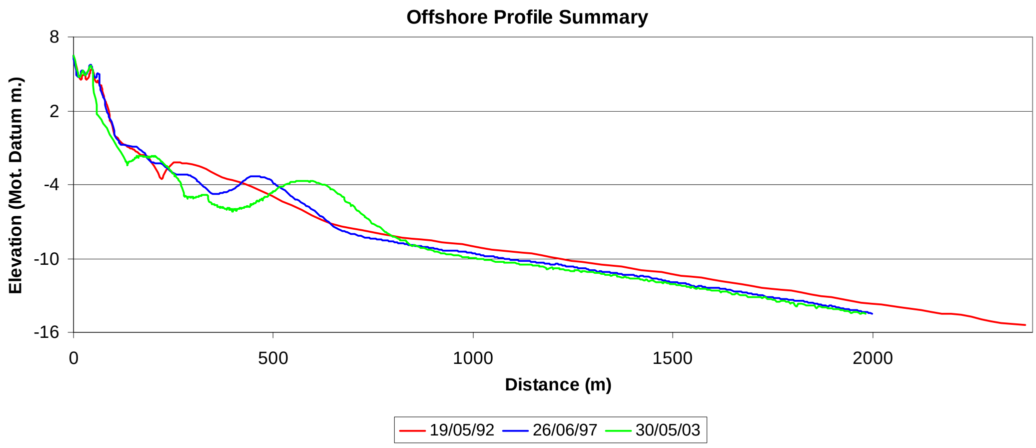
CCS 42 Bird Sanctuary

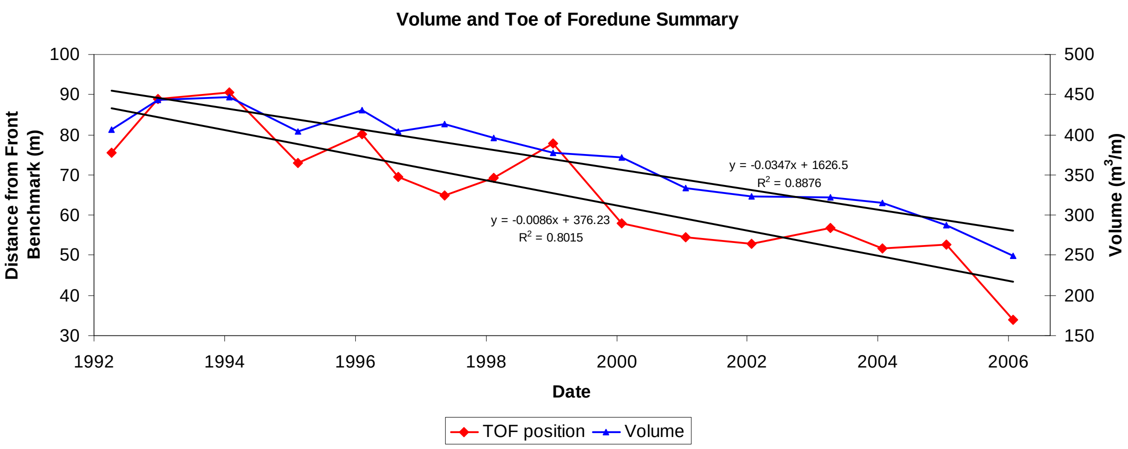


State: Erosion

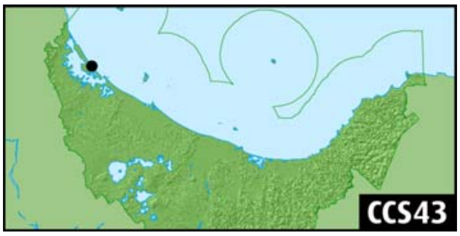
Location: NZMG 2786546E 6394424N
Period of record: 1992 – 2006
No. of profiles: 16
Morphodynamic type (Wright Short model): Transverse Bar and Rip
Volume p-level – 0.00 **TOF p-level –** 0.00







5.9.3 **Tank Road (CCS 43)**



Discussion

This site is located 7km from the Tauranga Harbour tidal inlet in the middle section of the barrier.

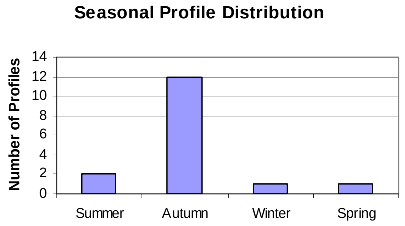
The profile record for this site shows a reversal of the patterns exhibited by CCS42. The latest 2006 profile shows the beach to be it most seaward position in the last 14 years although the profile finishes unusually short of the normal minimum MSL finishing position. The 1996 profile is the most landward position in the recorded dataset following a period of erosion where the berm and mid beach zone experienced sediment loss. The MHWS position plot also reflects this trend but more recently is showing a positive seaward position.

The offshore profiles show similar patterns and slopes for the entirety of the measured section (up to 2km offshore). Slight divergence at depth is shown in the 1992 plot. Convergence of all three profiles occurs shortly after the less dynamic offshore bar section approximately 500m offshore at a depth of approximately -6m.

The statistical analysis of the volume record and toe of foredune position indicates a *state heading towards accretion*. The test result for the volume is strong coupled with a positive regression slope. The variability in the toe of foredune position results in a less significant test result.

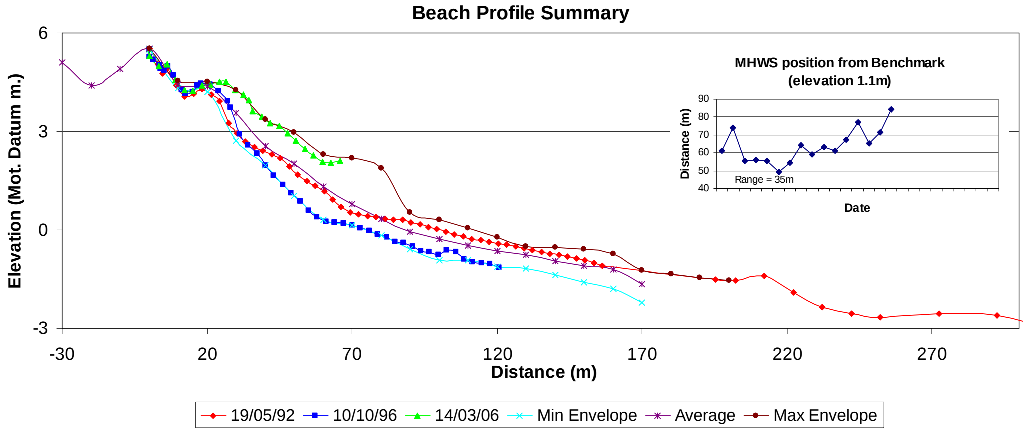
No photography is available for this site.

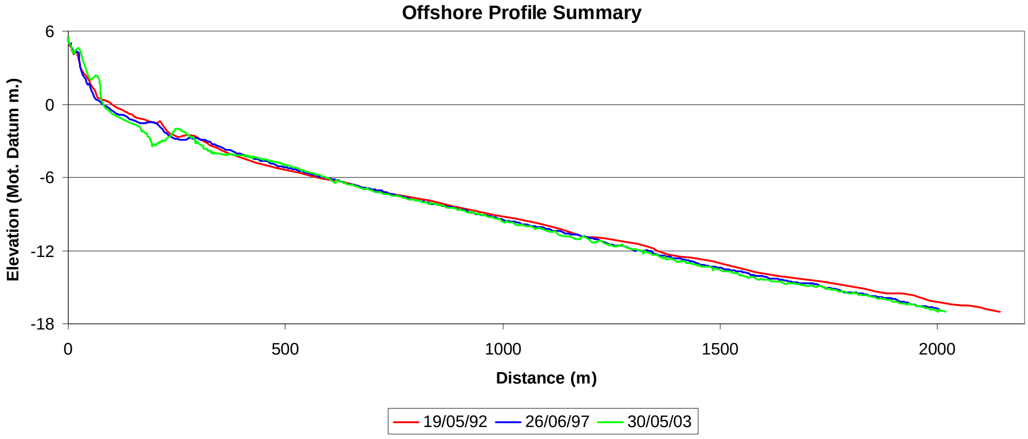
CCS 43 Tank Road

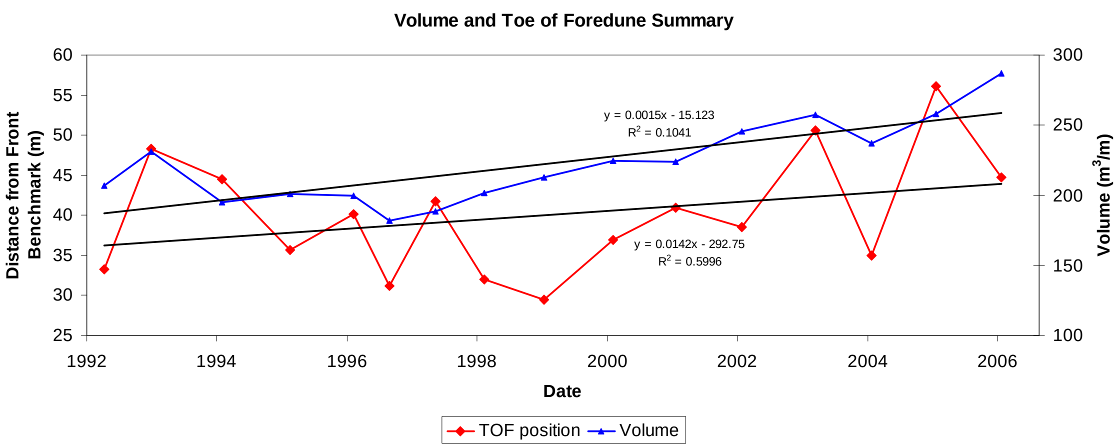


State: Accretion?

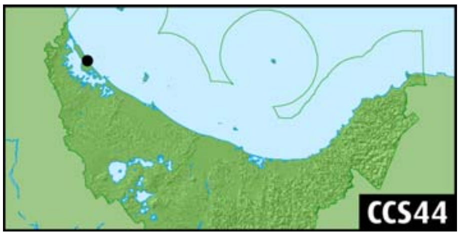
Location: NZMG 2783722E 6397525N
Period of record: 1992 – 2006
No. of profiles: 16
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.00 **TOF p-level –** 0.22







5.9.4 **Matakana Island Centre (CCS 44)**



Discussion

This site is located 12km from the Tauranga Harbour tidal inlet in a central position along the barrier island.

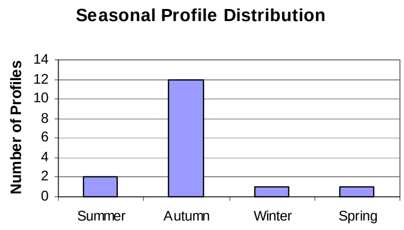
The profile history shows a tighter grouping of profiles with less variability at this site when compared with sites to the east on the barrier island. The 2006 profile is the most seaward of the recorded dataset.

The offshore profiles also reflect this pattern of low variability; once again the 1992 profile diverges with depth and should thus be used with caution. The 1997 and 2003 profiles mirror each other for the entirety of the profiles out to the endpoint at ~2000m offshore. Only slight offshore bar development is shown to occur at this site and is a reflection of the stable nature of the onshore profile sections.

Statistical p-tests and also regression analysis shows that this section of beach is in a stable state.

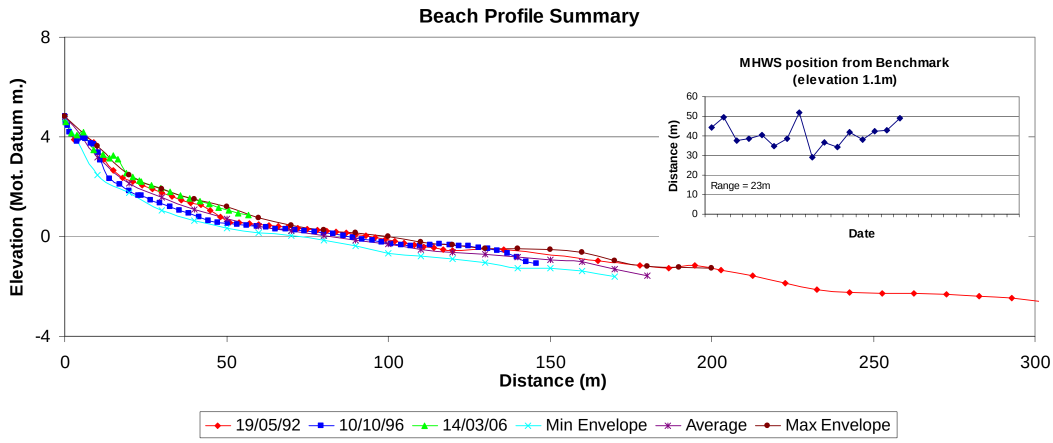
No photography is available for this site.

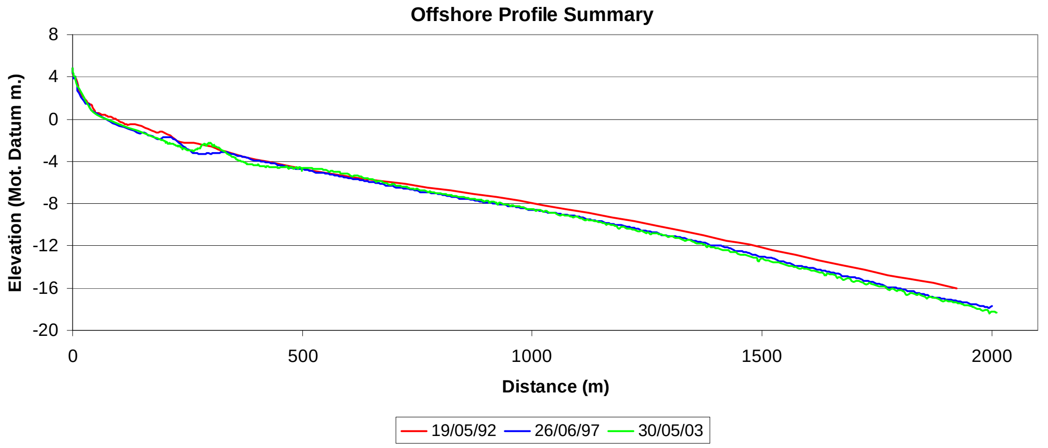
CCS 44 Matakana Island Centre

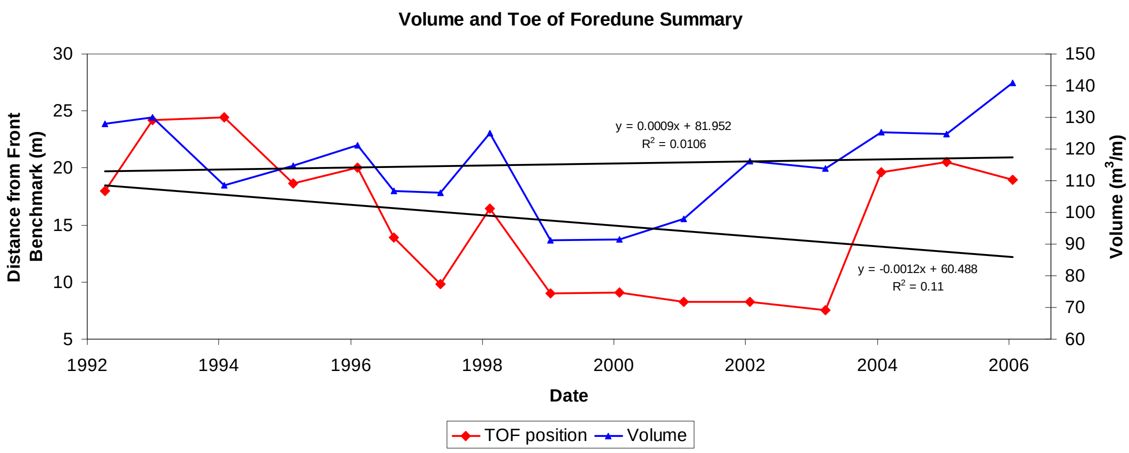


State: Stable

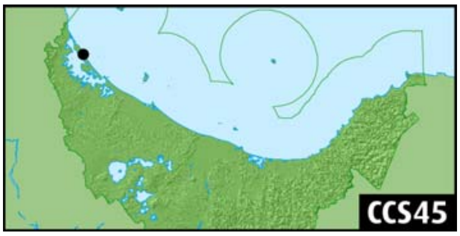
Location: NZMG 2781534E 6400587N
Period of record: 1992 – 2006
No. of profiles: 16
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.71 **TOF p-level –** 0.29







5.9.5 **Dead End Road (CCS 45)**



Discussion

This site is located 7km from the Tauranga Harbour northern entrance at Bowentown.

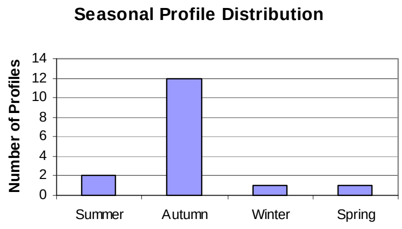
The profile history shows a tighter grouping of profiles with less variability at this site when compared with sites to the east on the barrier island. The 2006 profile is the most seaward of the recorded dataset.

The offshore profiles also reflect this pattern of low variability. All three profiles converge at -7m. Interestingly they then diverge at 1200m and continue to for the remainder of the measured profile. Only slight offshore bar development is shown to occur at this site and is a reflection of the stable nature of the onshore profile sections.

Statistical p-tests and also regression analysis shows that this section of beach is in a *stable state*.

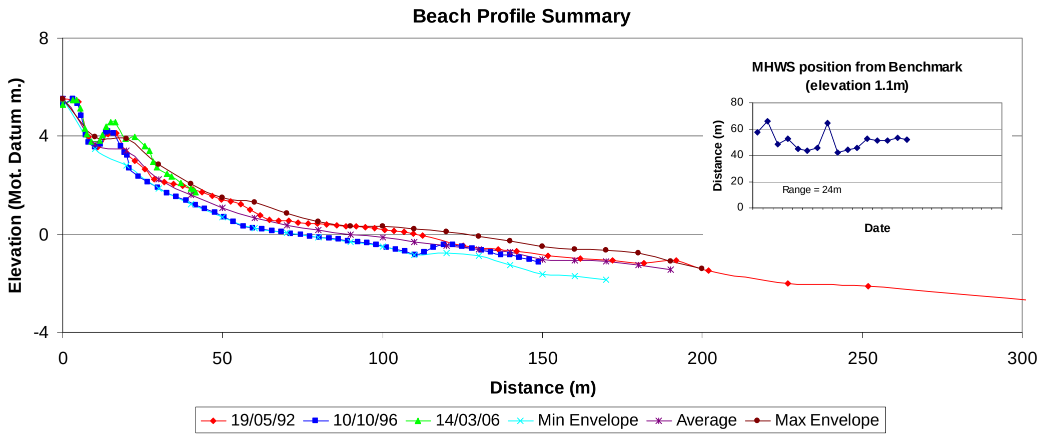
No photography is available for this site.

