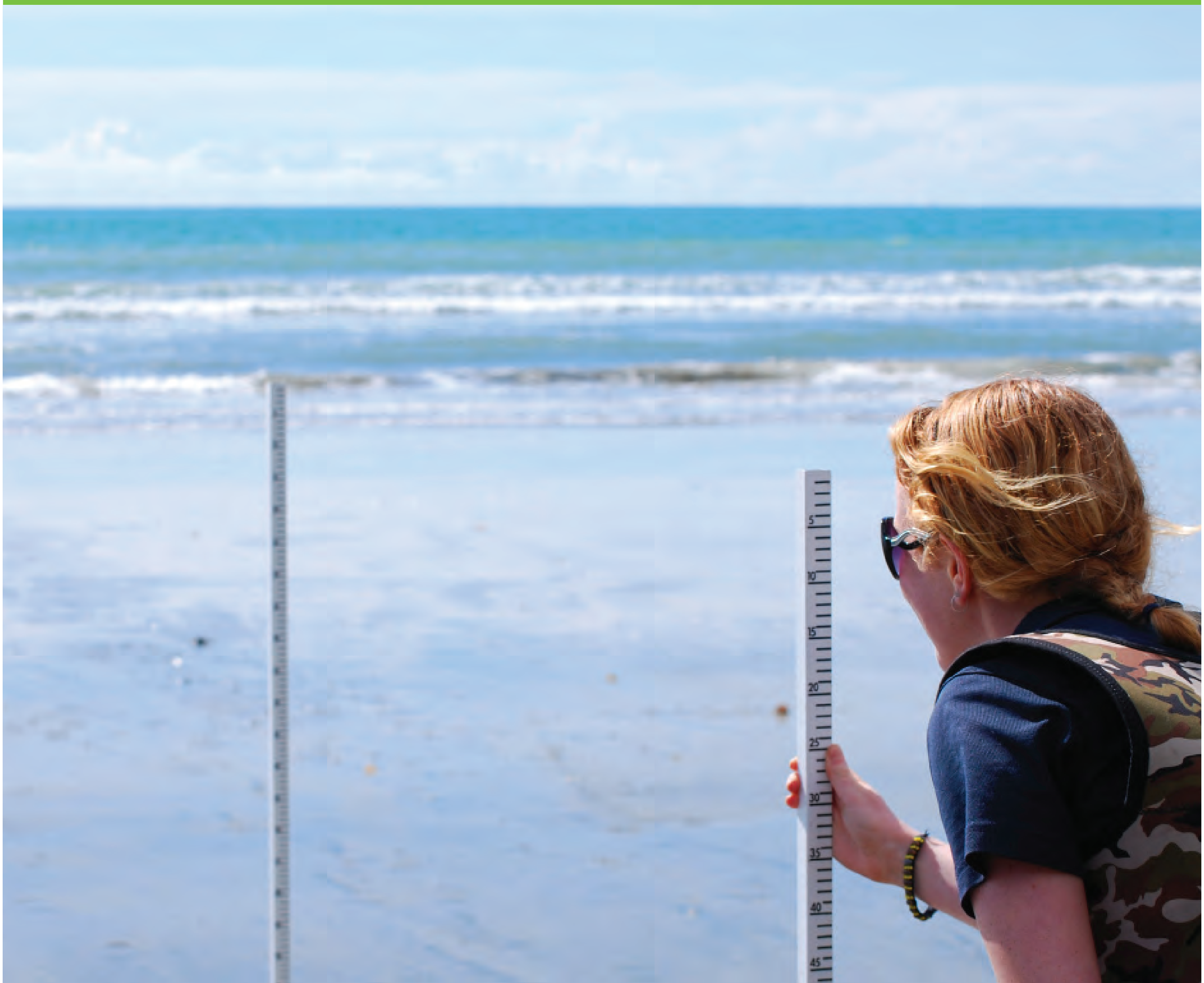
NERMN beach profile monitoring 2011

Prepared by Shane Iremonger, Environmental Scientist



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Cover Photo: Annabel Beattie undertaking a beach profile using the Emery Pole method, 2010.

Acknowledgements

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Executive summary

This is the third report detailing the results of the coastal monitoring network initiated by Bay of Plenty Regional Council 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 time, changes in the beach morphology along the sandy Bay of Plenty coastline result from “cut and fill” processes. The movement of sediment from this process is dependent 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 north-easterlies in the New Zealand region. During El Niño years, where a higher occurrence of south-westerlies occurs, wave conditions in the Bay of Plenty are somewhat reduced although episodic extra-tropical cyclones still occur.

Over the period of the physical coastal NERMN (typically 21 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. 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.

Results from this report show that the following beaches are showing trends of erosion for the period 1990-2011:

- 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 Part 3 of this report which will allow for timely and representative information to be collected and analysed.

Beach system	CCS site	Site Name	Beach state from statistical analysis of all profiles.
Hikuwai	1	Opape East	Accretion?
	2	Waiaua River West	Erosion
	3	Tirohanga Stream West	Erosion
	4	Hikuwai West	Erosion
	5	Waiotahi Beach East	Erosion?
	6	Waiwhakatoitoi	Stable
	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	Stable
	20	Matata Domain	Stable
	21	Matata	Stable
	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	Stable
	29	Pukehina West	Erosion
	30	Makatu Headland	Erosion?
Papamoa	32	Kaituna River East	Accretion
	33	Kaituna River West	Stable
	34	Taylor Street	Accretion
	35	Papamoa Beach	Stable
	36	Papamoa	Accretion?
	37	Papamoa Surf Club[1]	Accretion?
	38	Te Maunga	Erosion
	39	Mount Maunganui East	Accretion?
	40	Mount Maunganui	Accretion?
Matakana[2]	41	Fire Break Road	Stable
	42	Bird Sanctuary	Erosion
	43	Tank Road	Accretion?
	44	Matakana Island Centre	Stable
	45	Dead End Road	Stable
	46	Matakana Island North End	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	Accretion
	52	Waihi Beach Surf Club[1]	Accretion
	53	Waihi Beach Stream[1]	Accretion
	54	Esplanade Road[1]	Accretion

Note: 1 – Data is from 1998-2011, 2 – data is from 1992-2011.

Contents

Tables and Figures

Part 1: Introduction

1.1 Introduction

Bay of Plenty Regional Council established a coastal monitoring programme in 1990 as part of a Natural Environment Regional Monitoring programme covering the collection of varied environmental data - air quality, climate, hydrological, surface and groundwater, geothermal and marine and freshwater biological data. Such information allows the Council 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 (RMA).

A total of 53 sites (Figure 1) 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. This monitoring covers 135 kilometres of 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 a beach system will behave.

1.2 Requirements of RMA and regional plans

The purpose of the RMA (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 and 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.

In July 2003 the Bay of Plenty Regional Coastal Environment Plan was made operative. The purpose of this Plan is to enable Bay of Plenty Regional Council 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

Figure 1 Monitored coastal NERMN beach profile sites

(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. The information for plan monitoring will be drawn from a range of NERMN monitoring programmes including data collection and analysis performed for this report which investigates 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:

- Statistically assess profile and volumetric changes in Bay of Plenty beaches between 1990 and February 2011.
- The comparison of the current trends with earlier assessments.
- Provide an updated monitoring programme schedule.

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.

Part 1 forms an introduction to the report, outlining the responsibility of Bay of Plenty Regional Council under the Resource Management Act to monitor the coastal zone.

Part 2 presents the results of the Bay of Plenty Regional Council monitoring programme for the period 1990–2011. 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 Part 2.

Part 3 presents an updated monitoring schedule for the next five years.

Part 4 presents a general discussion on the state of the open coast sandy beaches for the 21 years of NERMN monitoring record.

Appendices 1 and 2 provide background information in relation to monitoring methods used within this NERMN module and information on the types of coastal processes and coastal landforms present within the Bay of Plenty, and gives a brief description of the factors affecting the region’s beaches. Wave buoy data is also briefly presented.

Part 2: Monitoring results

The monitoring results are presented in a double page spread form.

The sites are grouped based on beach system and are further divided if necessary to aid presentation and viewing. Note there is no CCS 31, this site was located on the Maketū Spit but was lost when the spit was breached in 1978 and has never been reinstated. Also CCS35 and CCS34 are not in order spatially, CCS34 is to the west of CCS35.

For this section of the report a general location map has been provided at the top of the initial page along with a photograph history of a single site in the group. Discussion has been included on this page which includes general comments about the section, site specific comments and commentary about what the photographs are showing. The facing page has a larger scale location map with site location shown. Maximum and minimum envelope plots along with the inclusion of the average profile position and the most recent profile. The inset graph shows toe of foredune (TOF) position over the period of record. A trend box is also presented next to the site location for the period 1990-2006 (the last reporting period) and 1990-2011 (the current reporting period).

2.1 Hikuwai Beach system

Hikuwai Beach section

This section of sandy beach coastline extends for 13.6 kms and has a morphodynamic type of "rhythmic bar and beach". The morphology of this section of coastline from the Waioeka River entrance to Opape has been the subject of a number of recent reports (Eco Nomos, 2007; Dahm, 2010; Iremonger, 2011). Detailed shoreline assessment was also undertaken by Gibb (1994). This coastline is thought to experience net alongshore sediment transport to the west toward Waioeka River entrance, though any net westward littoral drift is generally assumed to be relatively low (Gibb, 1994). Net drift may even be oscillatory, varying over time betwen easterly and westerly.