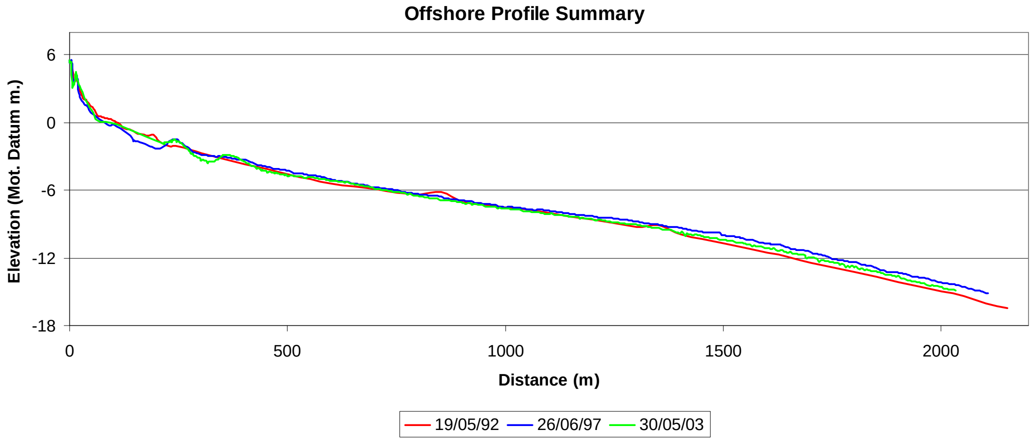
CCS 45 Dead End Road

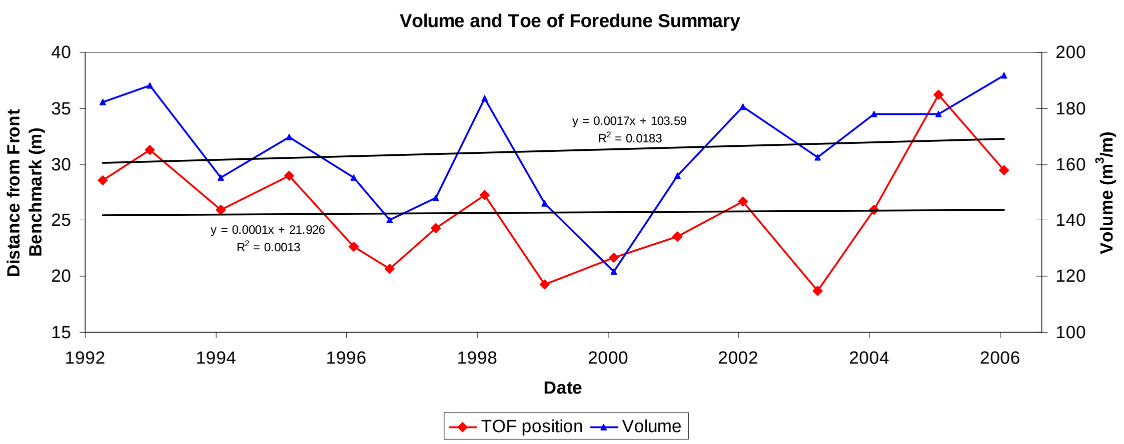


State: Stable

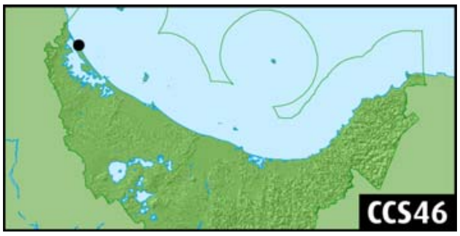
Location: NZMG 2779249E 6403986N
Period of record: 1992 – 2006
No. of profiles: 16
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.62 **TOF p-level –** 0.90







5.9.6 **Matakana Island North End (CCS 46)**



Discussion

This site is located 3km from the Tauranga Harbour northern entrance at Bowentown. The site is affected by the tidal inlet and the dynamic nature of the associated ebb tidal delta and the eastern orientated lateral channels that develop. The geology of the headland provides a nature barrier and restriction to any movement of the entrance to the northwest. This restriction means often tidal flows are directed towards the monitoring site.

Gibb (1994) states that this 3km-long sand beach borders Holocene sand dunes at the Katikati entrance to Tauranga Harbour. The foredune is 30 to 50m wide and decreases in height westwards from 4.8 to 2.5m above MHWS. Subject to wind erosion, overtopping and inundation from storm wave runup of 4 to 6m and the effects of channel migration near the entrance. Long-term trend (1923-1994) of shoreline advance of 55 to 60m, reversing to a trend of shoreline retreat of 65 to 140m at the entrance. Short-term shoreline fluctuations increase from 30 to 50m, up to 150 to 300m near the entrance in response to channel migration.

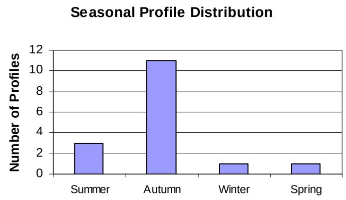
The profile history at this site shows a landward retreat for the 14 years of measurements. The magnitude of this retreat is approximately 70m. The 1992 profile shows the presence of a developed berm, this feature however has been lost from the two other representative profiles as the beach undergoes rapid and dominant erosion.

The offshore profiles show a very active offshore bar region to 900m offshore. This offshore section would bisect the eastern edge of the ebb tidal delta. The convergence of all three profiles occurs at approximately -8m.

Statistical analysis shows strong negative trends for both parameters giving an overall *state of erosion* for the period of record.

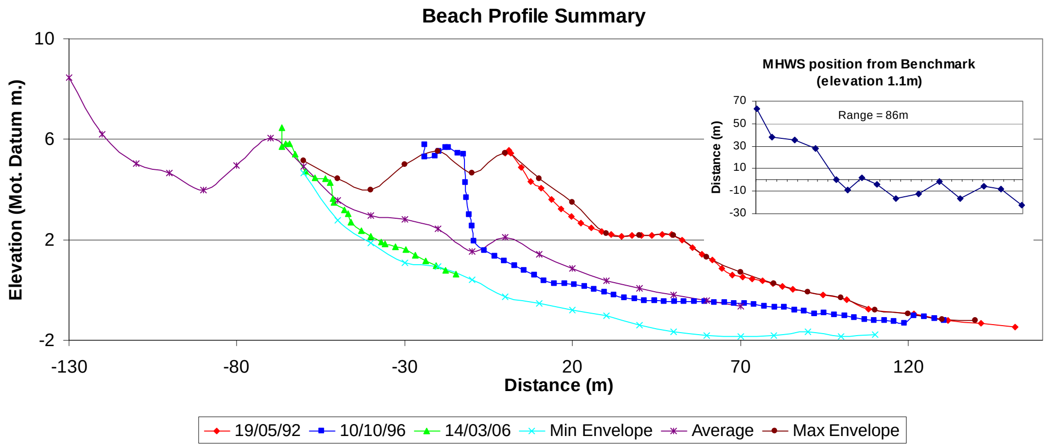
No photography is available for this site.

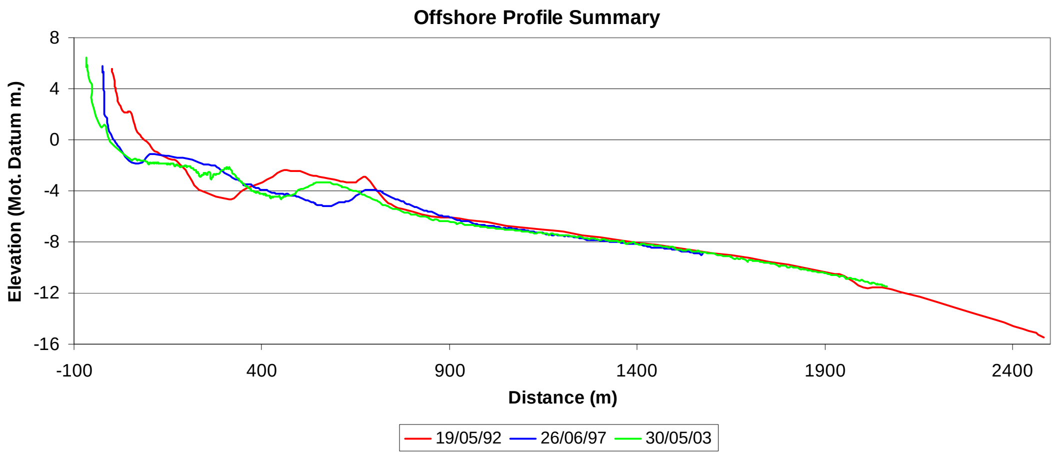
CCS 46 Matakana Island North End

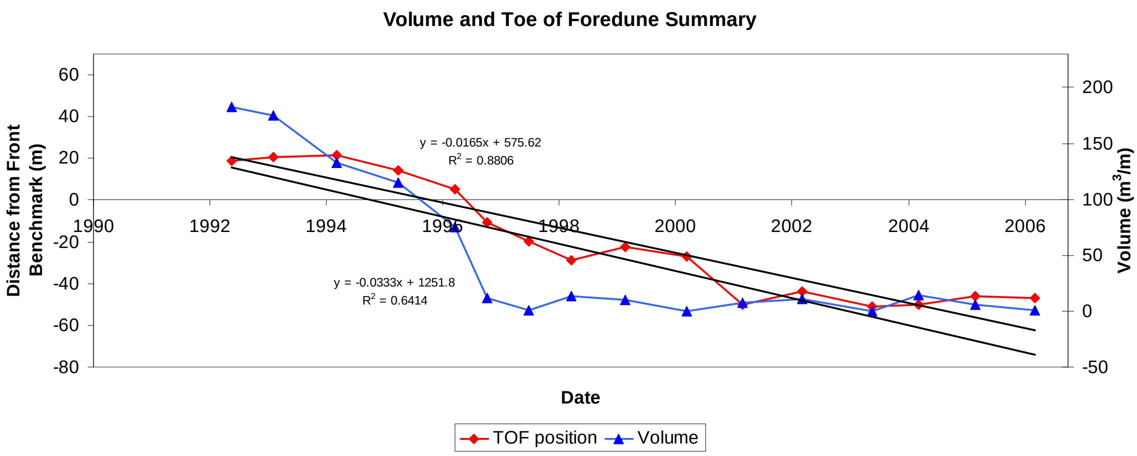


State: Erosion

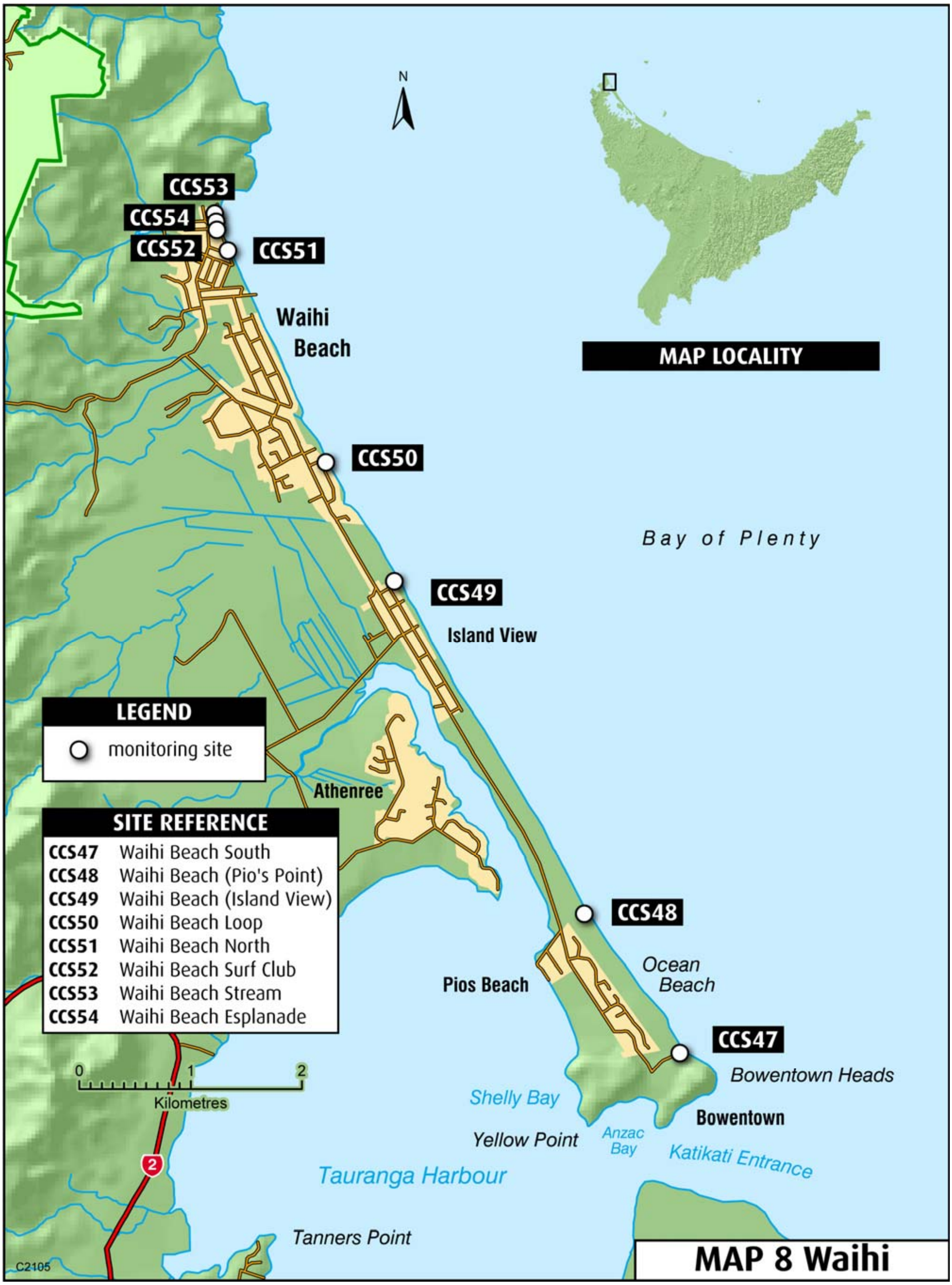
Location: NZMG 2776685E 6408571N
Period of record: 1992 – 2006
No. of profiles: 16
Morphodynamic type (Wright Short model): Rhythmic Bar and Beach
Volume p-level – 0.03 **TOF p-level –** 0.12



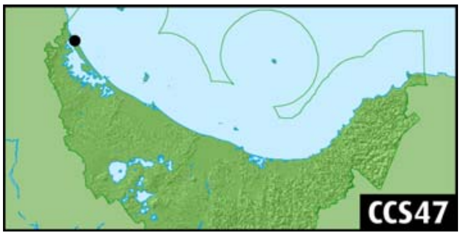




5.10 Waihi Beach system



5.10.1 **Waihi Beach South (CCS 47)**



Discussion

This site is located 500m northwest from the Bowentown entrance to the northern Tauranga Harbour. The site is strongly affected by the tidal inlet and associated localised circulation pattern with tidal flows through this inlet. Interaction of sediment between the ebb tidal delta and this section of beach is strongly linked. The frontal dune at this site has been modified dramatically by human activity. The site is located at a popular access point; historically this has not been well managed. Today a timber wall has been erected to try and halt foredune retreat. This work has also been supplemented with retiring sections of the dune and undertaking re-vegetation with native species. Eco Nomos Ltd (2003) stated a measure 19m of duneline progradation between September 1978 and April 1994.

The 2006 photograph shows a well vegetated frontal dune with a low spinifex vegetated slightly cut incipient dune in the foreground.

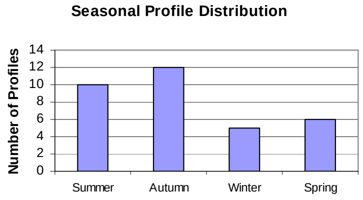
The profile history shows a wide band of movement in beach position evidenced by the maximum and minimum envelope location. The 1990 profile shows a healthy beach profile with a normally sloping frontal dune and a well developed berm. This has changed over the last 16 years with a landward movement of the frontal dune position and loss of beach sediment volume and expected beach features (berm) in 1996. The 2006 profile shows some recovery with an increase in elevation and the sign of early berm development.

The offshore profile record exhibits the effect of this sections close proximity to the ebb tidal delta. Marked sediment movement is shown to 1300m offshore at a depth of approximately -8m.

The beach volume fluctuates in accordance with sediment moving to a from the ebb tidal delta and probably affected by an eddy forming in the lee of the Bowen town headland, no significant result is determined by the statistical test. The foredune position however does exhibit a statistically significant trend with erosion being dominant for the 16 years of record analysed. These results give a combined state of that heading towards erosion.

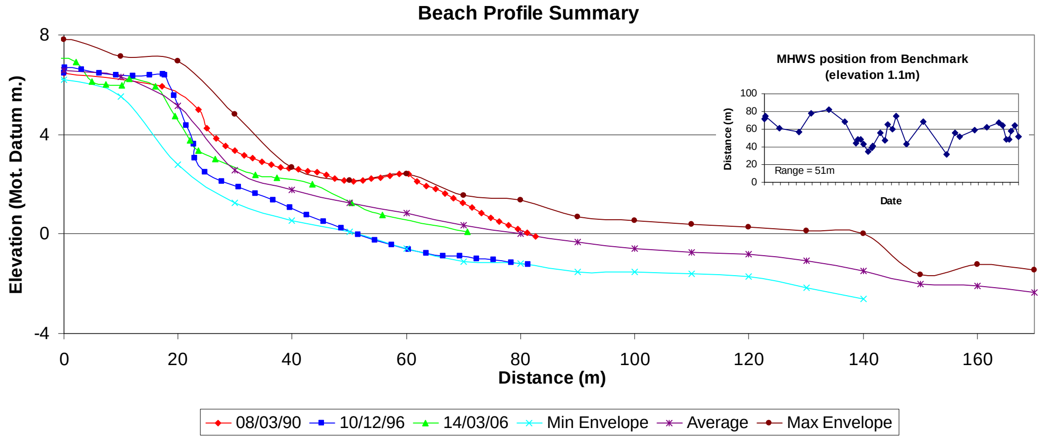
No early photograph (1970's) is available for this site.