CCS04 - 1978

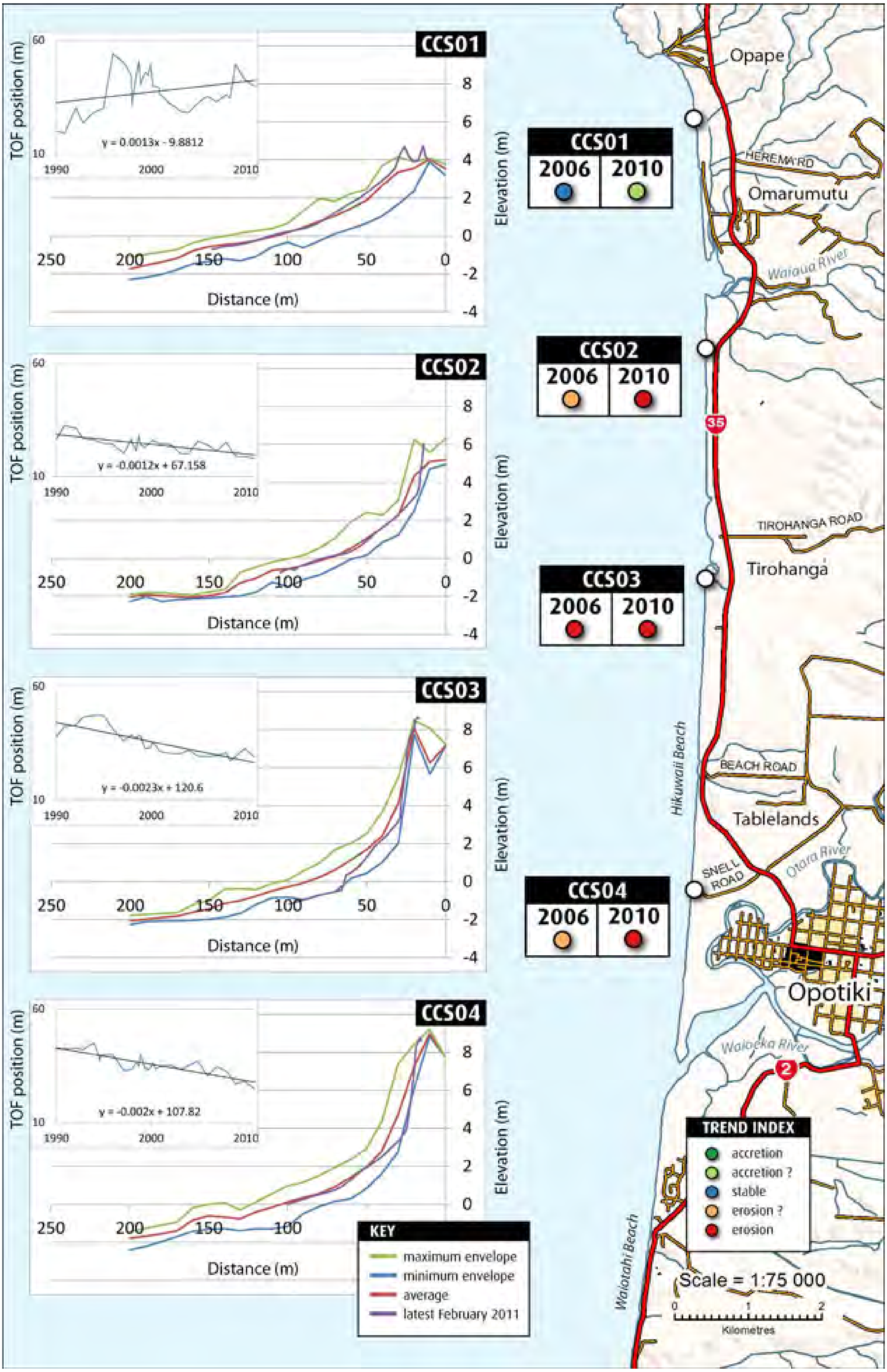

CCS04 - 2006


CCS04 - 2011

The four profile sites for this section show a prediminantly erosion pattern for the last 20 years. The site at Opape (CCS01) differs with an accumulation of sediment occuring. The Tarakeha headland would provide shelter to this eastern section of beach and a natural collection device for sediment drift migrating to the east. Along with Haurere Point these two features mark the divide between the sandy beaches which prevail in the central and western Bay of Plenty and the mixed sand/gravel and embayed beaches to the east.

The toe of foredune positions for profiles CCS02, CCS03 and CCS04 all show a strong pattern of shoreward retreat. The position of the foredune toe for CCS01 shows a dynamic trend, with a incipient dune forming in the mid 1990's. Photographic records show this feature is now well vegetated and continues to exist although has experienced some retreat in the early 2000's.

This section of beach will be the focus of more public attention in the future as the cycleway becomes operational in late 2011.


CCS01
TOF position (m)
y = 0.0013x - 9.8812
Elevation (m)
Distance (m)
CCS02
y = -0.0012x + 67.158
CCS03
y = -0.0023x + 120.6
CCS04
y = -0.002x + 107.82
KEY
maximum envelope
minimum envelope
average
latest February 2011
CCS01 2006 2010
CCS02 2006 2010
CCS03 2006 2010
CCS04 2006 2010
Opape
HEREMA RD
Omarumutu
Waiaua River
TIROHANGA ROAD
Tirohanga
Hikuwai Beach
BEACH ROAD
Tablelands
SNELL ROAD
Otara River
Opotiki
Waioeka River
Waiotahi Beach
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Scale = 1:75 000
Kilometres

2.2 Waiotahi Beach system

Waiotahi Beach section

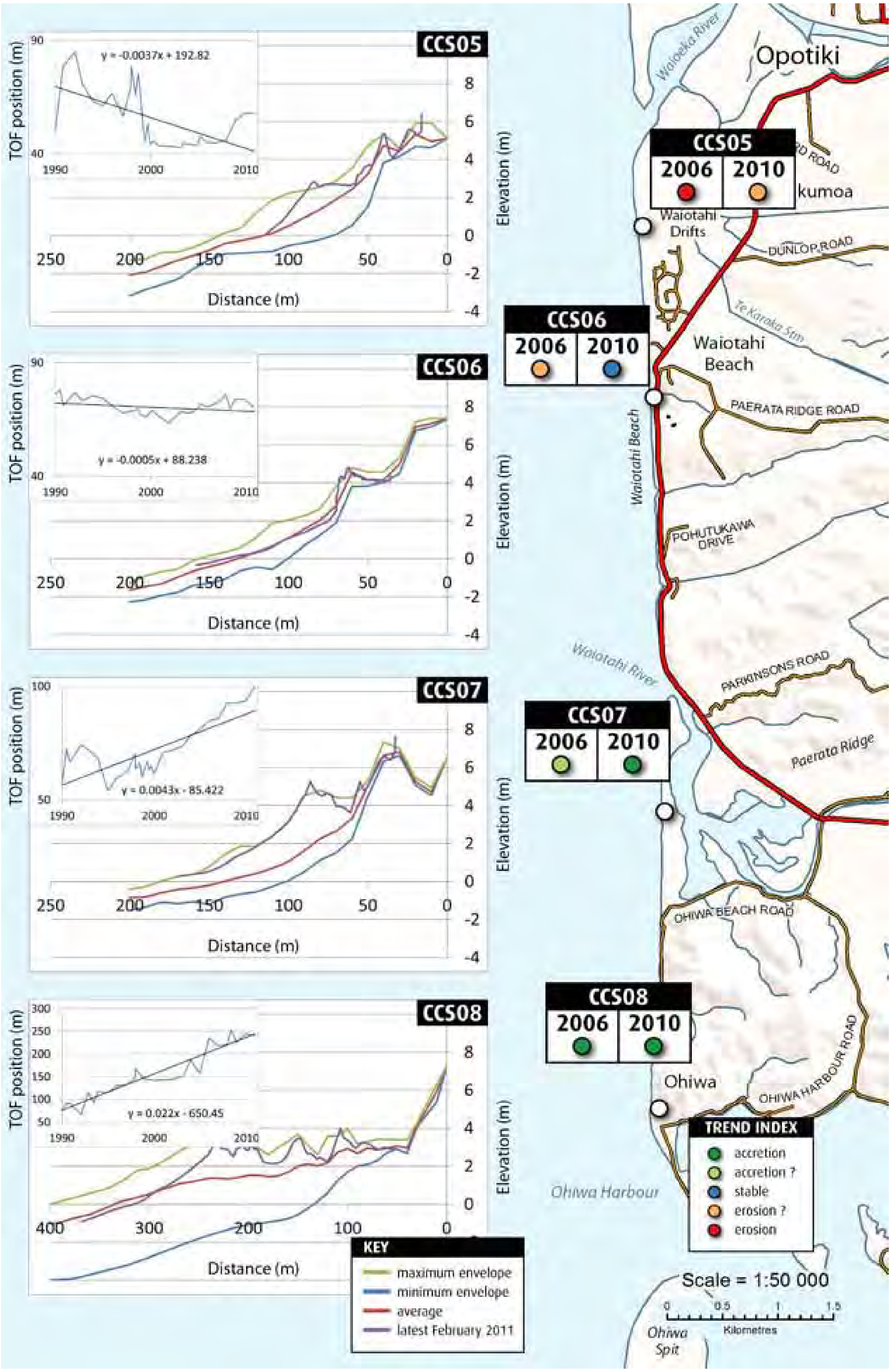
The four profile sites that cover this 9.5km section of sandy "longshore bar and trough" beach are bounded in the east by the Waioeka River entrance and in the west by the highly dynamic Ohiwa Harbour entrance. This area can be further divided into two groups due to the presence of the Waiotahi River entrance midway along this section. Like the previous section, this area has also received a fair amount of attention with the development of the Waiotahi Drifts subdivision (Gibb, 1998) and the more recent residential development on one of the beach front sections at Ohiwa Spit. (Gibb, 2006).

The profile at CCS05 which is within 600m of the Waioeka River entrance is still categorised as being in an erosion state for the collected record, although recent toe of foredune data shows a seaward progression when compared with positions measured in the early to mid 2000's.

Stability and acretion are the pattern for the three more eastern profile sites, with a strong patern for those sites east of the Waiotahi River entrance. Both CCS07 and CCS08 have exhibited strong seaward growth of the upper beach. CCS07 is curently in a maximum seaward position for the 20 years of monitoring, CCS08 shows a current toe of foredune position that is nearly 200m seaward of that measured in 1990.

Sediment supply should be strongly positive for this section of coast with three significant catchments bringing suspended sediment material into this system.

This accretion patern does fluctuate and during the early to mid 1970's this eastern section underwent a strong erosion cycle where at the CCS08 site several houses were lost to the sea (see Gibb,1977).



CCS05
TOF position (m)
y = -0.0037x + 192.82
Elevation (m)
Distance (m)
CCS06
y = -0.0005x + 88.238
CCS07
y = 0.0043x - 85.422
CCS08
y = 0.022x - 650.45
KEY
maximum envelope
minimum envelope
average
latest February 2011
Opotiki
Waioeka River
CCS05
2006
2010
kumoa
Waiotahi Drifts
DUNLOP ROAD
Te Karaka Strm
CCS06
2006
2010
Waiotahi Beach
PAERATA RIDGE ROAD
Waiotahi Beach
POHUTUKAWA DRIVE
Waiotahi River
PARKINSONS ROAD
Paerata Ridge
CCS07
2006
2010
OHIWA BEACH ROAD
CCS08
2006
2010
Ohiwa
OHIWA HARBOUR ROAD
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Ohiwa Harbour
Scale = 1:50 000
Kilometres
Ohiwa Spit

2.3 Ōhope Beach system

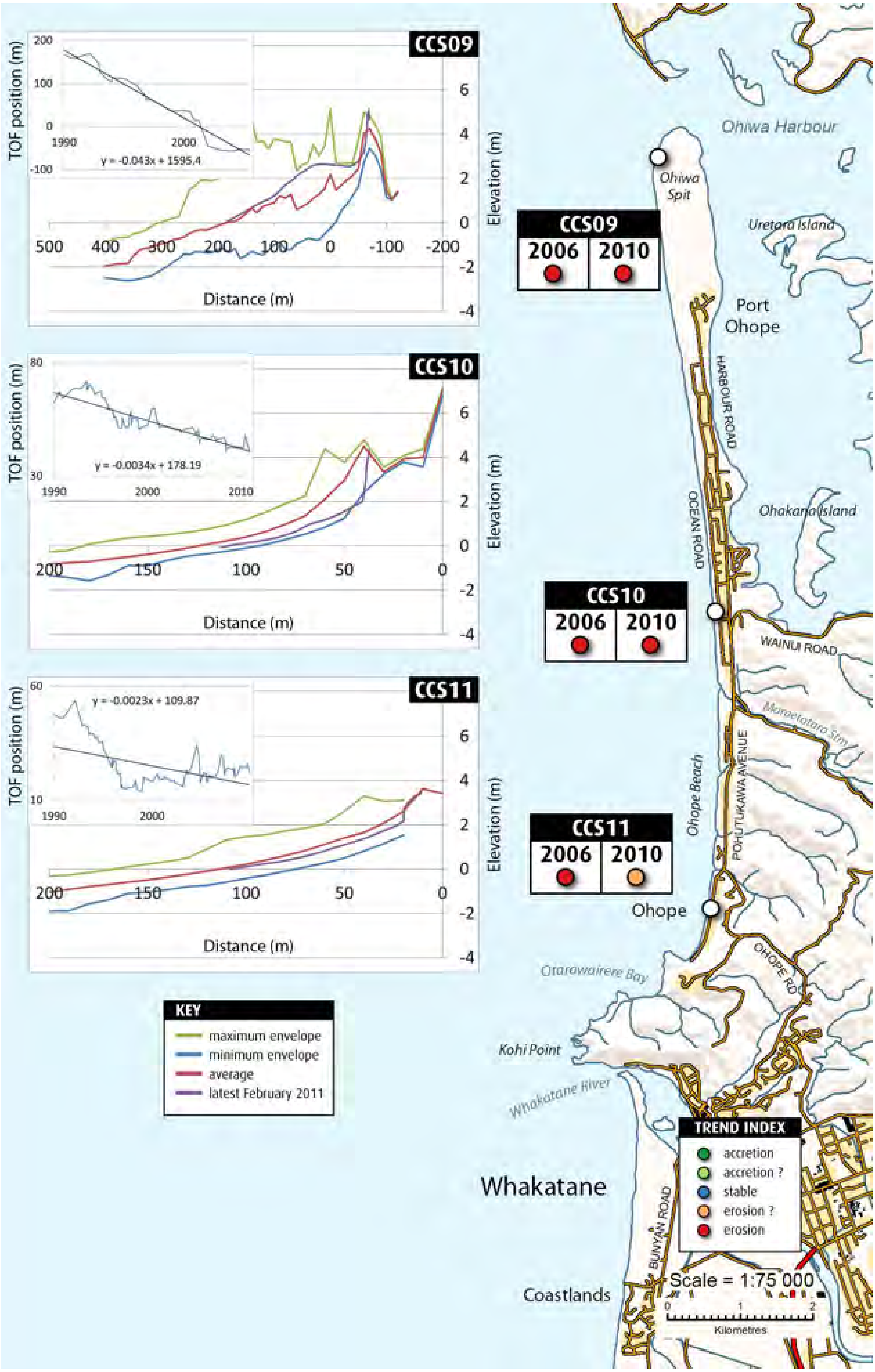
Ohope Beach section

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.

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. The orientation of Ohope Spit and the parallel dune ridges indicate a long term littoral drift towards the east (Gibb, 1977; Healy et.al, 1977; Murdoch, 2005).

Under normal conditions West End receives sediment from that 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 path towards the west).