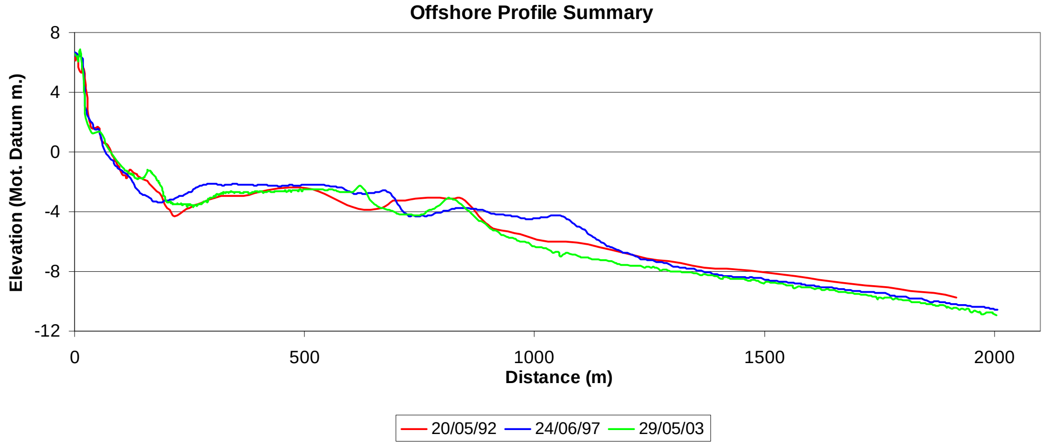
CCS 47 Waihi Beach South

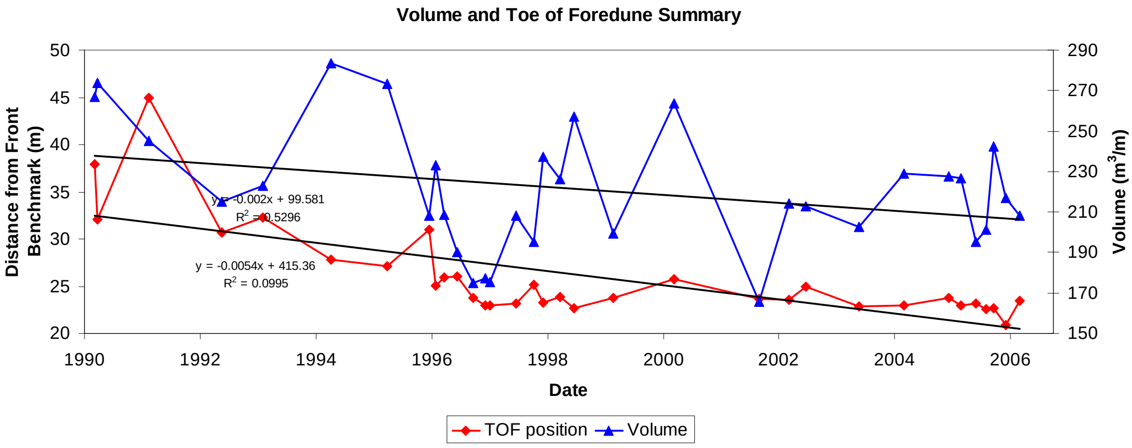


State: Erosion?

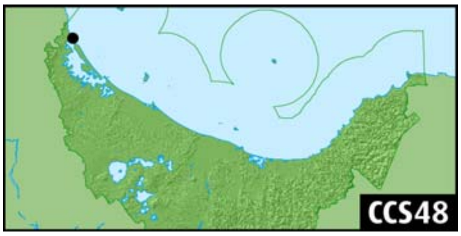
Location: NZMG 2774543E 6411088N
Period of record: 1990 – 2006
No. of profiles: 33
Morphodynamic type (Wright Short model): Rhythmic Bar and Beach
Volume p-level – 0.07 **TOF p-level –** 0.00







5.10.2 **Waihi Beach (Pio's Point) (CCS 48)**



Discussion

This site is located 2km to the northwest of the Bowentown entrance. Gibb (1994) states the section of beach from Ocean Beach to Island View is 4km long sand beach bordering a 250 to 750m wide tombolo of Pleistocene and Holocene dune complexes derived primarily from offshore sources. The 2006 photograph shows a gently sloping beach with no berm formation present. The foredune is currently in a state of erosion with undercut vegetation occupying a steepened face.

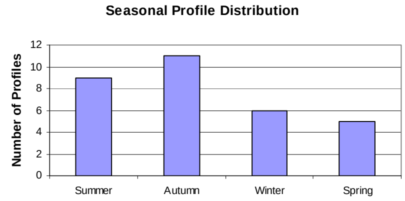
The profile history also reflects this steepened and eroded frontal dune. The 2006 profile has retreated by some 6m when compared with the more tradition frontal dune shape exhibited by the 1996 profile. The 1996 profile also shows a well developed berm which forms the maximum position the beach has been in at that elevation. The MHWS plot shows a variation of 33m for the 1.1m elevation.

The offshore profiles show an interesting pattern for this site. It is normally common for the profiles to "pinch out" or converge at a depth which normally marks the extent of typical sediment exchange caused by wave action. For this site all three profiles run parallel for the entirety of the survey. This could be the result of an origin datum issue which requires further analysis of the initial survey processing.

Both the volume and toe of foredune datasets show negative slope for the timeseries. Statistical significance tests show only the toe of foredune to be significant. These results give a state heading towards erosion for this beach section.

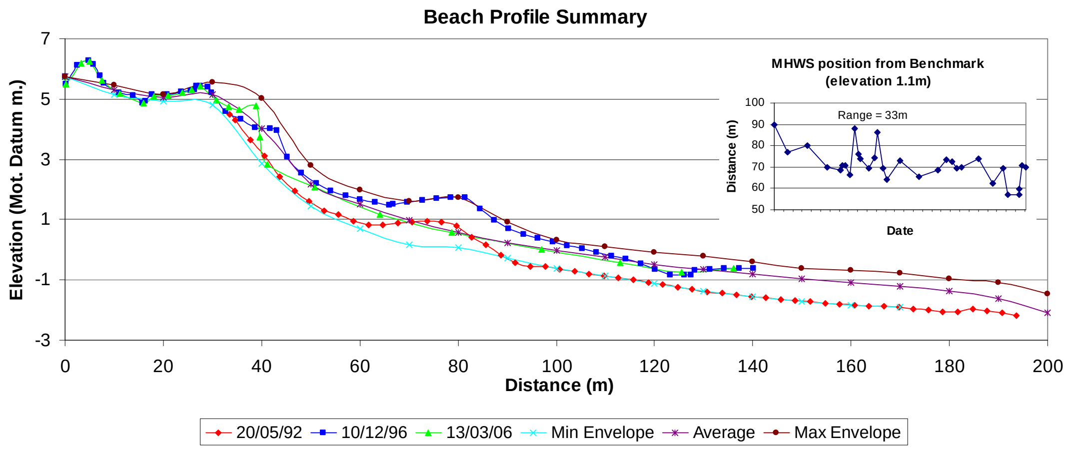
No early photograph (1970's) is available for this site.

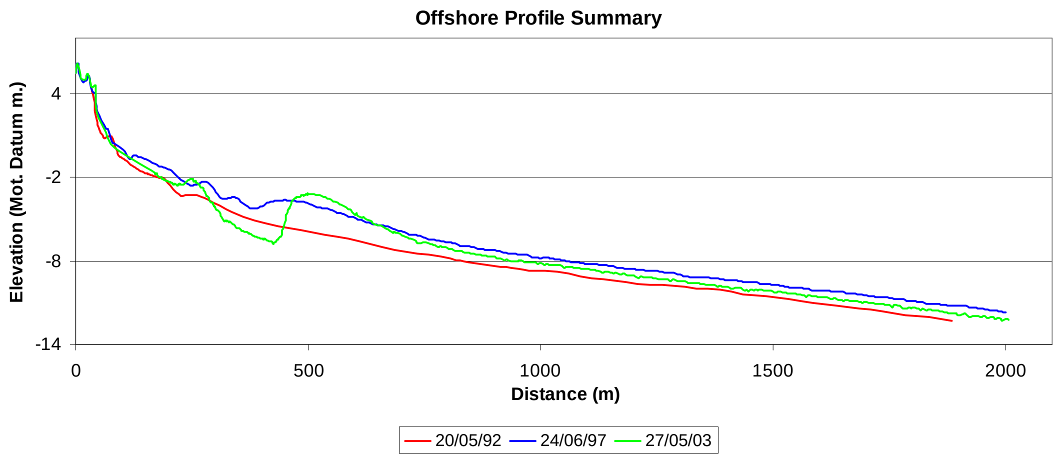
CCS 48 Waihi Beach (Pio's Point)

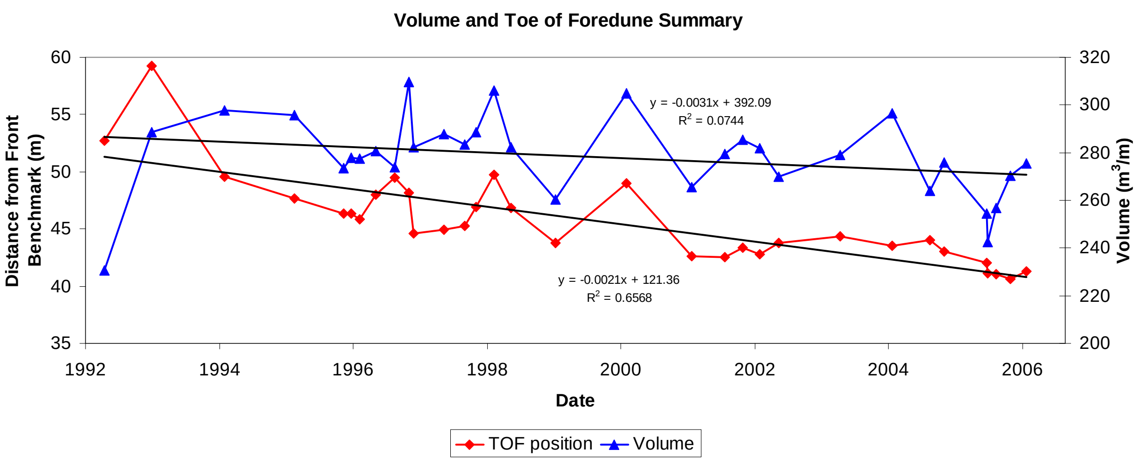


State: Erosion?

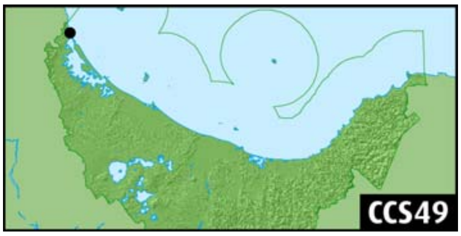
Location: NZMG 2773683E 6412344N
Period of record: 1990 – 2006
No. of profiles: 33
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.13 **TOF p-level –** 0.00







5.10.3 Waihi Beach (Island View) (CCS 49)



Discussion

This site is located approximately half way along the Waihi Beach system, 6km northwest of the Bowentown Entrance. Eco Nomos (2003) stated that in the area of Waihi Beach to the south of Island View, available data is limited and subject to significant uncertainties but suggests that (i) duneline fluctuations considerably exceed the scale of changes likely to be associated with storm cut and recovery, and (ii) the larger fluctuations evident in this area probably reflect the additional influence of deep, arcuate duneline embayments (see Stephens, 1996) and (at the southern end of the beach) the adjacent Bowentown ebb tide delta.

The 2006 photograph shows a beach with a well vegetated foredune and the development of an incipient dune in the foreground, no berm or low beach feature is present. This is also some evidence of cusp features present.

The profile history shows no remarkable characteristics. The 1996 profile shows a change in the upper beach position, although this is most probably the result of a slightly different survey line being used. The maximum/minimum envelope shows a reasonably confined range of vertical movement.

The offshore profiles show bar movement in the zone within 400m of the shore. The 1997 and 2003 profiles converge at -6m, approximately 600m offshore.

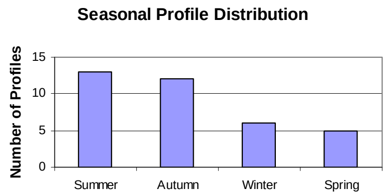
The volume and toe of foredune record both show positive slopes, however both show no significant trend when the statistical test is applied, therefore a state of stable has been derived for this section for the last 16 years of profiling record.

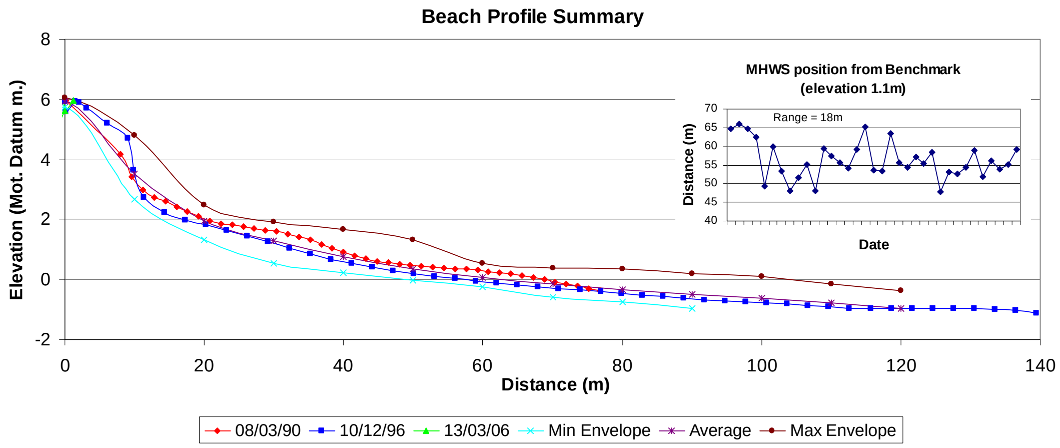
No early photograph (1970's) is available for this site.

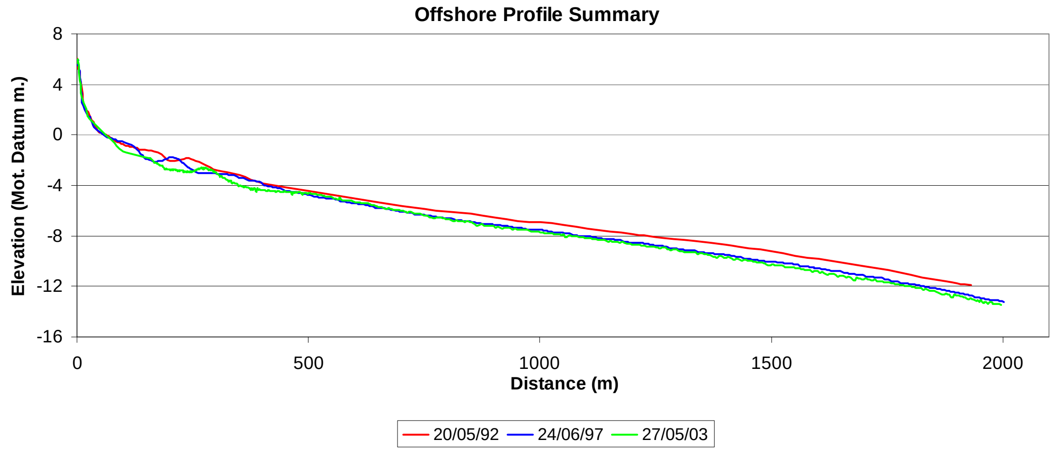
CCS 49 Waihi Beach (Island View)

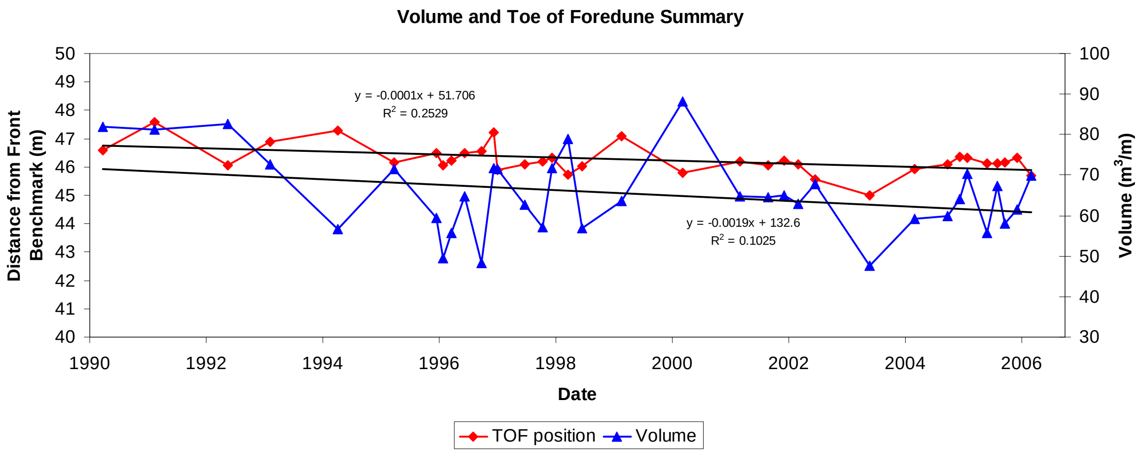
State: Stable

Location: NZMG 2771978E 6415346N
Period of record: 1990 – 2006
No.of profiles: 35
Morphodynamic type (Wright Short model): Longshore Bar and Trough
Volume p-level – 0.06 **TOF p-level –** 0.15

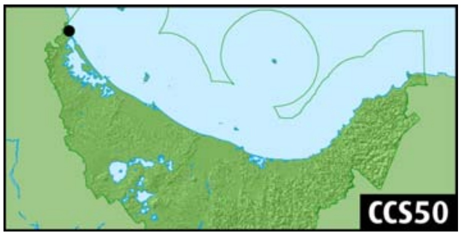








5.10.4 **Waihi Beach Loop (CCS 50)**



Discussion

This site is located 4km from Rapatiotio Point. The site is in front of the residential development at The Loop and is equidistant between Two and Three Mile Creeks. This section of beach has a several metre high rock revetment present (along with the remnants of an older timber wall) as shown in the 2006 photograph.

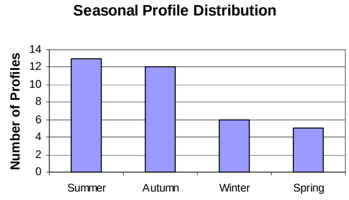
The profile history reflects the presence of this engineering works as a means of providing stability to the upper section of beach. As a result of the revetment the “dune” position has remained stable for the period of record. The vertical position of the mid to lower beach profile changes markedly as a result of negligible sediment transfer from the upper beach to maintain the equilibrium beach profile. The vertical envelope moves approximately 1.5m for this profile site. This movement means that during periods of lower beach elevation no dry beach is present during the upper portion of the tidal cycle.

The offshore profile record shows moderate bar development in the 1997 and 2003 profiles. These two profiles converge at -5m at a distance of approximately 500m from the shoreline.

The statistical tests give results indicating stability for this beach profile site.

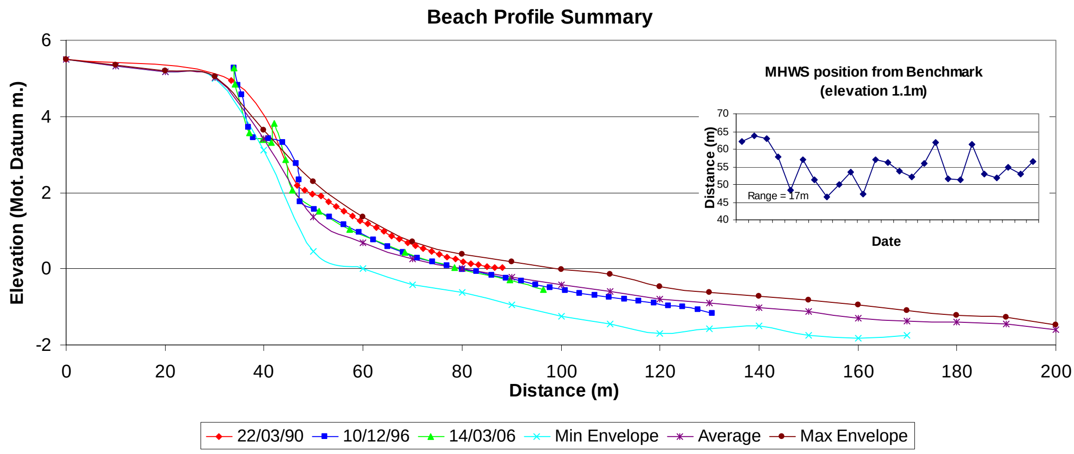
No early photograph (1970’s) is available for this site.

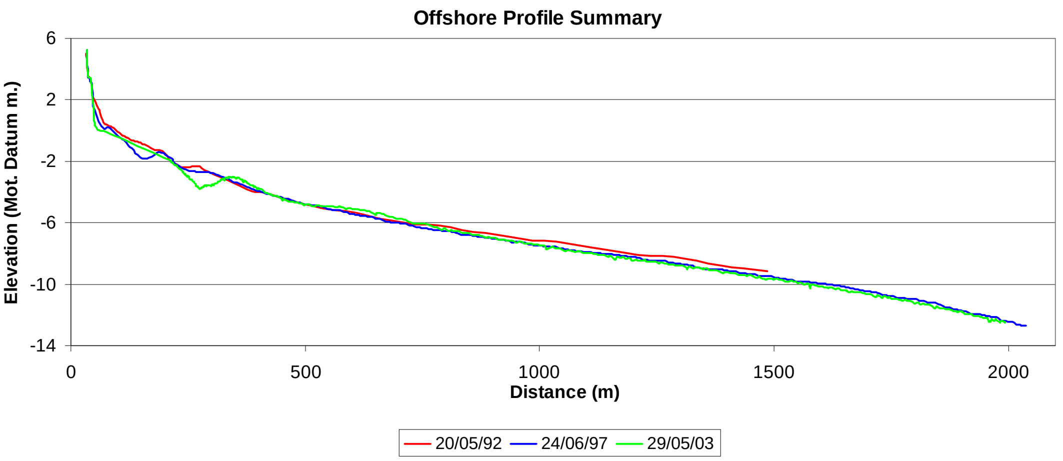
CCS 50 Waihi Beach Loop

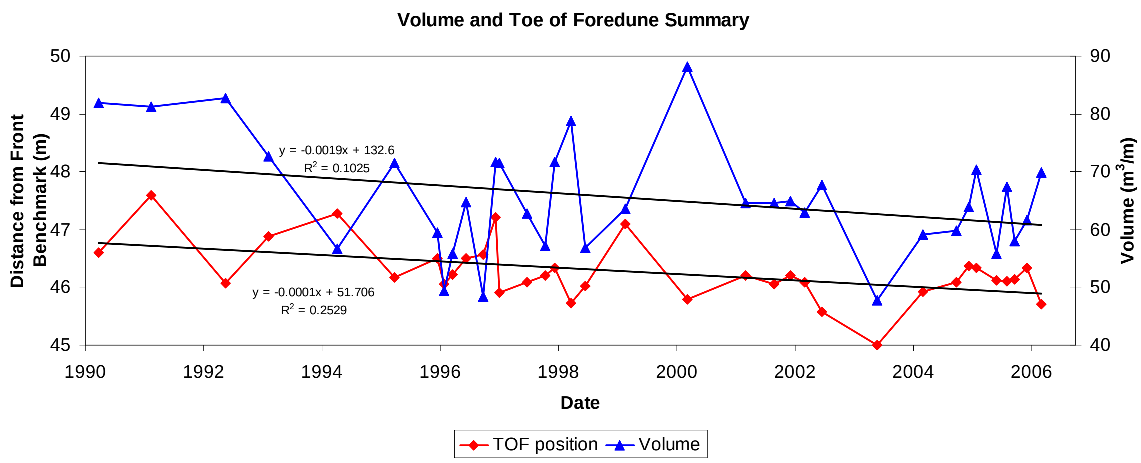


State: Stable

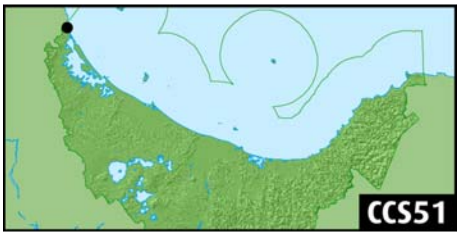
Location: NZMG 2771362E 6416419N
Period of record: 1990 – 2006
No.of profiles: 35
Morphodynamic type (Wright Short model): Seawall modified
Volume p-level – 0.06 **TOF p-level –** 0.00







5.10.5 **Waihi Beach North (CCS 51)**



Discussion

This site is located at the southern boundary of the popular Waihi Beach. A 5 m high frontal dune is present at this site which is vegetated by a mixture of exotic and native species. An incipient dune has also formed and is presently colonised by a dense cover of spinifex. The 2006 photograph shows a 15m wide high tide beach.

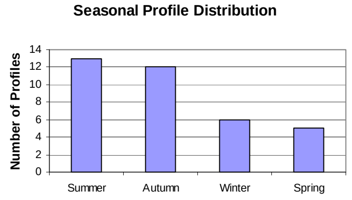
The profile history shows a tight grouping of representative profiles for this site. The minimum envelope however highlights that at certain times this section of beach can exhibit a marked negative vertical translation. Lower beach features are typically subtle at this site with no prominent berm development evident in the record.

The offshore profile record shows strong similarity between the three measured surveys. The convergence of all three occurs 1km offshore at -6m. No dominant bar development is evident which is common for all the sites in the Bay of Plenty which are located in the lee of rocky headlands (i.e CCS11).

The toe of foredune position for this site has remained statistically stable for the last 16 years. This trend is also applicable to the beach volume timeseries, although more variation is exhibited, particularly during the period 1991 to 1995. This combined analysis gives an overall state of stable for this beach profile site.

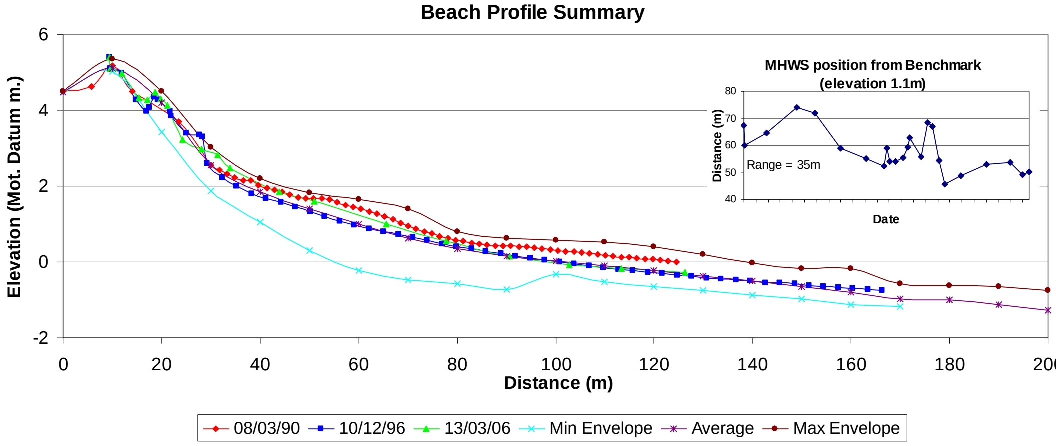
No early photograph (1970's) is available for this site.

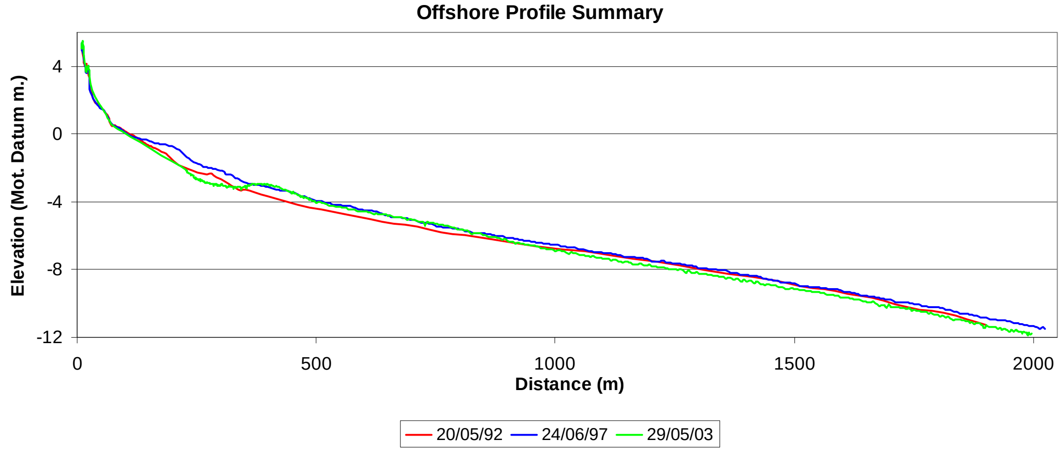
CCS 51 Waihi Beach North

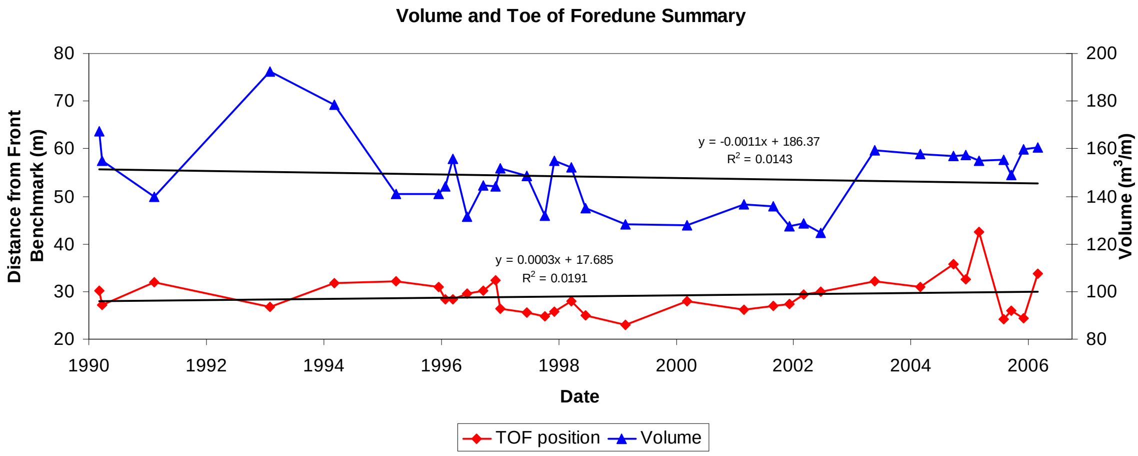


State: Stable

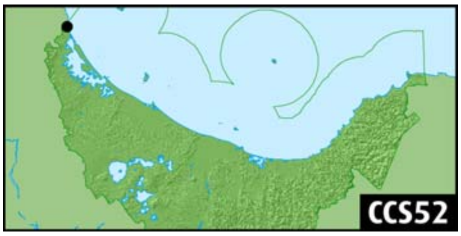
Location: NZMG 2770479E 6418326N
Period of record: 1990 – 2006
No. of profiles: 34
Morphodynamic type (Wright Short model): Dissipative
Volume p-level – 0.50 **TOF p-level –** 0.44







5.10.6 **Waihi Beach Surf Club (CCS 52)**



Discussion

This site is located at Waihi Beach at The Esplanade. The site was installed in 1998 as part of a monitoring programme focussing on an area were significant Dune Care work was to be undertaken. The profile origin for this site is located in an area that has been fenced to deter human traffic and planted with a range of native species.

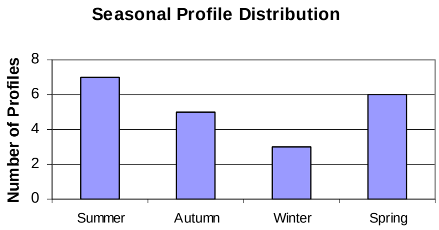
The profile history shows a low angle beach with no berm development. The frontal dune has undergone some change in shape due to the early Dune Care work. The envelope plots shows less than 1m of vertical movement in the upper beach profile, widening to 1.5m as the profile approaches MSL. The MHWS plot also reflects this variation with a period between 1999 and 2002 showing the 1.1m elevation to be in a more landward position, indicating a short period of sediment depletion.

No offshore profiles have been measured at this site.

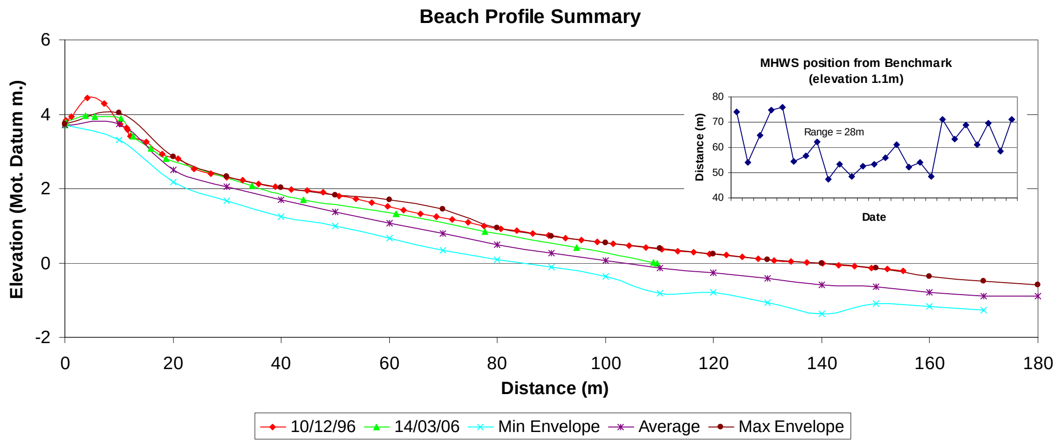
The statistical analysis shows that for the toe of foredune position and the beach volume datasets there is a *pattern of stability* for the 8 years of record.

CCS 52 Waihi Beach Surf Club

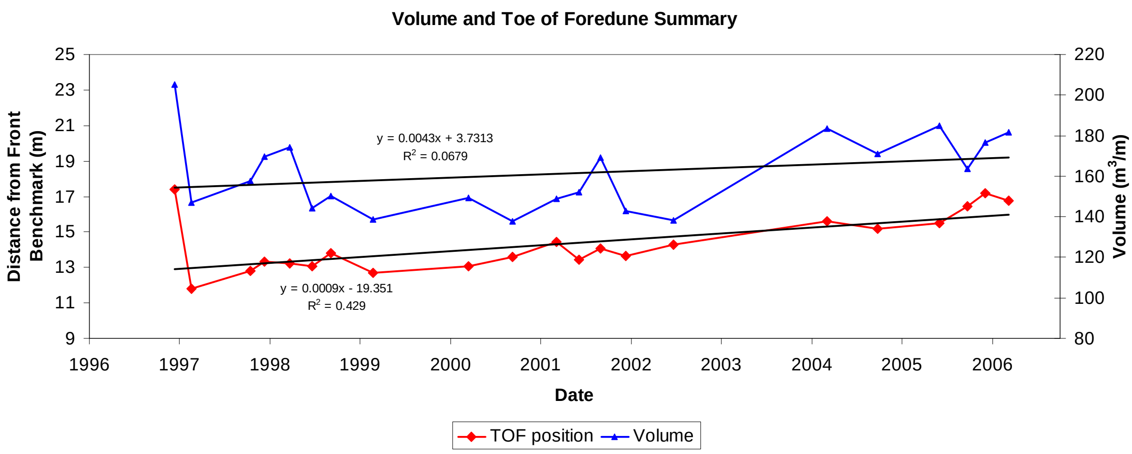
State: Accretion?



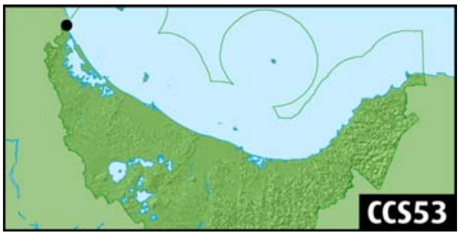
Location: NZMG 2770380E 6418534N
Period of record: 1998 – 2006
No. of profiles: 21
Morphodynamic type (Wright Short model): Dissipative
Volume p-level – 0.25 **TOF p-level –** 0.00



No offshore profiles have been measured at this site.



5.10.7 **Waihi Beach Stream (CCS 53)**



Discussion

This site is the western most of the beach profile monitoring sites. The site is located at the western end of The Esplanade on the eastern side of the small stream. Like CCS 52 this sites origin is located in a Dune Care fenced area planted with native vegetation.

The profile history shows the earthworks undertaken to develop a dune at the beginning of the Dune Care programme. As with the other two sites in this area the beach exhibits a low angle with a wide high tide beach present. No berm feature is present for the majority of the time although the maximum envelope plot does show evidence of sand accumulating in a berm shape approximately 70m from the benchmark.

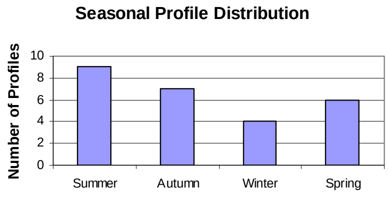
No offshore profiles have been measured at this site.

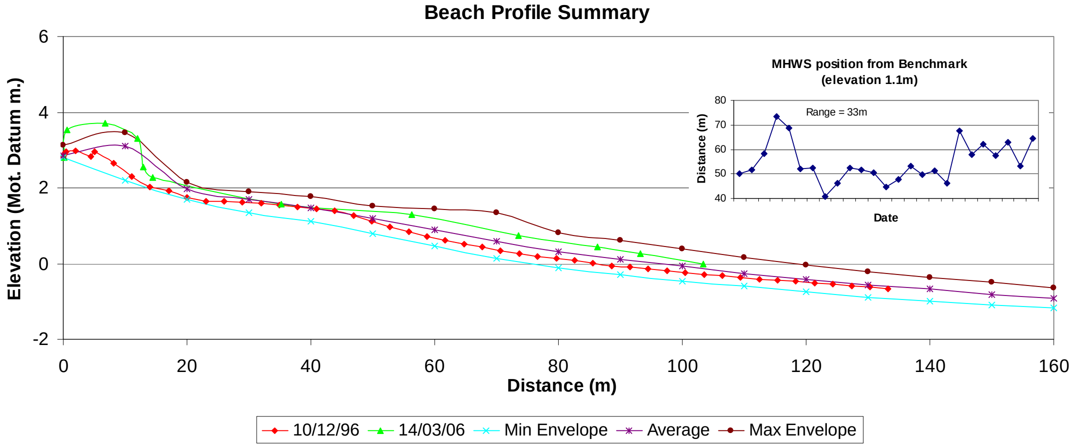
The statistical analysis shows that for the toe of foredune position and the beach volume datasets there is a *pattern suggesting accretion* for the 8 years of record.