All three monitoring sites continue to show an erosion trend for the last 20 years. CCS11 has stabilised in relation to the marked retreat in the late 1990's. Although retreat is still common during events as the dune in this area has been modified and affected by human activity. The latest profile shows a position close to the long term average . A wide vertical band of ~2m is shown in the CCS11 dataset.



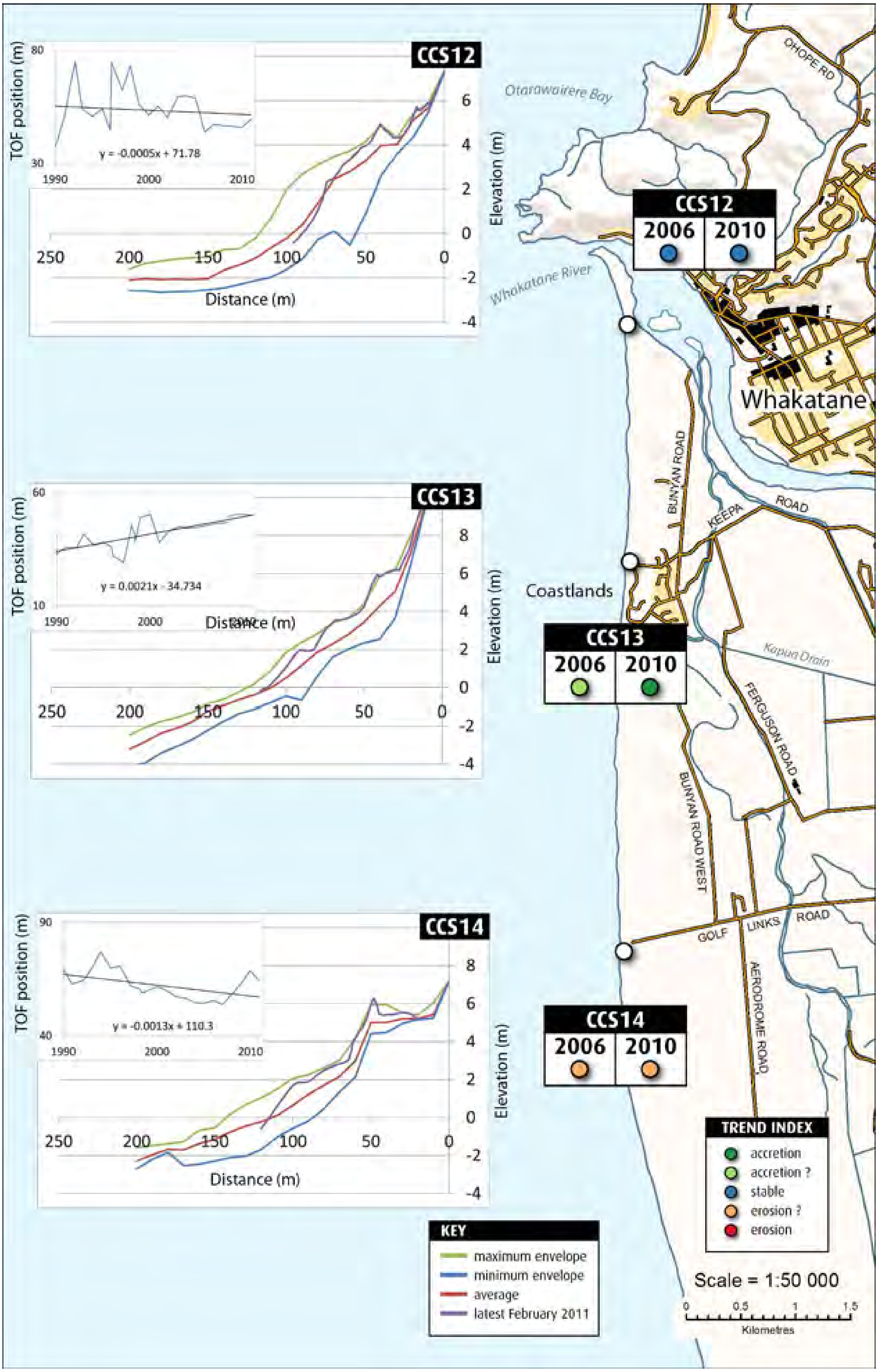
CCS09
TOF position (m)
y = -0.043x + 1595.4
Elevation (m)
Distance (m)
CCS10
y = -0.0034x + 178.19
CCS11
y = -0.0023x + 109.87
KEY
maximum envelope
minimum envelope
average
latest February 2011
CCS09 2006 2010
CCS10 2006 2010
CCS11 2006 2010
Ohiwa Harbour
Ohiwa Spit
Uretara Island
Port Ohope
HARBOUR ROAD
OCEAN ROAD
Ohakana Island
WAINUI ROAD
Moraetotara Stm
POHUTUKAWA AVENUE
Ohope Beach
Ohope
OHOPE RD
Otarawairere Bay
Kohi Point
Whakatane River
Whakatane
BUNYAN ROAD
Coastlands
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Scale = 1:75 000
Kilometres

2.4 Whakatane Beach system

Whakatane Beach section

The Whakatane Beach system is occupied by three monitoring sites and stretches from the Whakatane River to the eastern flank of the cuspate foreland at Golf Links Road. The distance of sandy beach covered by these sites is 6.3km. For the 20 year period of record an assortment of trends are calculated for these sites, a pattern of stability is evident in close proximity to the river entrance, suggesting a neutral to positive sediment supply available to the adjacent beach system. The Tonkin & Taylor (2002) report, highlights beach movement patterns since 1875 for this section of beach at the spit. From 1875 to 1923 +1.3m/yr, 1923 to 1939 -3.1m/yr, 1939 to 1952 +4.0m/yr, 1952 - 1962 -3.5m/yr, 1973 - 1977 0m/yr, 1990 - 2006 +1.9m/yr.

For CCS13 the record to date shows a pattern of accretion with the latest profile showing the upper beach section to be in the most seaward position within the last 20 years, the lower beach section is above average as well. A well established and vegetated incipient dune is now present which is a marked change from the situation in the late 1970's where blowouts where present and steep poorly vegatated zones evident.
For CCS14 the pattern is reversed even though the site is only located ~3km to the west of CCS13. Erosion has been the overall trend for the last 20 year although in the last 5 years a seaward building of the dune system has developed. The latest profile is at a near maximum seaward position. This site would be more affected from wave focussing caused by Whale Island located ~7km offshore. 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.