CCS 53 Waihi Beach Stream

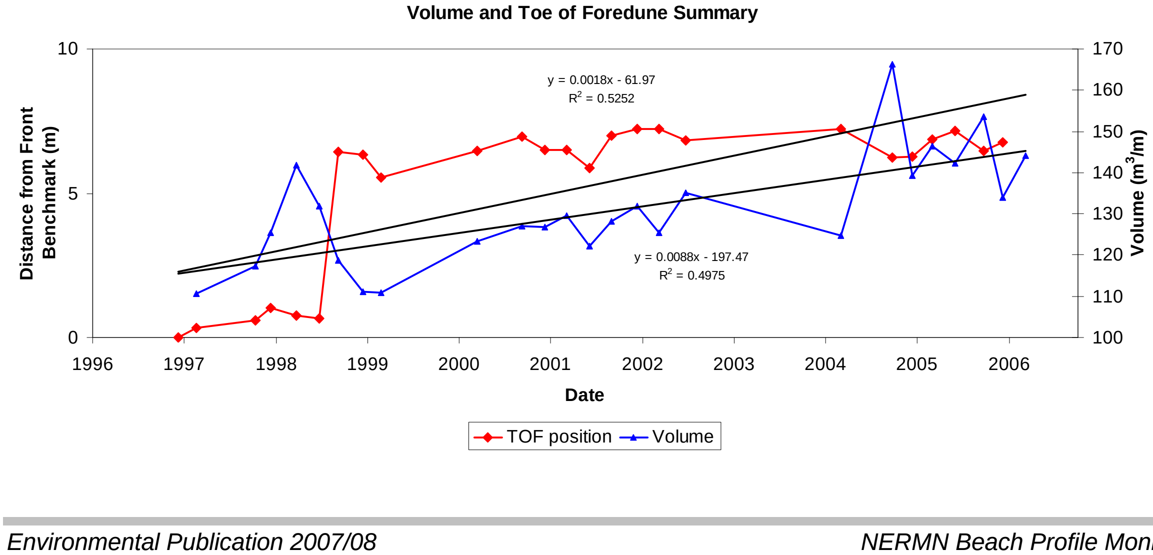
State: Accretion

Location: NZMG 2770450E 6418040N
Period of record: 1998 – 2006
No.of profiles: 26
Morphodynamic type (Wright Short model): Dissipative
Volume p-level – 0.00 **TOF p-level** – 0.00

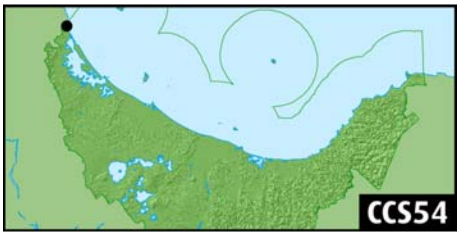




No offshore profiles have been measured at this site.



5.10.8 **Waihi Beach Esplanade (CCS 54)**



Discussion

This site is the western most of the beach profile monitoring sites. The site is located at the western end of The Esplanade on the eastern side of the small stream. Like CCS 52 this sites origin is located in a Dune Care fenced area planted with native vegetation.

The profile history shows the “earthworks” undertaken to develop a dune at the beginning of the Dune Care programme. As with the other two sites in this area the beach exhibits a low angle with a wide high tide beach present. No berm feature is present for the majority of the time although the maximum envelope plot does show evidence of sand accumulating in a berm shape approximately 70m from the benchmark.

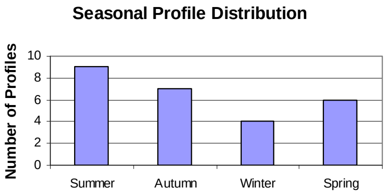
No offshore profiles have been measured at this site.

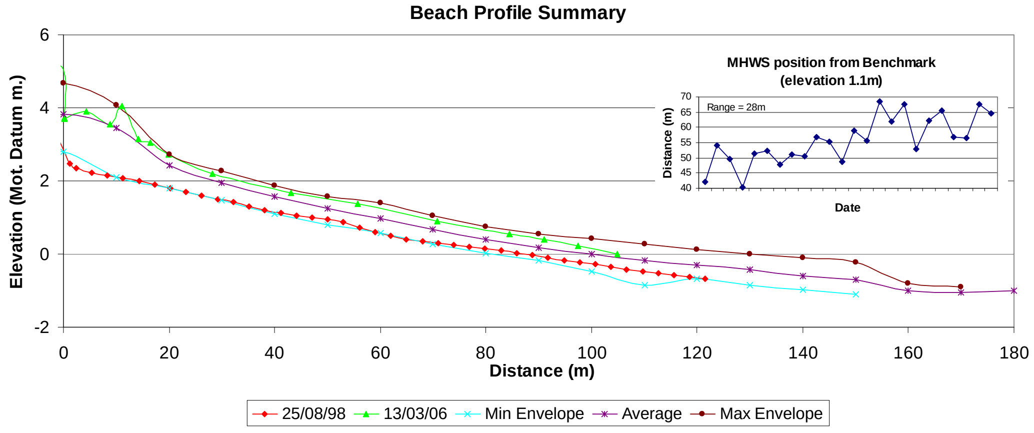
The statistical analysis shows that for the toe of foredune position and the beach volume datasets there is a pattern of accretion for the 8 years of record.

CCS 54 Waihi Beach Esplanade

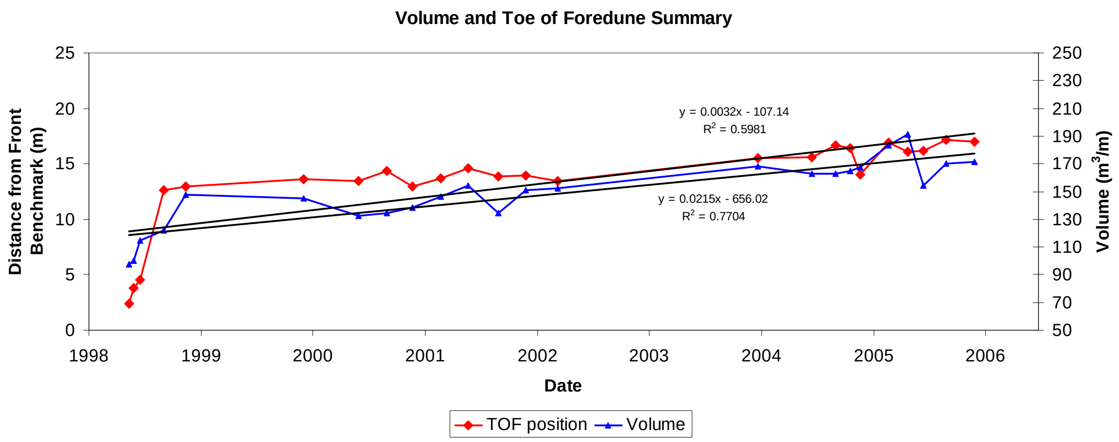
State: Accretion

Location: NZMG 2770230E 6418030N
Period of record: 1998 – 2006
No. of profiles: 24
Morphodynamic type (Wright Short model): Dissipative
Volume p-level – 0.00 **TOF p-level** – 0.00





No offshore profiles have been measured at this site.



Chapter 6: Future Monitoring Schedule

This section is designed to provide guidance to the Environmental Data Service section for required profile monitoring.

6.1 Monitoring Schedule

The following table (Table 6.1) contains the proposed schedule of profile measurements for the NERMN profiles. This schedule also contains the recently installed Coast Care sites at Waihi, eastern Papamoa and Waiotahi beaches. The schedule reflects the requirement for both the annual and quarterly monitoring. This schedule also includes beach profiling performed under contract for 3rd parties within the Bay of Plenty region (the Tauranga City Council monitoring adds further definition to the dataset in the heavily developed residential Mt Maunganui/Papamoa areas).

Table 6.1 Monitoring schedule for the next 5 years (2006-2010).

Site	Monitoring frequency
All sites (Total = 79). • CCS1 to CCS54 inclusive. • Coast Care sites at Papamoa (2 sites), Waiotahi Drifts (5 sites) Waihi Beach (1 site) and Mt Maunganui (1 site). • TCC contract sites (17 sites)	Annually
Selected sites (Total = 40). • CCS9 – CCS11 • CCS25 – CCS29 • CCS34 – CCS40 • CCS47 – CCS54 • TCC contract sites (17 sites)	Quarterly
Pre and post significant storm sites. (typically a selection of the quarterly sites and/or a selection based on reports of erosion)	As required

It should be recognised that additional profiling should be undertaken where possible prior to, and post *significant* storm/erosive events. These significant events are typically associated with the progression of tropical cyclones or sub tropical depressions towards or through the Bay of Plenty region. These systems are normally generated in the tropics in the December to April period.

At this time there is no requirement for further offshore profiles to be measured. The majority of the sites now have three offshore surveys measure over a 15 year period. Where more detailed information is required, a specific project could be developed to gather this explicit information. Typically these investigations would use technology (like multibeam technology) to allow for the development of three dimensional bathymetry layers. This technology was outside the specification required for the collection of the historic offshore profile datasets.

Chapter 7: Discussion

Over the course of a year along the Bay of Plenty coastline, changes in the beach morphology result from "cut and fill" processes. The movement of sediment from this process is dependant on wind and wave action as well as sediment properties. These seasonal changes are superimposed on short and long term processes which act to produce periods (tens of years) of erosion, accretion and dynamic equilibrium.

Wave action is the dominant forcing process causing changes in erosion and accretion patterns along the Bay of Plenty coastline. Wave conditions in the Bay of Plenty are moderately influenced by the El Niño Southern Oscillation. More stormy conditions than average tend to occur during La Niña periods, which are associated with an increase in northeasterlies in the New Zealand region. During El Niño years, where a higher occurrence of southwesterlies occurs, wave conditions in the Bay of Plenty are somewhat reduced although episodic extra-tropical cyclones still occur. Given that since 1998 we have entered a negative phase of the Interdecadal Pacific Oscillation where neutral or La Niña conditions may be more likely to occur, it is possible that the Bay of Plenty region may experience increased rates of erosion over the next 20 to 30 years, similar to that experienced in the late 1960s and early to mid 1970s (Bell et. al., 2006).

Over the period of the physical coastal NERMN (typically 16 years of data to date), 53 sites have been monitored to access changes in beach profile position and beach volume. Figure 7.1 and Table 7.1 presents the overall trends since 1990 for each of the 53 sites.

The overall trends generally show common patterns per reported beach system. This is not unexpected as typically these beach systems are affected by sources of localised sediment influx from fluvial sources or are separated by a number of natural obstructions, such as:

- hard-rock coastline north of Waihi Beach
- northern Tauranga Harbour entrance
- southern Tauranga Harbour entrance
- Mount Maunganui
- Town Point, Maketu
- Kohi Point headland, Whakatane
- Ohiwa Harbour entrance

Figure 7.1 Trend Overview for the Bay of Plenty (1990-2006)

These features punctuate the general direction of littoral drift in the Bay of Plenty of north west to south east flux, though there are areas where the direction of net sediment movement has been modelled to be orientated towards the north west (Bell et. al., 2006; Phizacklea 1993). Littoral drift is the main mechanism by which sediment is supplied to a beach, it is also a value that is difficult to measure directly. Hodges and Deely (1997) state that Gibb (1983) estimated the rate of littoral drift along the Bay of Plenty Coastline as <100,000 m³/yr. Hicks and Hume (1991) give an estimate of 70,000 m³/yr for inlets to both the Ohiwa and Tauranga Harbours.

Recent estimates (Bell et. al., 2006) of sand and gravel yield currently delivered to the coast by Bay of Plenty rivers (the Whangaparoa catchment in the east to the Tauranga Harbour in the west) totals 5.8Mt/yr.

Table 7.1 Trends in foredune position change.

Beach system	CCS site	Site Name	Toe of foredune change from 1990 to 2006 (+ accretion, - erosion)	Beach state
Hikuwai	1	Opape East	+12	Stable
	2	Waiaua River West	-3	Erosion?
	3	Tirohanga Stream West	-7	Erosion
	4	Hikuwai West	-12	Erosion?
	5	Waiotahi Beach East	-5	Erosion
	6	Waiwhakatoitoi	-6	Erosion?
	7	Waiotahi Spit	+28	Accretion?
	8	Ohiwa Spit	+90	Accretion
Ohope	9	Ohope Spit	-220	Erosion
	10	Ohope	-16	Erosion
	11	West End	-27	Erosion?
Thornton	12	Whakatane Spit	+30	Stable
	13	Piripai	+10	Accretion?
	14	Golf Links Road	-12	Erosion?
	15	Airport	-12	Erosion?
	16	Rangitaiki East	0	Stable
Matata	17	Rangitaiki West	+4	Stable
	18	Lawrences Farm	+2	Stable
	19	Tarawera East	-19	Accretion?
	20	Matata Domain	0	Stable
	21	Matata	+6	Accretion?
	22	Murphy's Motor Camp	+10	Stable
	23	Pikowai Motor Camp	-17	Erosion?
	24	Otamarakau	-6	Erosion
Pukehina	25	Rodgers Road	-4	Erosion?
	26	Pukehina Trig	-4	Erosion
	27	Pukehina West	-11	Erosion
	28	Pukehina Middle	-15	Erosion
	29	Pukehina West	-2	Erosion
	30	Makatu Headland	-18	Erosion?
Papamoa	32	Kaituna River East	+9	Accretion?
	33	Kaituna River West	-7	Erosion
	34	Taylor Street	-4	Erosion
	35	Papamoa Beach	+15	Accretion?
	36	Papamoa	0	Accretion?
	37	Papamoa Surf Club[1]	+2	Accretion?
	38	Te Maunga	-3	Erosion
	39	Mount Maunganui East	-2	Erosion?
	40	Mount Maunganui	-2	Accretion?
Matakana[2]	41	Fire Break Road	+7	Stable
	42	Bird Santuary	-40	Erosion
	43	Tank Road	+11	Accretion?
	44	Matakana Island Centre	+1	Stable
	45	Dead End Road	+1	Stable
	46	Matakana Island North	-65	Erosion

Beach system	CCS site	Site Name	Toe of foredune change from 1990 to 2006 (+ accretion, - erosion)	Beach state
Waihi	47	Waihi Beach South	-15	Erosion?
	48	Waihi Beach- Pio's Point	-12	Erosion?
	49	Waihi Beach Island View	-1	Stable
	50	Waihi Beach Island Loop	-2	Stable
	51	Waihi Beach North	+2	Stable
	52	Waihi Beach Surf Club[1]	+4	Accretion?
	53	Waihi Beach Stream[1]	0	Accretion
	54	Esplanade Road[1]	+4	Accretion

Note: 1 – data is from 1998 - 2006, 2 – data is from 1992 - 2006

7.1 Hikuwai Beach system

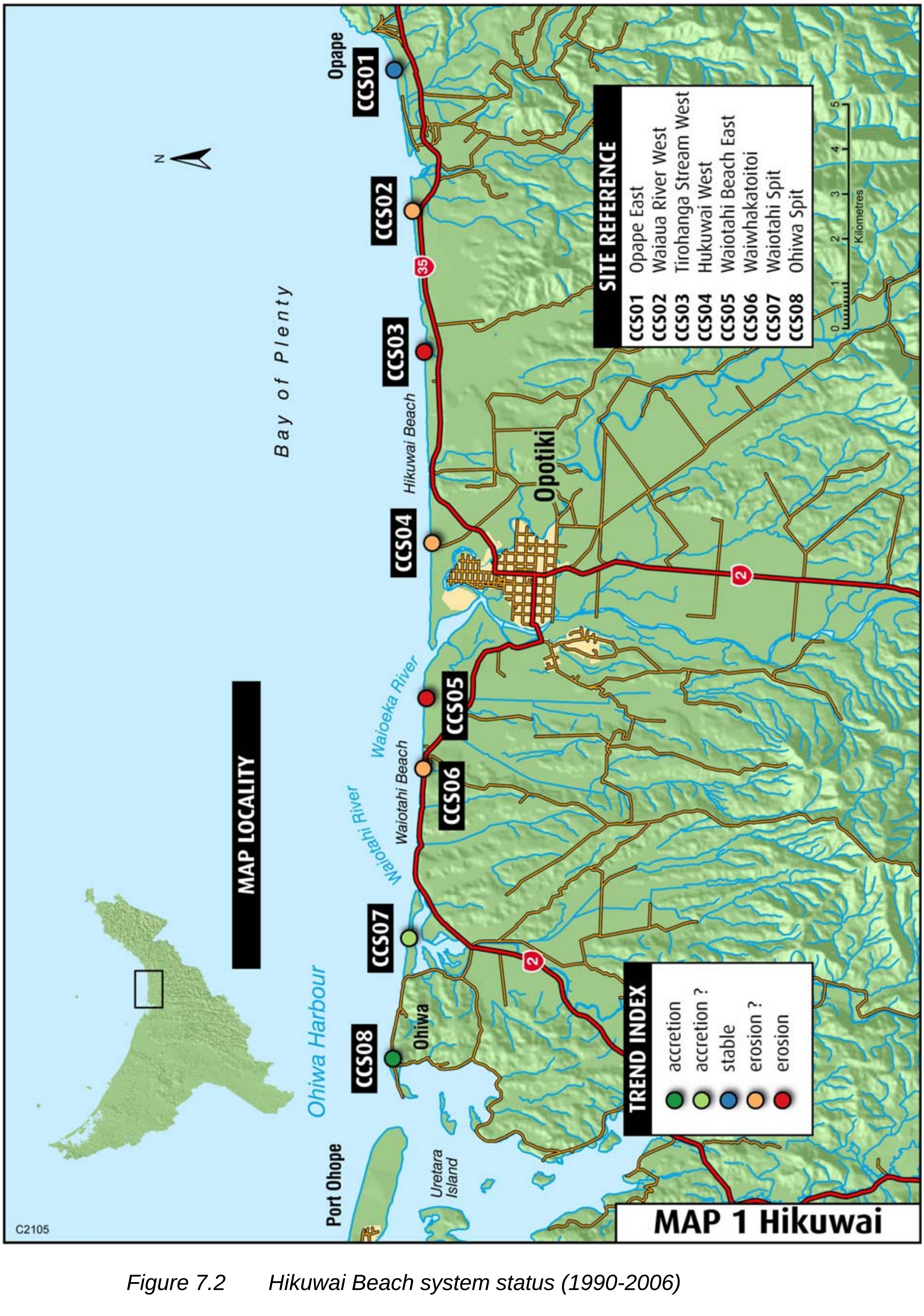


Figure 7.2 Hikuwai Beach system status (1990-2006)

The 16 years of NERMN record for this eastern group of sandy beach profiling sites shows a dominance of erosion patterns being exhibited (Figure 7.2). The eastern most site at Opape shows signs of stability, possibly a reflection of it proximity to the headland at the eastern end of the beach, a localised eddy effect in the longshore drift (as a result of the headland) could cause sediment supplied by the Opape Stream to remain in the vicinity.