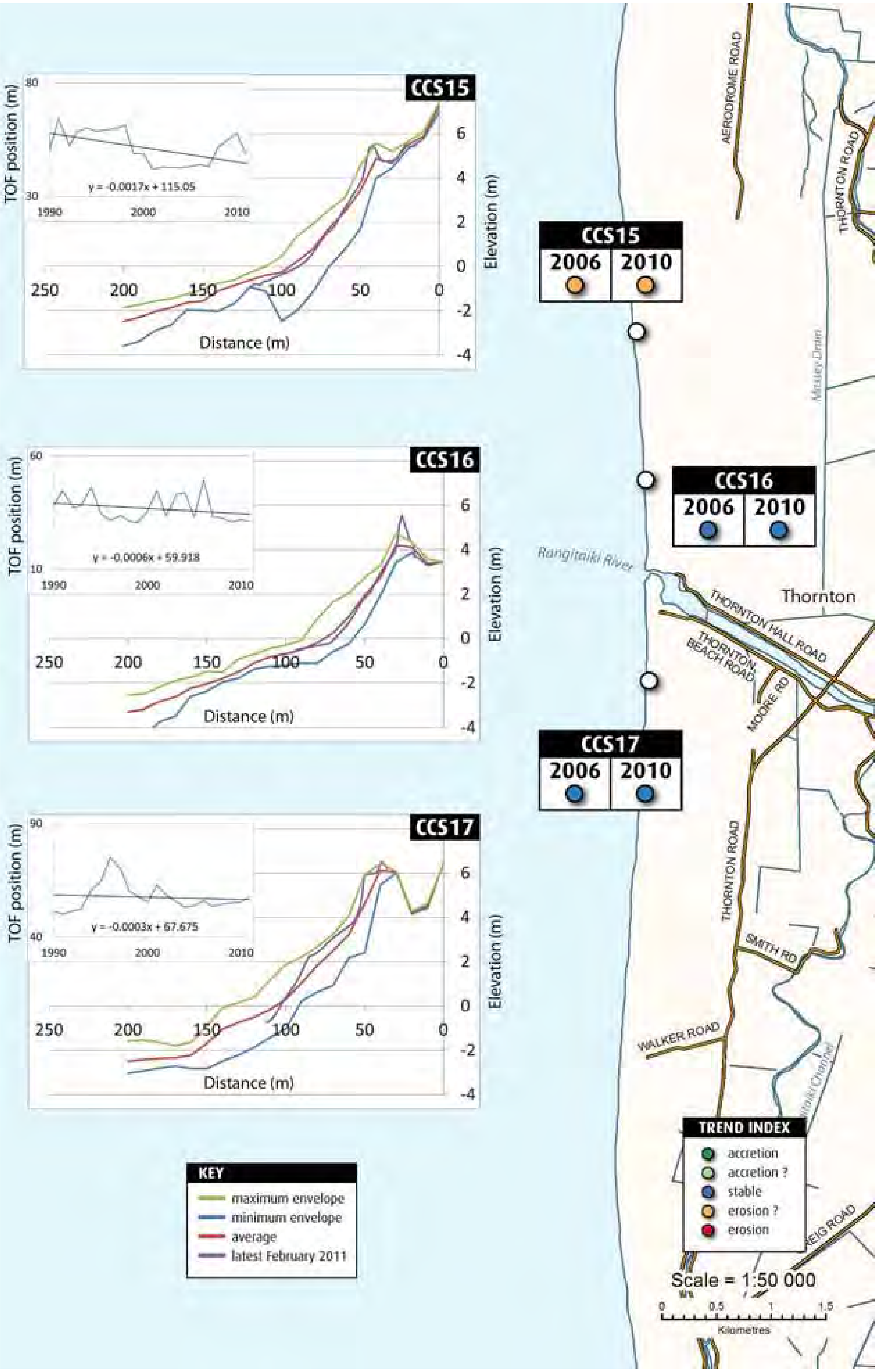

CCS12
TOF position (m)
y = -0.0005x + 71.78
Elevation (m)
Distance (m)
CCS13
y = 0.0021x - 34.734
CCS14
y = -0.0013x + 110.3
KEY
maximum envelope
minimum envelope
average
latest February 2011
Otarawairere Bay
Whakatane River
OHOPE RD
Whakatane
BUNYAN ROAD
KEEPA ROAD
Coastlands
Kapua Drain
FERGUSON ROAD
BUNYAN ROAD WEST
GOLF LINKS ROAD
AERODROME ROAD
CCS12 2006 2010
CCS13 2006 2010
CCS14 2006 2010
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Scale = 1:50 000
Kilometres

2.5 Rangitaiki Beach system

Rangitaiki Beach section

Three sites are reported on for this section of sandy coastline. The longshore distance covered by these sites equates to aproximately 5km, spread either side of the Rangitaiki River entrance. CCS15 is located 2.3 km east of the Rangitaiki River entrance. This section of coast , located in the lee of Moutohora (Whale) Island, shows dynamic fluctuation on beach position as a result of the wave shadow/focusing effect from the island and sediment supply from both Whakatane and Rangitaiki rivers. The Rangitaiki River sediment contribution has diminished since the construction of the mid catchment Matahina Dam, commissioned in the late 1960's.

The 20 year pattern for CCS15 is one of erosion, but recent toe of foredune position data shows a reversal. The latest profile is plotting around the long term average.
Sites CCS16 and CCS17 are equally spaced (~800m) either side of the Rangitaiki River entrance, and in the central area of the cuspate forelands. The toe of foredune plots show flucutations of equal magnitude to CCS15 but statisically both of these sites are showing a stable trend for this parameter. CCS16 beach profile is curently positioned near the long term average with CCS17 plotting slightly above. Both sites would benefit from the local addition of sediment from the Rangitaiki River although this is minor in relation to the volume of sediment moving along the coast in an easterly net direction.
The photography shows little change since 1978 with a well vegetated frontal dune evident in all three images, a berm is present in 1978, although this is a dynamic area on the beach with several metres of veritcal movement being recorded.