The profiling sites from Waiaua to Waiwhakatoitoi all show signs of erosion trends. A number of small streams would provide a minor amount of material to the nearshore beach system for this section of beach. This contribution would however be overshadowed by the sediment input from the Waioeka River (and probably a contribution from the Motu River). A westward longshore drift would mean Waiaua, Tirohanga and Hukuwai would not benefit directly from this sediment supply, this deficit would be further exaggerated under La Nina conditions (predominance of north easterly (onshore/alongshore) winds) which would intensify the westward sediment movement.

Interestingly the profile sites at Waiotahi and Waiwhakatoitoi to the west of the Waioeka River also exhibit this erosion trend. The Waiotahi site shows significant fluctuations in the beach volume, probably as a result of pulses of sediment during flood events, but the frontal dune continues its landward transgression.

The erosion trend changes at Waiotahi Spit and Ohiwa Spit, both of these sites have recently be going through a period of strong accretion. For the Ohiwa Spit site this seaward movement of the beach has been in the order of ~90m.

7.2 Ohope Beach system

Ohope Beach is located on the non volcanic eastern side of the Volcanic Front, and therefore does not share the same downward movement of the Rangitaiki Plains (Mitchell, 1998). This beach system can be generally divided into three zones – West End, central Ohope Beach and the Ohope barrier spit. There is one representative profiling site in each of these zones. The total length of this system is approximately 12km.

West End is the western 2-3km of Ohope Beach and currently consists of a flat wide beach at the western end and decreases in width and increases in gradient towards the eastern section of West End. The central Ohope beach is a ~5km narrow strip of sand, approximately 200m in width that backs onto steep cliffs. The barrier spit section is approximately 5 km in length and varying in width from 300-1000m. A dominant feature of the spit is a series of six well vegetated sub parallel dune ridges that recurve on their distal eastern end towards the harbour. The orientation of Ohope Spit and the parallel dune ridges indicate a long term littoral drift towards the south east and also show progradation of the spit (Gibb, 1977; Healy et.al, 1977).

West End, Ohope receives sediment under normal conditions from sediment transported down the Whakatane River and around Kohi Point (although Smith (1987) and Mitchell (1998) noted a reduced grain size and improved sorting towards West End indicating a small but significant sediment transport towards the west). If the supply of this material is limited, or the erosion rate is faster than the rate of accretion, then net erosion of material from West End will occur.

Three sites (Figure 7.3) have been monitored over the last 16 as part of the NERMN programme. Within the Ohope Beach system the results show an overall pattern of erosion.

The monitoring site at the end of the Spit has shown a trend of several hundred metres of retreat which is directly opposite to the trend at CCS8 on the other side of the Ohiwa Harbour Entrance. Results suggest a complex link between the two spits which is controlled by climatic factors, sediment exchange between the ebb tidal delta and beach, and the location and orientation of the main and lateral channels of the tidal inlet. Historically the spit has been highly mobile over the last century, advancing over 700m eastward from 1868 to 1976, and then retreating 150m to the west between 1976 and 1997 (Smith and Ovenden, 1997)

The central beach site also exhibits a significant level of erosion (15m). This is typical as shown in Table 7.2 which is a combination of data from Gibb (1978) and Saunders (1999). The current rate is similar to the rate of retreat that was determined for the 1868-1914 period.

Table 7.2 Historical shoreline movement for Moana Road.

Period	Movement	Rate
1868-1914	-65.7m	-1.42m/yr
1914-1944	+14.0m	+0.47m/yr
1944-1976	+30.0m	+0.91m/yr
1976-1997	-7.4m	-0.35m/yr
1868-1997	-29.0	-0.22m/yr
1990-2006*	-16.0	-1.0m/yr

* NERMN record Source: Tonkin &Taylor (2002)

The West End site also shows patterns of erosion. In particular was the 1996-1997 period where 15m of retreat occurred mainly as the result of tropical cyclones (see Section 3.2) approaching the Bay of Plenty and the associated increase in wave energy and storm surge. Historical analysis shows that significant shoreline movement has been experienced at this site. The current rate of retreat is within the range of movement previously recorded for periods of retreat.

The West End area appears to be generally stable but with significant variation over periods of decades (Tonkin & Taylor, 2002).

Table 7.3 Historical shoreline movement for West End, CCS11.

Period	Movement	Rate
1868-1914	+42.5m	+0.92m/yr
1914-1929	-3.7m	-0.25m/yr
1929-1976	+127.1m	+2.70m/yr
1976-1997	-100m	-4.76m/yr
1868-1997	+65.7m	+0.54m/yr
1990-2006*	-27m	-1.69m/yr

* NERMN record Source: Tonkin &Taylor (2002)

Given that beach profiles adjust towards an equilibrium with wave climate and sediment supply, both the West End and the Ohiwa Harbour Spit sites appear to be adjusting (in the short term at least) to a higher energy, lower sediment supply environment. West End has very little buffer for this type of change (given that the buffer has been developed), whereas the Ohiwa Harbour Spit site did have a large reserve of sediment to compensate for changes to wave climate.

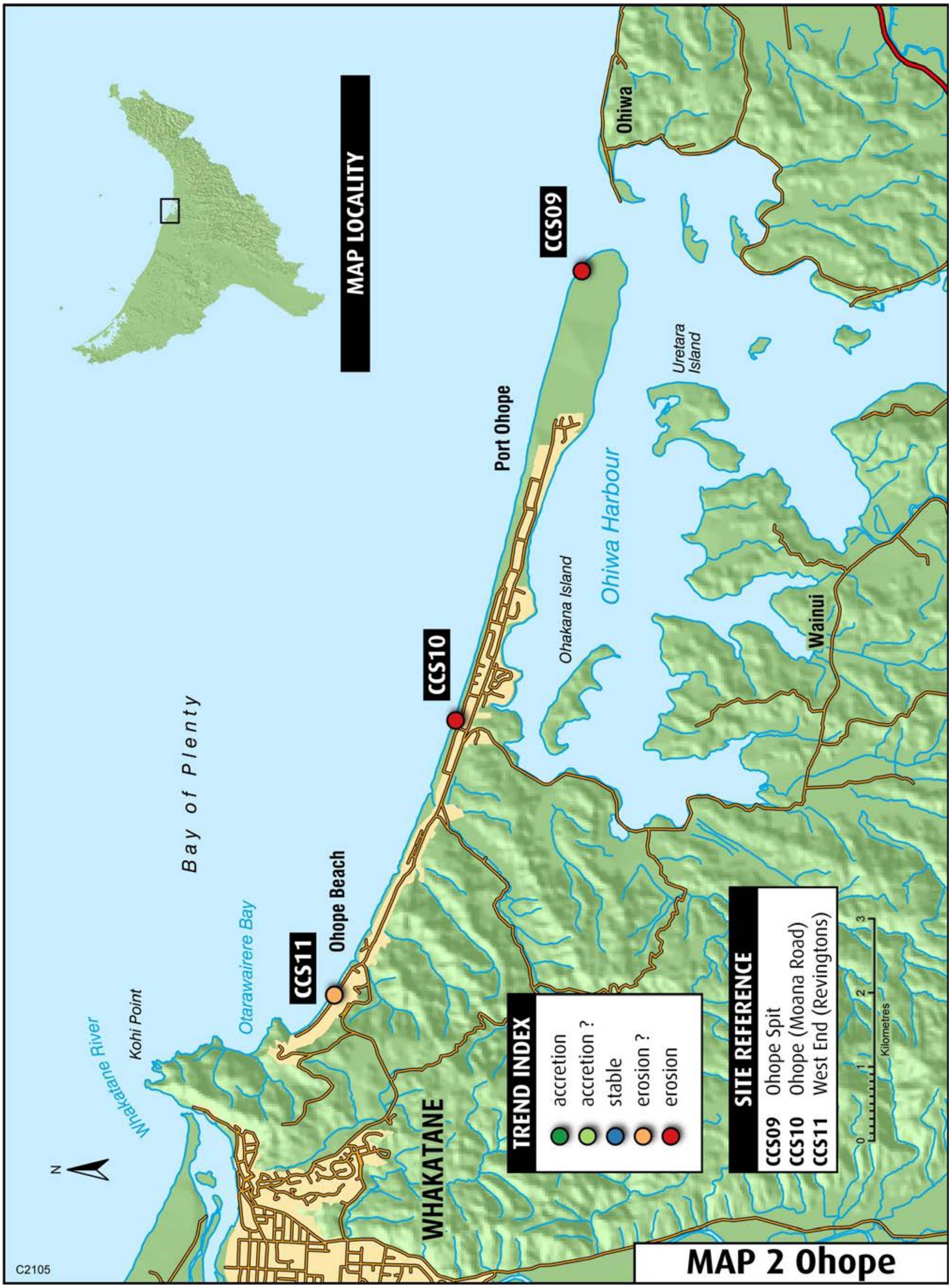


Figure 7.3 Ohope Beach system status.

7.3 Thornton Beach system

The Thornton Beach system (Figure 7.4) is occupied by five monitoring sites and stretches between the Whakatane River and Rangitaiki River.

For the 16 year period of record an assortment of trends are calculated for these sites, a pattern of stability is evident in close proximity to each of the river entrances, suggesting a neutral to positive sediment supply available to the adjacent beach system.

At the eastern end of the system this pattern of stability changes to one of slight accretion at Piripai (+0.6m/yr). Historically, Pullar & Selby (1971) state a rate of shoreline advance of 0.3m/yr since the Tarawera eruption in 1886. Healy (1976a) however considered progradation had ceased and that the most dominant trend in the last 30 years was net erosion. Gibb (1978) stated accretion at 0.26m/yr for 1886 to 1962 and 30m of erosion at a rate on -2.3m/yr from 1961 to 1974. The current recorded movement and rates are within those recorded historically indicating a continued stable pattern of dynamic equilibrium.

Healy (1983) used old survey plans and aerial photographs to look in detail at the movements of the Whakatane Spit. Using the boundary of the Ngatiawa burial reserve as a reference position at the basal end of the spit, Healy mapped the following movements (Table 7.4) of the MHWM (Tonkin & Taylor, 2002).

Table 7.4 Historical shoreline movement for Whakatane Spit.

Period	Movement	Rate
1875-1923	+62.5m	+1.3m/yr
1923-1939	-50m	-3.1m/yr
1939-1952	+152.5m	+4.0m/yr
1952-1962	-35m	-3.5m/yr
1962-1973	+25m	+2.3m/yr
1973-1977	Static	0
1875-1977	+55m	+0.5m/yr
1990-2006*	+30m	+1.9m/yr

* NERMN record Source: Tonkin &Taylor (2002)

This analysis suggests that since 1923, the spit has been in a state of dynamic equilibrium, with the advance prior to 1923 being due to sediment inputs from the Tarawera eruption. This state of dynamic equilibrium is also indicated in the CCS12 dataset that shows the foredune toe to be in the same position in 2001 as it was in 1977.

For the two central sites (CCS14 and 15) located on the flanks of the cuspate foreland, the pattern is tending towards erosion. This trend is possibly a result of the modified local wave climate caused by this geomorphic feature during this current climatic cycle. Historically this area has shown steady signs of progradation due to the wave shadow effect of Whale Island and the supply of sand from the Rangitaiki and Whakatane Rivers. Positive shoreline change rates of 1.08 to 1.54m/yr have been determined by Gibb (1994). Current rates from the NERMN record show retreat of 0.75m/yr.

The site adjacent to the Rangitaiki River shows a trend of stability, which is most likely linked to the increased sediment contribution from the river.

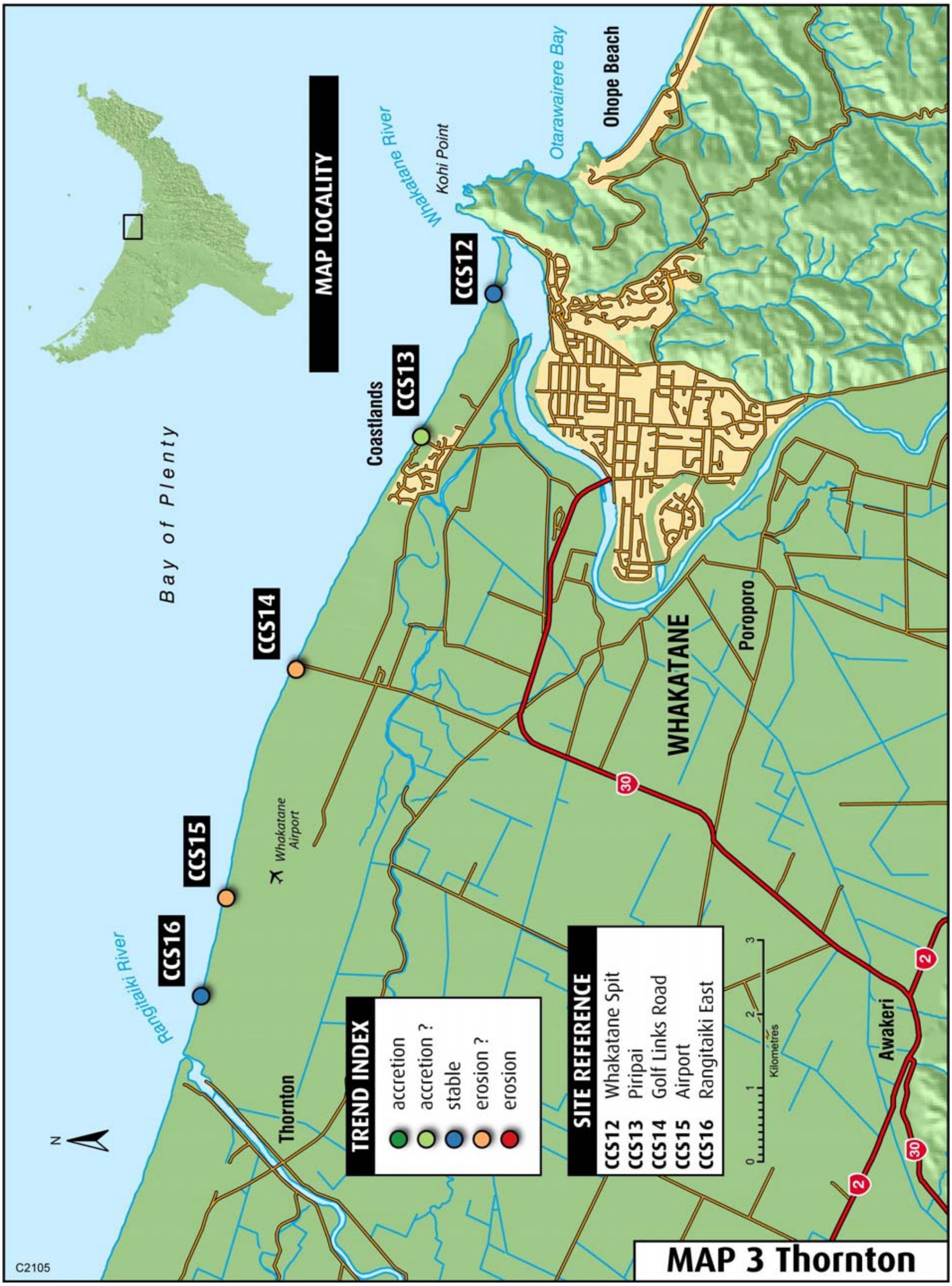


Figure 7.4 Thornton Beach system status.

7.4 Matata Beach system

The eight sites from Rangitaiki west to Otamarakau cover the Matata Beach system (Figure 7.5).

A consistent pattern of beach stability tending towards accretion is measured for CCS17 to CCS22 inclusive. Sediment contributions from both the Tarawera and Rangitaiki Rivers affect this section of beach. Beach volumes for these 6 sites all show positive increases. The foredune position trends are not as definitive especially where intense human activity (sand mining) has been present in the past.

Historically for the section between the Rangitaiki and Tarawera rivers Gibb (1978) gives the following rates in Table 7.5. Within this 76 year period there would have been periods of slower progradation and no doubt minor erosional cycles, the accretion rate for the NERMN report period (1990-2006) is 0.25m/yr reflecting a period of stability.

Table 7.5 Historical shoreline movement for Tarawera and Rangitaiki sections.

Site	Period	Movement	Rate
Tarawera	1886-1962	+101m	+1.3m/yr
Rangitaiki	1886-1962	+101m	+1.3m/yr

Source: Tonkin & Taylor (2002).

The diversion of the Tarawera River mouth away from the township in 1917 and the mining of approximately 6,000m^3/yr of foreshore and dune sand at the same site for 20 years up to 1985 is likely to have influence historical shoreline movement at Matata (CCS21). Healy (1977) in giving the following long term shoreline movements (Table 7.6) at Clem Elliot Drive from 1868 to 1977 noted that the diversion of the Tarawera River from the township was probably responsible for the change in trend from retreat to advance for 1914 to 1949 (Tonkin & Taylor, 2002).

Table 7.6 Historical shoreline movement for CCS21.

Period	Movement	Rate
1868-1914	-34m	-0.74m/yr
1914-1949	+25m	+0.71m/yr
1949-1977	-22m	-0.79m/yr
1868-1977	+55m	-0.28m/yr
1990-2006*	+6m	+0.4m/yr

* NERMN record Source: Tonkin & Taylor (2002).

The effects of this human activity have also been evident in the monitoring record at Otamarakau which was also a site of historical sand mining. A trend of erosion was determined for both Pikowai and Otamarakau profile sites, for the 1990-2006 period.

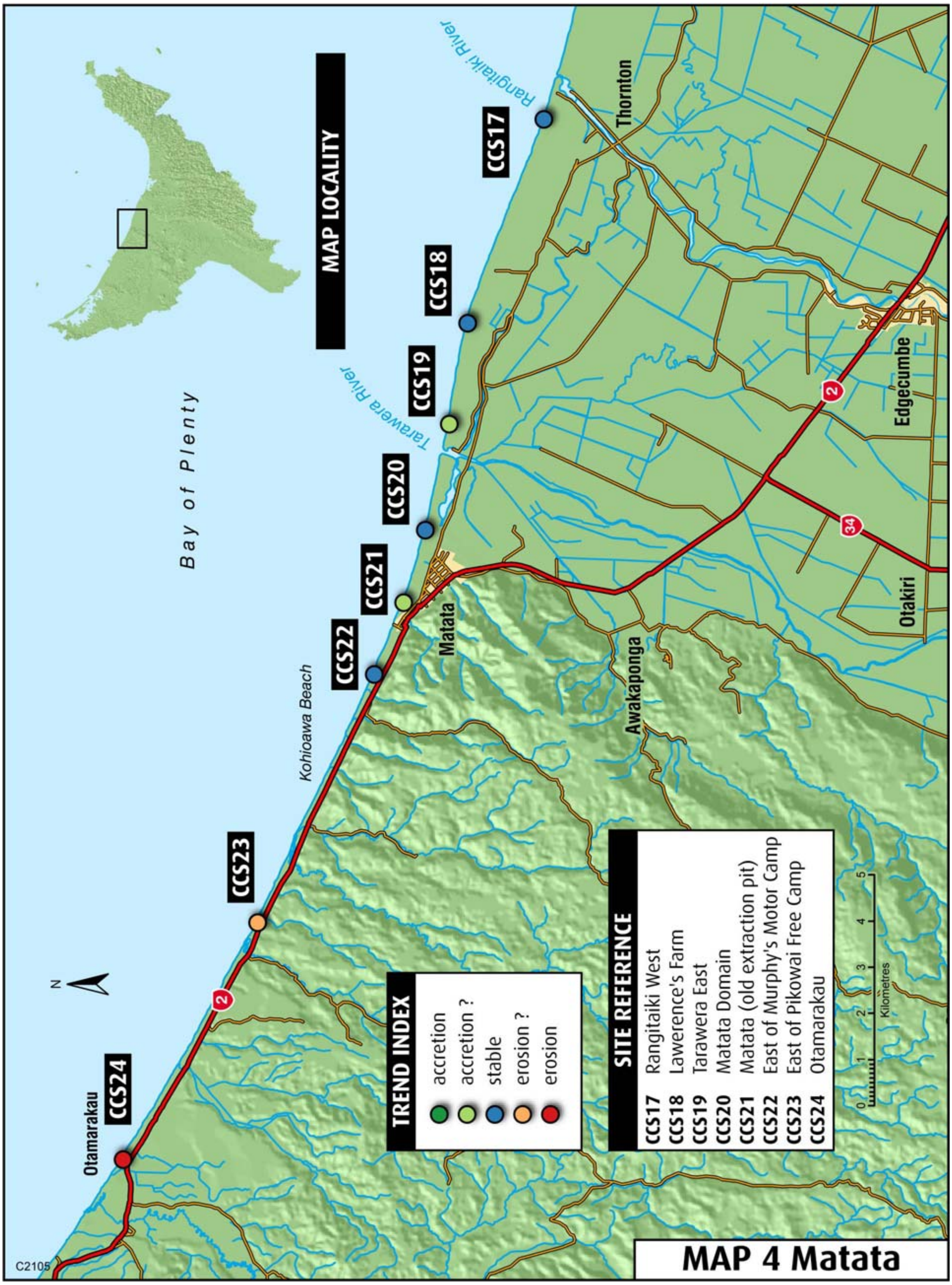


Figure 7.5 Matata Beach system status (1990-2006).

7.5 Pukehina Beach system

The 16 years of NERMN data shows a common trend of erosion for the six beach profile sites within the Pukehina Beach System (Figure 7.6). This system stretches from Rodgers Road in the east 11km to the west to end at Newdicks Beach on the eastern side of the Maketu Headland.

An overall pattern of erosion has been determined for these sites. An interesting pattern of short term erosion often occurs during moderate sized storm events where isolated pockets of beach can show marked erosion while nearby adjacent areas go untouched. This was recently exhibited during a short duration storm in September 2005 where up to 8m of dune retreat was measured in a very confined area (50m in width) and 100m either side of this zone no retreat was measured. Easton (2002) stated that this wave focusing (and associated erosion) was observed along the Pukehina coastal sector due to offshore undulations in bathymetry.

Masters thesis submitted by Phizacklea (1993) and Easton (2002) provide a very detailed collection of work summarising the coastal processes for this section of beach. A generalised conceptual model of the factors that cause erosion or accretion on this beach is taken from Phizacklea (1993). The model is based on profile sites CCS27 and CCS28 (Pukehina south to Pukehina central).

> *Under fair-weather conditions, sediments with a mineralogical composition characterised by high amounts of pumice and glass are transported onshore by low swell waves .... Transportation of sediment in an onshore direction results in a steady accumulation of sediment on the beachface, and slow onshore movement of the offshore bar ... which under prolonged periods of calm wave conditions becomes part of the beach berm with a non-existent to flattened offshore bar of less than half a metre in height.*
>
> *Under storm conditions waves break further offshore, and in deeper water (up to 15m water depth) entraining sediments at greater depths, with sands continually in suspension. Sediment is removed from the beach and swash zones, transported seawards by strong rip-currents, and deposited in the upper nearshore zone developing a sub-tidal platform at the point where the wave orbital motions can no longer move the coarser sediments. Downwelling bottom return flows transport the fine sands onto the lower nearshore and inner shelf.*

Easton (2002) expands on this highlighting that nearshore sediment transport rates within the region are significantly influenced by localised wind patterns within the Pukehina coastal sector. This sector was identified as having a net deficit of sediment, approximately 4,500m^3/year. However due to errors involved in the estimate calculations this value may be larger.

Easton noted sediment textural distributions have altered since work conducted by Phizacklea (1993). Texturally, offshore sediments vary from fine sand sized sediments to very coarse sand, while beach sediments are predominantly medium sized sands, with a decrease in sediment size towards Okurei Point indicating a westward sediment transport direction.

Due to the proximity of dwellings to the frontal dune and the measured trends for this section of beach, quarterly profiling will continue to monitor this situation (see Chapter 6).

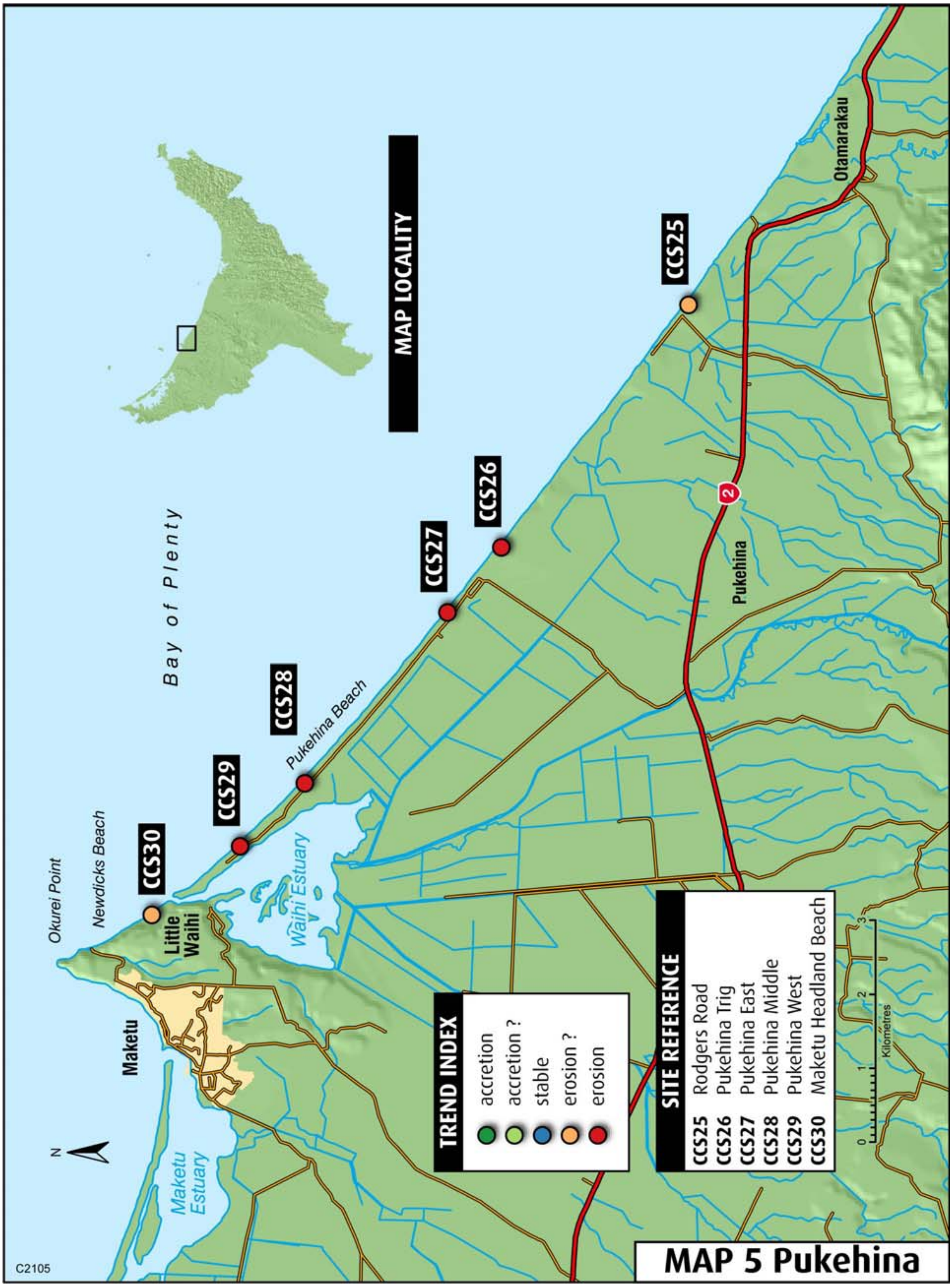


Figure 7.6 Pukehina Beach system status (1990-2006).

7.6 Papamoa Beach system

This section of sandy beach between Mt Maunganui and Maketu Estuary (Figure 7.7) are composed of fragile sand dune complexes. The dunes are relatively ancient with the 2000 year old dune complex being less than 80m from the beach. Much of the coast has reached dynamic equilibrium and sand is either being reworked by wind and wave action or there is a small surplus towards Mt Maunganui. The dune complexes are extremely susceptible to wind and sea erosion processes. Damage to sensitive dune binding vegetation by uncontrolled pedestrian and vehicle traffic and storm water outlets, destabilises the dune opening them up to wind erosion (Gibb, 1995).

Nine profile sites make up the physical coastal NERMN programme for this section of the beach, which starts at the Maketu Estuary in the east and stretches 28km to the base of Mt Maunganui in the west.

A mixture of trends is present for this section. There appears to be no strong beach widepattern, with erosion trends calculated for the sites fronting residential development at CCS 34, 38 and 39. Marked erosion is also present at the site on the western side of the Kaituna Cut which is in contrast with its mirror site on the eastern side at CCS32. CCS32 has the benefit of:

- onshore movement of sediment due to long period swell waves (this area is outside of the wave shadow cast by Motiti Island,
- bed load material from the Kaituna River adding to the littoral drift system in this area,
- a localised eddy associated with the Maketu Headland which maintains a deposition point of sediment which is being transferred along the coast.

The site at the Mount Maunganui shows a trend heading towards accretion. This site has the added benefit of reworked material being transported from the dredge spoil sites onshore during favourable climatic and weather conditions (Foster, 1991).

The section of beach from CCS35 to CCS40 which fronts residential development will continue to be monitored quarterly along with additional sites (12) funded by Tauranga City Council.

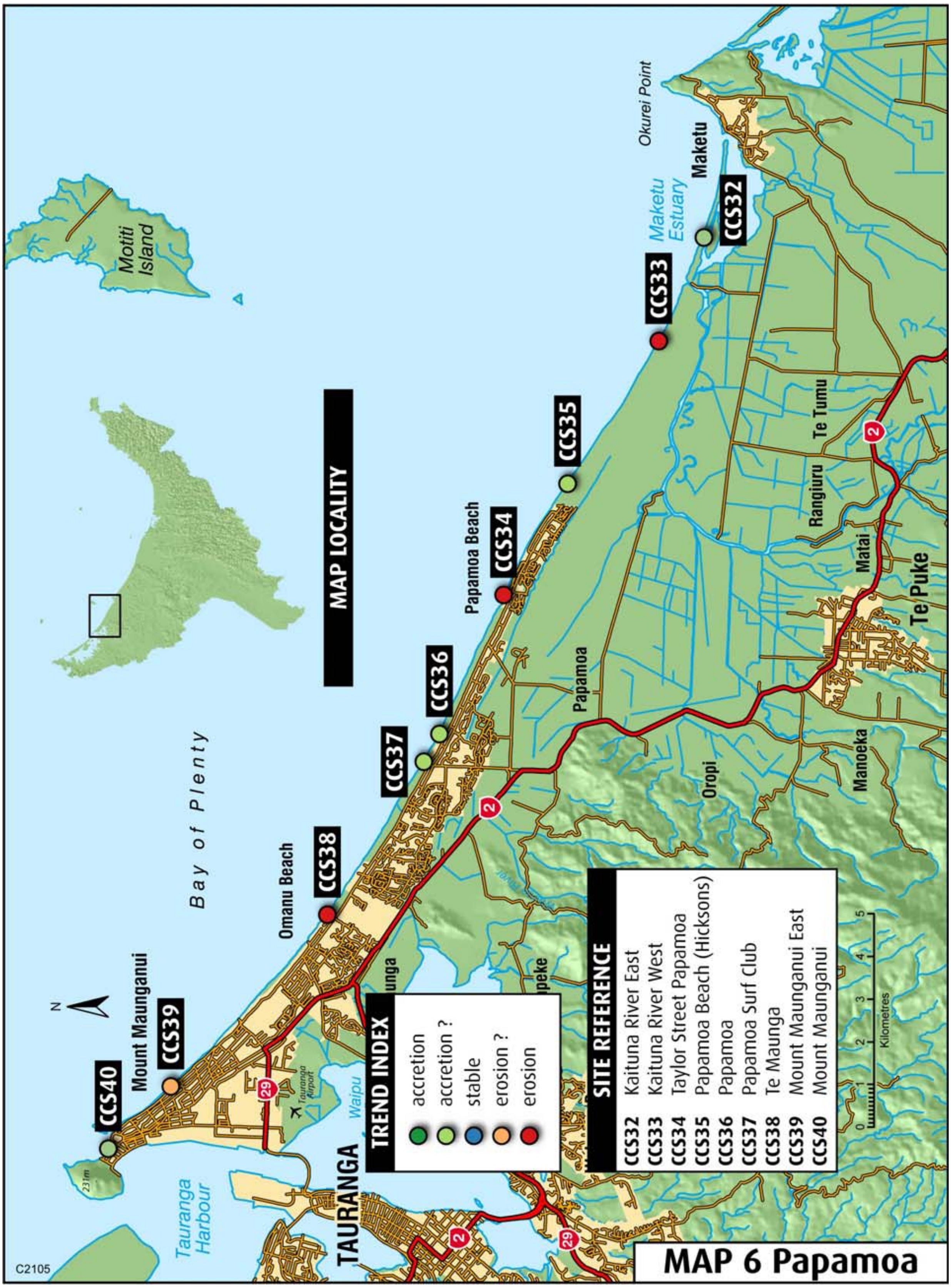


Figure 7.7 Papamoa Beach system status (1990-2006).

7.7 Matakana Beach system

Six coastal NERMN sites occupy the 24km long Matakana barrier island. The dominant trend is one of stability (dynamic equilibrium), with one site (CCS43) also exhibiting some signs of accretion (Figure 7.8).

Erosion patterns are evident at CCS42, which are difficult to explain in relation to the trends measured at the profile sites either side and with the limited physical information available. Offshore bar presence and orientation could be causing wave focussing resulting in this localised erosion. The trend of erosion at the North End site is easier to describe due to its close proximity to the Bowentown tidal inlet. Changes in entrance dynamics, in particular the formation of lateral channels affects sediment supply and removal markedly at this site. Additional wave focussing caused by the size and orientation of the ebb delta will also be a contributing factor to this measured upper beach instability.

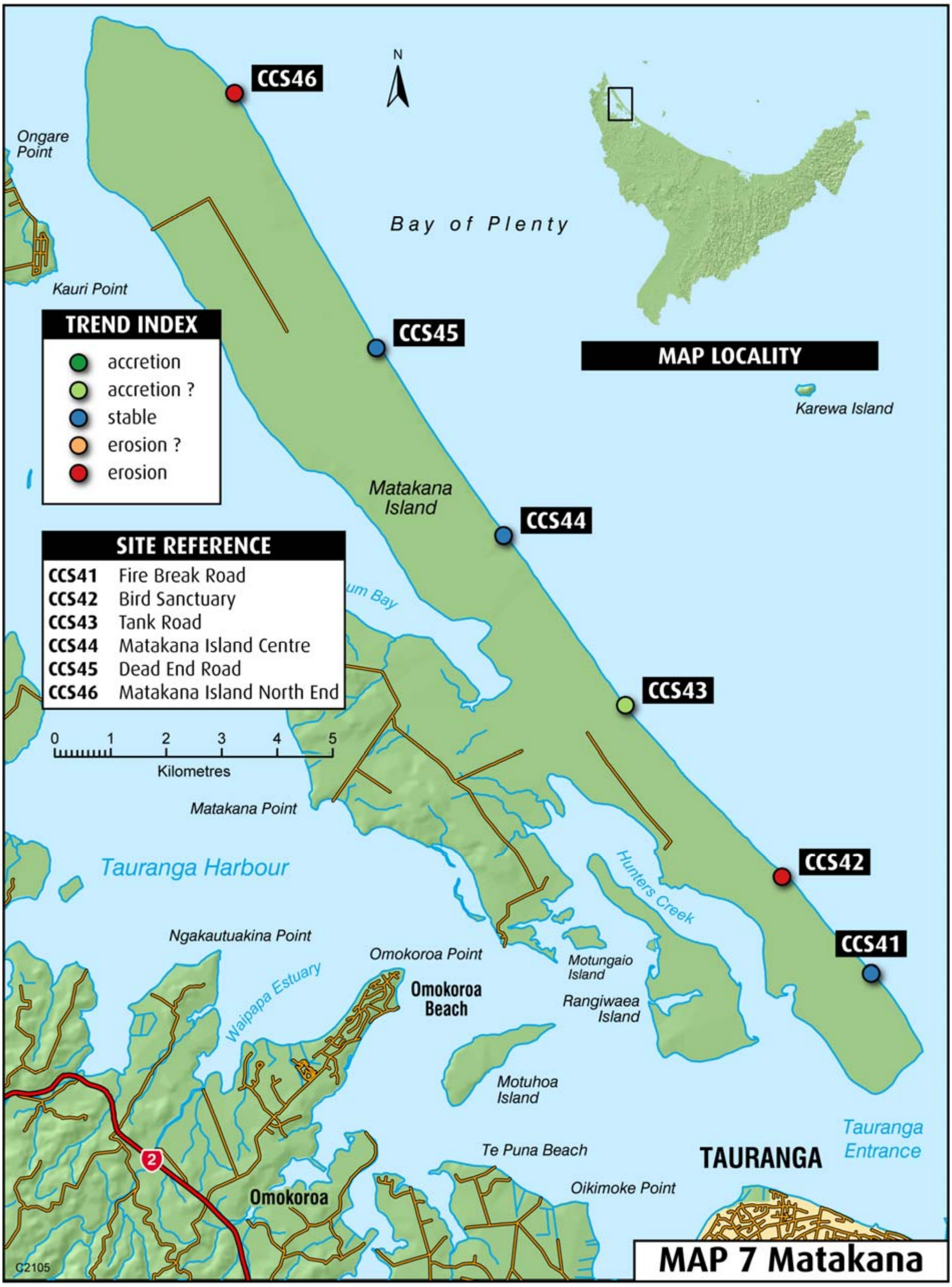


Figure 7.8 Matakana Beach system status (1992-2006)..