CCS15
TOF position (m)
80
30
1990
2000
2010
y = -0.0017x + 115.05
Elevation (m)
Distance (m)
CCS15
2006
2010
CCS16
TOF position (m)
60
10
y = -0.0006x + 59.918
Elevation (m)
Distance (m)
CCS16
2006
2010
CCS17
TOF position (m)
90
40
y = -0.0003x + 67.675
Elevation (m)
Distance (m)
CCS17
2006
2010
KEY
maximum envelope
minimum envelope
average
latest February 2011
AERODROME ROAD
THORNTON ROAD
Massey Drain
Rangitaiki River
Thornton
THORNTON HALL ROAD
THORNTON BEACH ROAD
MOORE RD
THORNTON ROAD
SMITH RD
WALKER ROAD
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Scale = 1:50 000
Kilometres

2.6 Tarawera Beach system

Tarawera Beach section

These three sites are located in proximity to the Tarawera River entrance. CCS18 is 2.8km to the east and CCSS20 is located 1.8km to the west of the entrance. The sand and gravel yield from the Tarawera River entering the coastal environment has been calculated at 82,000 tones/year (Bell, et.al. 2006). Trend analysis suggests all three sites are in a stable equilibrium state. The toe of foredune trends for CS19 and CCS20 are slightly negative although the curent position of this feature for both sites is within the envelope measured over the last 20 years.

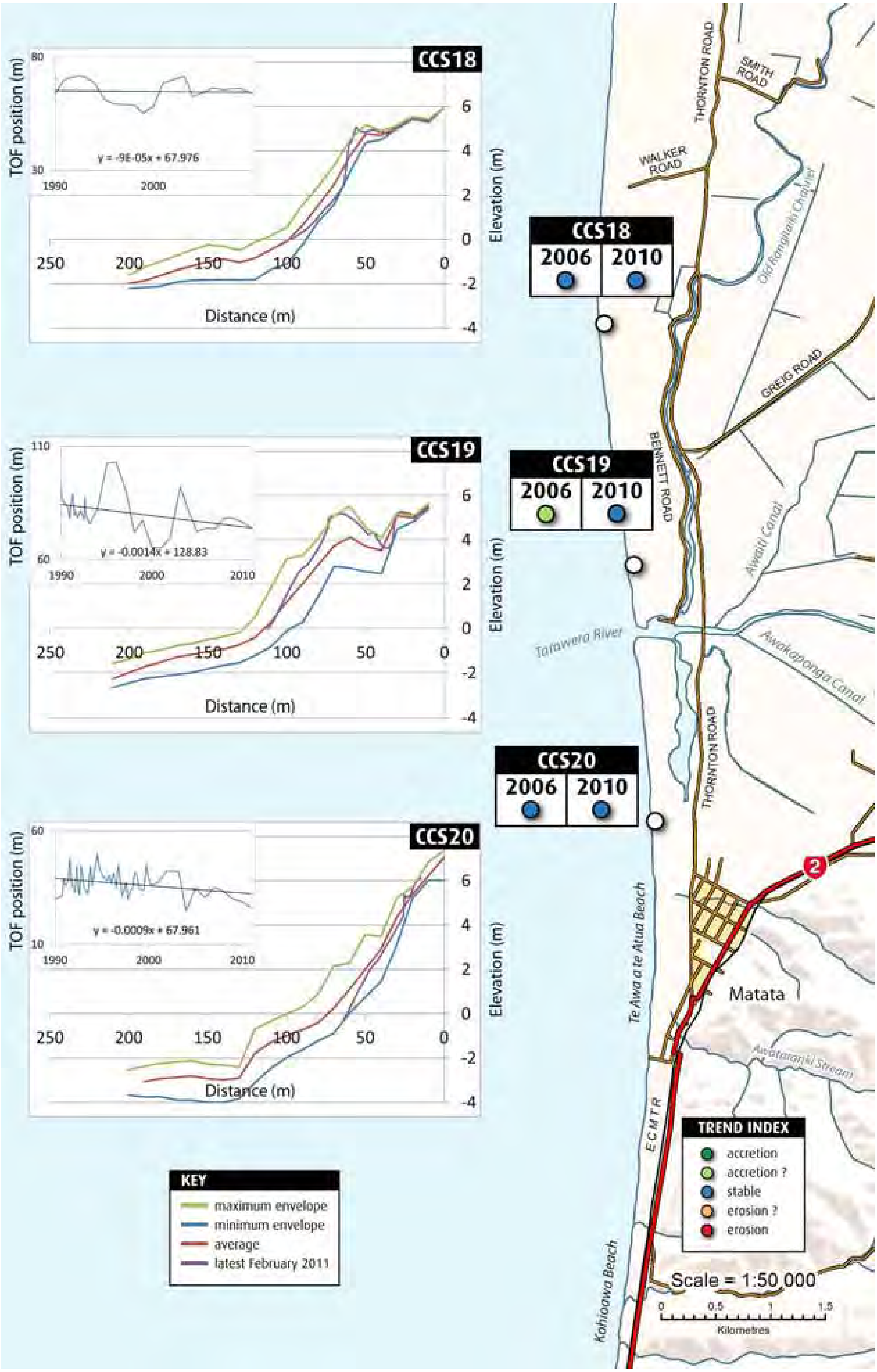
For CCS19 monitoring data indicates that the beach was in it's most landward position in 1991 and most accreted position in 1996. The surveys show the establishment of a new frontal dune (see maximum envelope).

Site CCS20 was profiled quarterly up to 2000 (and annually thereafter) due to its inclusion in the sand mining monitoring programme.

Analysis of the trends for the volume and toe of foredune shows that this profile site is in a stable state for the period of monitoring (1990 - 2011).

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.

The beach volume data shows stable trends for all three sites.



CCS18
CCS19
CCS20
TOF position (m)
Elevation (m)
Distance (m)
y = -9E-05x + 67.976
y = -0.0014x + 128.83
y = -0.0009x + 67.961
CCS18
2006
2010
CCS19
2006
2010
CCS20
2006
2010
KEY
maximum envelope
minimum envelope
average
latest February 2011
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
THORNTON ROAD
SMITH ROAD
WALKER ROAD
Old Rangitaiki Channel
GREIG ROAD
BENNETT ROAD
Awaiti Canal
Tarawera River
Awakaponga Canal
Te Awa a te Atua Beach
Matata
Awatarariki Stream
ECMTR
Kohioawa Beach
Scale = 1:50 000
Kilometres