7.8 Waihi Beach system

Wave driven sediment transport dominates the coastal processes at this location, although the stream mouths at Two Mile and Three Mile Creeks result in localised erosion of the upper beach (Gibb& Tonkin& Taylor, 1997) in the vicinity of the creek outlets (Tonkin & Taylor, 2004).

Numerous studies have assessed the net and gross rates of longshore drift with no apparent consensus. It is likely that over the long term longshore drift is largely oscillatory, with reasonably large rates of gross transport and with possibly a slight northwest trend, although a examination of stream mouth location at the creeks would suggest a slight south east drift. Cross shore transport is likely to be the most significant factor affecting shorter term shoreline change, with sand moved offshore during periods of strong onshore winds and storm activity, with onshore movement of sand during periods of low swell and offshore winds (Tonkin & Taylor, 2004).

The length of monitoring record for the Waihi Beach section (Figure 7.9) is 16 years for the sites from CCS47 to CCS51, the Coast Care sites at the northern end (CCS52-54) have been monitored for the last eight years. The recent Eco Nomos Ltd (2003) report concluded that the Waihi Beach profiles show considerable evidence of short term fluctuations over periods ranging from several weeks to 2-3 years.

For the reported datasets the general pattern is one of erosion at the southern end of the beach, stability in the middle section (CCS49 to CCS50) and indications of accretion at the three northern Coast Care sites.

These short term trends differ from the general long term trends (1902 to present). Tonkin & Taylor (2004) state:

> *Assessments using historic cadastral information and aerial photographs present a stable to slightly accretionary shoreline to the north of Coronation Park, dynamically stable from Coronation Park to Elizabeth Street and increasingly erosional from Elizabeth Street to Two Mile Creek. The Loop was erosionary at either side largely due to the creeks and Glen Isla Place experienced erosion, also presumably due to lee side erosion effects from Three Mile Creek.*

Quarterly monitoring will be continued for this Waihi Beach system.

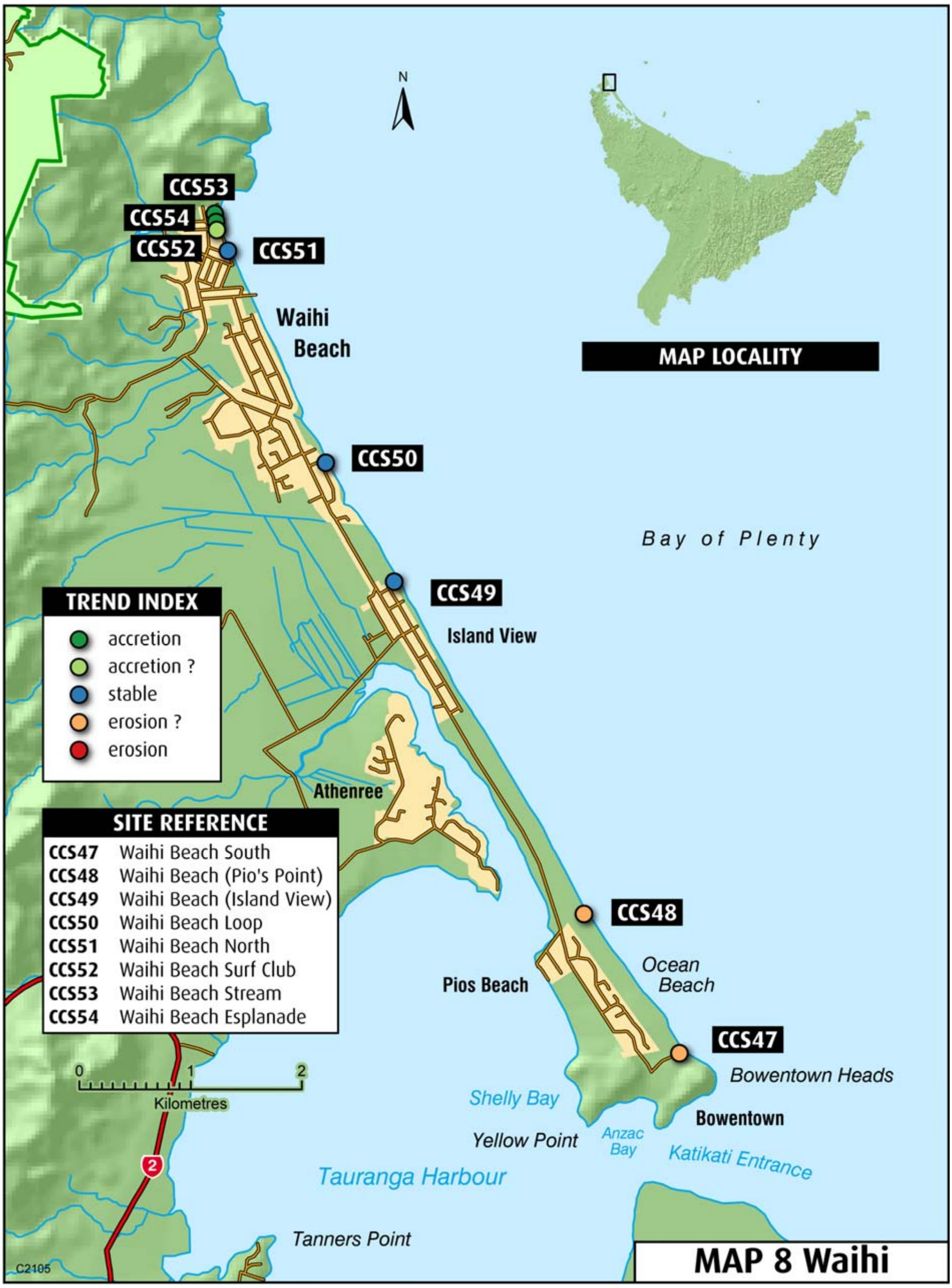


Figure 7.9 *Waihi Beach system status (1990-2006) (CCS52 to CCS54 – 1998-2006).*

Chapter 8: Conclusion

The current monitoring programme is adequate for long-term trend determinations along the Bay of Plenty coastline. However the frequency of profile measurements does not allow for the full analysis of beach process to be undertaken. The inclusion of storm specific monitoring (as programmed in Chapter 6) will partly address this and increase the value of these datasets when undertaking future coastal erosion hazard investigations and trend analysis.

Results from this report show that the following beaches are showing trends of ongoing erosion:

- Ohope Beach
- Pukehina Beach
- Southern area of Waihi Beach
- Central section of Hikuwai Beach

All of these beaches have been covered recently (within the last 5 years) by detailed investigations. The central section of Hikuwai Beach will be part of a current investigation looking at proposed modifications to the Waioeka River entrance.

Hodges and Deely (1997) listed a number of conclusion items in the last Coastal NERMN data review. These are outlined in Table 8.1 with comments outlining progress.

Table 8.1 Previous Coastal NERMN review conclusions.

Hodges and Deely (1997) conclusions	Comment
There is currently no coastal monitoring east of Opape Beach. Gibb's (1994) defines a number of beaches in this area as having a CSI rating of "High Sensitivity", with long-term trends of shoreline retreat. Based on his sections, increase monitoring in this area.	Reference sites have been developed by the Technical Services team and surveyed as required post storm events. The mixed gravel beaches which are predominant in the eastern area behave differently to the sandy beaches to the west, this frequency of monitoring should be sufficient to monitor trends.
More monitoring is necessary along Ohope Beach — Ohiwa Spit in the short term.	This site is to be installed and monitored for Whakatane District Council between the Whakekura and Maraetotara Streams.
More seasonal monitoring is required along successive sections coastline to assess magnitude of seasonal cut and fill.	This has been adopted with 35 sites currently being monitored on a quarterly basis to get a representative seasonal distribution.
Need sediment sampling at profile locations on an annual / 5 yearly basis to look at changes in grain size, sorting, mineralogy and source.	This work has been typically part of thesis research projects where field programmes have been supported by the council in order to gain this information. This has happened at Ohope, Pukehina, Mt Maunganui beaches recently.
Need to set up a wave rider buoy to collect wave information in order to assess wave climate in the region	This instrument was installed in September 2003 and continues to provide information for coastal and oceanographic investigations.
Need studies to determine bedload transport rates in the regions rivers to assess how much sediment is made available to the coastal area	Completed as part of the NIWA investigation looking at the impacts of climate change on coastal margins of the Bay of Plenty (see Bell et. al., 2006)

A number of conclusions from this current report are outlined below:

- A continuation of this monitoring is important in the management regime of this coastal area. There are increasing pressures (development and recreational) in this coastal environment. The profile monitoring provides a baseline dataset for determining the physical state of these beach systems. Additional increasing pressures such as sea level rise further enforce the requirement for this monitoring to continue. A future monitoring schedule has been outlined in Chapter 6 which will allow for timely and representative information to be collected and analysed.

- There should be a continuation of the grant in aid assistance for university research students investigating issues within this field.

- Maintain the Kohi Point tidal sensor, as this information provides valuable data for erosion causing storm events.

- Investigate the continued monitoring requirement for the Pukehina wave buoy.

- Further develop monitoring linkages with the Coast Care programme to quantify the benefits of this work.

- Continue to investigate monitoring methods and measurement technology to ensure the profile data is of a high standard and collected efficiently.

Chapter 9: References

Beanland, S. & Berryman, K.R., 1992, *Holocene coastal evolution in a continental rift setting*, Bay of Plenty, New Zealand, Quaternary International, 15/16.

Bell et. al., 2006, *Impacts of Climate Change on the coastal margin of the Bay of Plenty*, NIWA Client report, Hamilton, New Zealand.

Brownlee, K. A., 1960, *Statistical Theory and Methodology in Science and Engineering*. New York: John Wiley.

Bruun, P. 1962. *Sea-level rise as a cause of shore erosion*. Journal of Waterways and Harbours Division 88: 117–130.

Easton, H. R., 2002, *Coastal Erosion and Sedimentation of Pukehina Beach and Waihi Estuary*, MSc Thesis, Department of Earth Science, University of Waikato, New Zealand.

Eco Nomos Ltd, 2003, *Waihi and Pukehina Beaches: Assessment of Storm Cut Dune Erosion*, report prepared for Environment Bay of Plenty.

Eco Nomos Ltd, 2005, *Draft Opotiki District Erosion Hazard Assessment*, report prepared for Opotiki District Council.

Environment Bay of Plenty, 2006, *Digitised Coastal Resource Sheets for the Bay of Plenty*, MapInfo tables, GIS section, Whakatane, New Zealand.

Ellery, G., 2003, *Offshore Coastal Dynamics Survey*, Internal Report 2003/03, Environment Bay of Plenty, Whakatane, New Zealand.

Emery, K.O. 1961, *A Simple Method of Measuring Beach Profiles*, Limnology and Oceanography, 6, pp. 90-93.

Foster, G. A., 1991, *Beach nourishment from a nearshore dredge spoil dump at Mount Maunganui Beach*, MSc thesis, University of Waikato, New Zealand.

Gibb, J. G., 1977, *Late Quaternary sediment processes at Ohiwa Harbour eastern Bay of Plenty with special reference to property loss on Ohiwa Spit*, Water and Soil technical publication 5, Ministry of Works and Development, Wellington.

Gibb, J. G., 1994, *Initial Assessment of Areas Sensitive to Coastal Hazards for selected parts of the Bay of Plenty coast*, report prepared for the Bay of Plenty Regional Council.

Gibb, J. G., 1994, *The Otamarakau Coastal System, Bay of Plenty, with special reference to the effects of sand extraction,* Evidence prepared for Bay of Plenty Conservancy, Department of Conservation.

Gibb, J. G., 1995, *Coastal Reserves Management Plan, Strategies for managing Physical Elements between Mussel Rocks and Papamoa, Tauranga District*. Report prepared for Isthmus Group and Tauranga District Council.

Gibb, J. G., 1996, *Coastal Hazard Risk Assessment between Mauao and Papamoa, Tauranga District, Bay of Plenty*, Report prepared for the Tauranga District Council.

Harris, T.F., 1985, *North Cape to East Cape: Aspects of physical oceanography*, University of Auckland report, New Zealand.

Hay, D. N., 1991, *Storm and oceanographic databases for the Western Bay of Plenty*, MSc thesis, University of Waikato, New Zealand.

Healy, T.R., 1976, *Report to Whakatane District Council regarding Piripai Dunes: Coastal Erosion Hazard.*

Healy, T.R. et. al. 1977, *Bay of Plenty Coastal Erosion Survey*, Occasional Report No.3, University of Waikato, Department of Earth Sciences, New Zealand.

Healy T.R., 1978, *Beach Photographic locations and beach descriptions*, University of Waikato, Department of Earth Sciences, New Zealand.

Healy, T.R., 1978, *Some Textural and Mineralogical Investigations of the Rangitaiki Plains Foreshore and River Sands*, Bay of Plenty Coastal Survey Report 78/4, University of Waikato, New Zealand.

Healy, T.R., 1983, *Assessment of Stability and Natural Hazard Risk of the Whakatane Spit and Inlet in Relation to Proposed Marina Development, and Environmental Impact Assessment of the sediment and hydrological aspects of the Marina Development*, Report prepared for the Whakatane District Council, Coastal Investigations.

Healy, T.R., 1989, *Coastal stability at the Magee Subdivision*, Matata, report to Whakatane District Council.

Hicks, D.M. and Hume, T.M., 1991, *Sand storage at New Zealand tidal inlets*, 10th Australian Conference on Coastal and Ocean Engineering.

Hodges, S. & Deely, J., 1997, *Coastal Monitoring Programme – Summary to 1992 – 1996*, Environmental Report 97/3, Environment Bay of Plenty, Whakatane, New Zealand.

Hume, T.M & Hicks, D.M., 1993, *Morphology and processes near an ebb tidal delta, Katikati Inlet, New Zealand*, Proceedings of the 11th Australian Conference on Coastal and Ocean Engineering, Townsville, Queensland, Australia 23-27 August 1993.

IPCC, 2006, Climate Change 2007: *The Physical Science Basis, Summary for Policymakers*, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, www.ipcc.ch.

Julian, K., 2006, *Coastal Processes Influencing Beach Erosion at Ohope Spit*, MSc thesis, University of Waikato, Department of Earth Sciences, New Zealand.

Komar, P. D., 1976, *Beach processes and sedimentation*, Prentice Hall, New Jersey, USA.

Lawrie, A., 1997, *Compliance report – Sand mining in the Bay of Plenty*, Environmental Report 97/18, Environment bay of Plenty, Whakatane, New Zealand.

McNutt, K. et. al., 2006, *Trial Mapping of Dune Vegetation in the Bay of Plenty*, Environmental Publication 2006/04, Environment Bay of Plenty, Whakatane, New Zealand.

Macky, G.H. et. al., 1995, *Wave climate of the Western Bay of Plenty*, New Zealand 1991-1993, New Zealand Journal of Marine and Freshwater Research, vol. 29(3), 311-328.

Mitchell, M. T., 1998, *Ohope Beach Coastline assessment and management plan*, Report for Whakatane District Council.

MfE, 2001, *Overview of climate change effects and impacts assessment. A Guidance Note for local government in New Zealand*. New Zealand Climate Change Programme, Ministry for the Environment.

MfE, 2004, *Climate Change Effects and Impact Assessment, A guidance manual for Local Government New Zealand*, Published by the New Zealand Climate Change Office.

Murdoch, B., 2005, *Holocene evolution of Ohope Barrier Spit*, MSc thesis, University of Waikato, Department of Earth Sciences, New Zealand.

NIWA, 2007, *Climate Change, IPCC Fourth Assessment Report leaflet*, NIWA National Climate Centre.

Park, S.G., 1991, *Bay of Plenty Regional Council Coastal Overview Report 1991,* Bay of Plenty Regional Council, Technical Publication Number 3, August 1991.

Phizacklea, D.J.D, 1993, *Littoral Sediment Budget and Beach Morphodynamics, Pukehina Beach to Matata, Bay of Plenty*, MSc Thesis, Department of Earth Science, University of Waikato, New Zealand.

Pickett, V.I., 2004, *The Application of equilibrium beach profile theory to coastal hazard identification in the Bay of Plenty*, DPhil Thesis, University of Waikato, Coastal Marine Group, New Zealand.

Pickrill, R.A. & Mitchell, J.S., 1979, *Ocean wave characteristics around New Zealand*, New Zealand Journal of Marine and Freshwater Research, 15(4), 501-520.

Pullar, W.A. & Selby, M.J., 1971, *Coastal progradation of the Rangitaiki Plains, New Zealand*, New Zealand Journal of Science, 14.

Richmond, B.M., Nelson, C.M., Healy, T.R., 1984, *Sedimentology and evolution of Ohiwa Harbour, a barrier impounded estuarine lagoon in the Bay of Plenty, New Zealand*, Journal of Marine and Freshwater Research, 18.

Saunders, H.A., 1999, *Coastal Processes Influencing Beach Erosion at West End Ohope*, MSc Thesis, Department of Earth Sciences, University of Waikato, New Zealand.

Smith, R. K., 1987, *Coastal stability at West End Ohope and the assessment of a coastal hazard zone*, Ministry of Works & Development Hamilton, Consultancy Report T7041.

Smith, K.R. & Ovenden, R., 1997, *Sand mining review and report on the effect of sand extraction, prepared for J.W. Paterson and Sons Ltd, Matata*, NIWA Client Report PAT 70201/2, NIWA, Hamilton.

Smith, K.R. & Ovenden, R., 1997, *Ohope Beach coastal stability investigation*. Report for Whakatane District Council.

Stephens, S. A., 1996, *The formation of arcuate duneline embayments at Waihi Beach, New Zealand.* MSc Thesis, Department of Earth Sciences, University of Waikato, New Zealand.

Tonkin & Taylor Ltd, 2002, *Whakatane District Council Coastal Hazard Analysis*, Reference Number 18731, Tonkin & Taylor Ltd, Auckland, New Zealand.

Tonkin & Taylor Ltd, 2004, *Waihi Beach Erosion Protection Works, Assessment of Environmental Effects*, report for Western Bay of Plenty District Council.