2.7 Matata Beach system

Matata Beach section

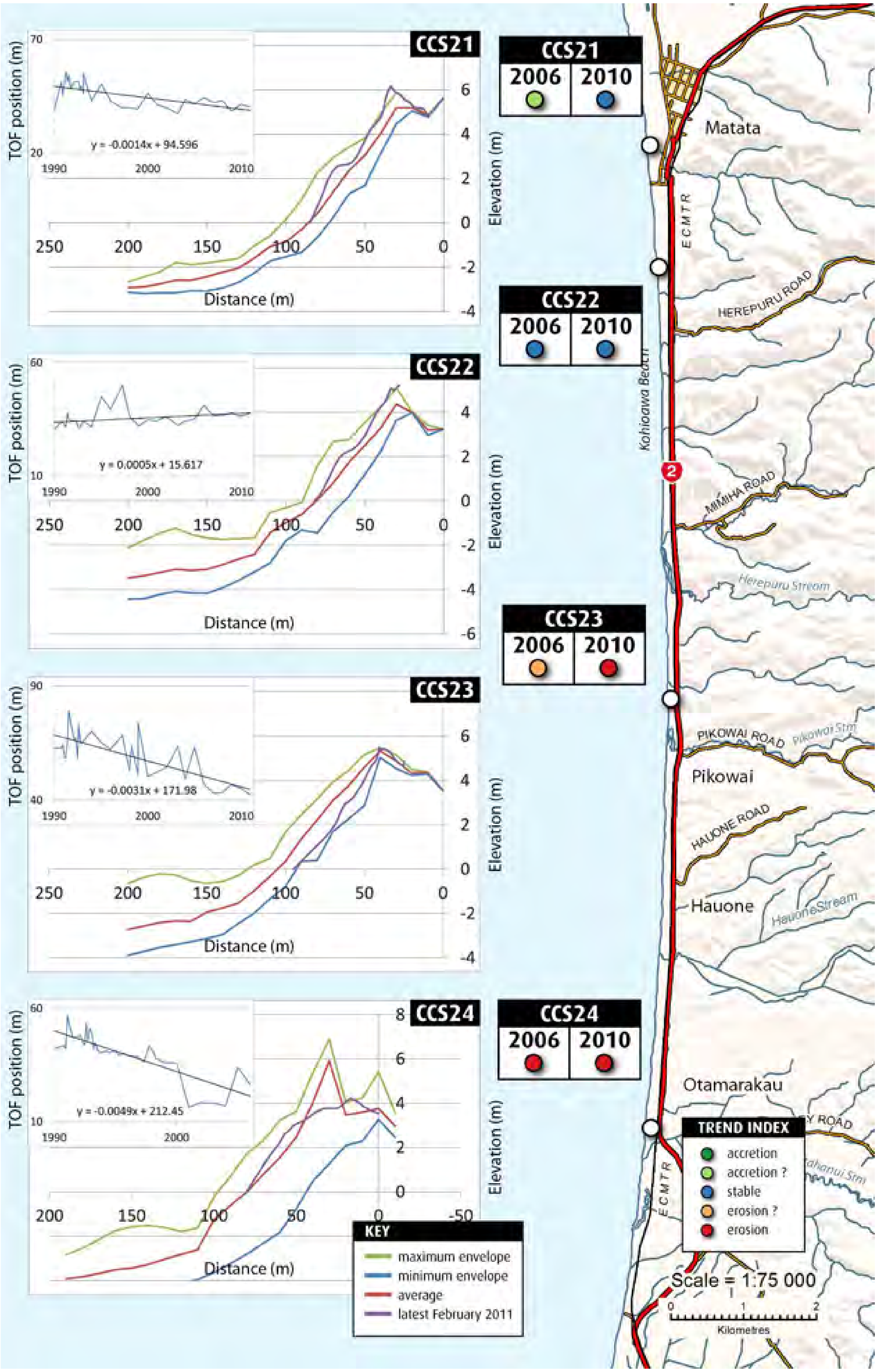
Site CCS21 is located 1km to the west of the Matata Domain. This site fronts Clem Elliot Drive and the adjacent sand mining area. Healy (1977) gave the movement of 31m retreat for the period 1868 to 1977 (during this period there was a time of advance (1914-1949) which was attributed to the diversion of the Tarawera River). Site CCS22 is situated 500m of the east Murphys Motor Camp. The beach borders a narrow Holocene coastal plain of sand barriers. CCS23 is located 200m east of the Pikowai Camping Ground and the Pikowai Stream, both of these features have had an effect on this section of beach due to pedestrian trafic and stream migration.


CCS24 - 1978


CCS24 - 2006


CCS24 - 2011

CCS24 is located 1km to the east of where the Waitahanui Stream passes beneath the railway line. Historicaly this was one of the most intensely monitored sites within the Matata beach system with over 50 profiles collected. This interest was derived from the sand extraction operation undertaken by JW Paterson & Sons. Their consent (40289) for this extraction was surrendered in 2001. This extraction occurred within 3 zones between the Waitahanui Stream and the Pikowai Stream (6km of beach) (Smith, 1997).
The two eastern monitoring sites continue to maintain a stable pattern, which is in marked contrast to the two western sites which both show strong retreat (-1.0m/yr 1990-2011). Sediment supply would be from littoral drift and fluvial inputs from the many small catchments exiting on this section of coastline. Pedestrian and vehicle pressures are significant as the two western sites are in close proximity to the two main beach access point for this section of beach. Coastcare and WDC work has endeavoured to control these access points recently.


CCS21
TOF position (m)
y = -0.0014x + 94.596
Elevation (m)
Distance (m)
CCS21
2006 2010
CCS22
TOF position (m)
y = 0.0005x + 15.617
Elevation (m)
Distance (m)
CCS22
2006 2010
CCS23
TOF position (m)
y = -0.0031x + 171.98
Elevation (m)
Distance (m)
CCS23
2006 2010
CCS24
TOF position (m)
y = -0.0049x + 212.45
Elevation (m)
Distance (m)
CCS24
2006 2010
KEY
maximum envelope
minimum envelope
average
latest February 2011
Matata
ECMTR
HEREPURU ROAD
Kohioawa Beach
MIMIHA ROAD
Herepuru Stream
PIKOWAI ROAD
Pikowai
HAUONE ROAD
Hauone
Hauone Stream
Otamarakau
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Scale = 1:75 000
Kilometres

2.8 Pukehina Beach system

Pukehina Beach Section (1)

Site CCS25 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). Gibb (1994) states a long-term trend (1927-1994) of shoreline retreat of approximately ranging from 15 to 25m, a rate of retreat of -0.2m/yr has been calculated for 1990-2011. Site CCS26 is located 6.5km to the east of the Waihi Estuary. This site is backed by 40m high vegetated Pleistocene cliffs. The site shows 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.

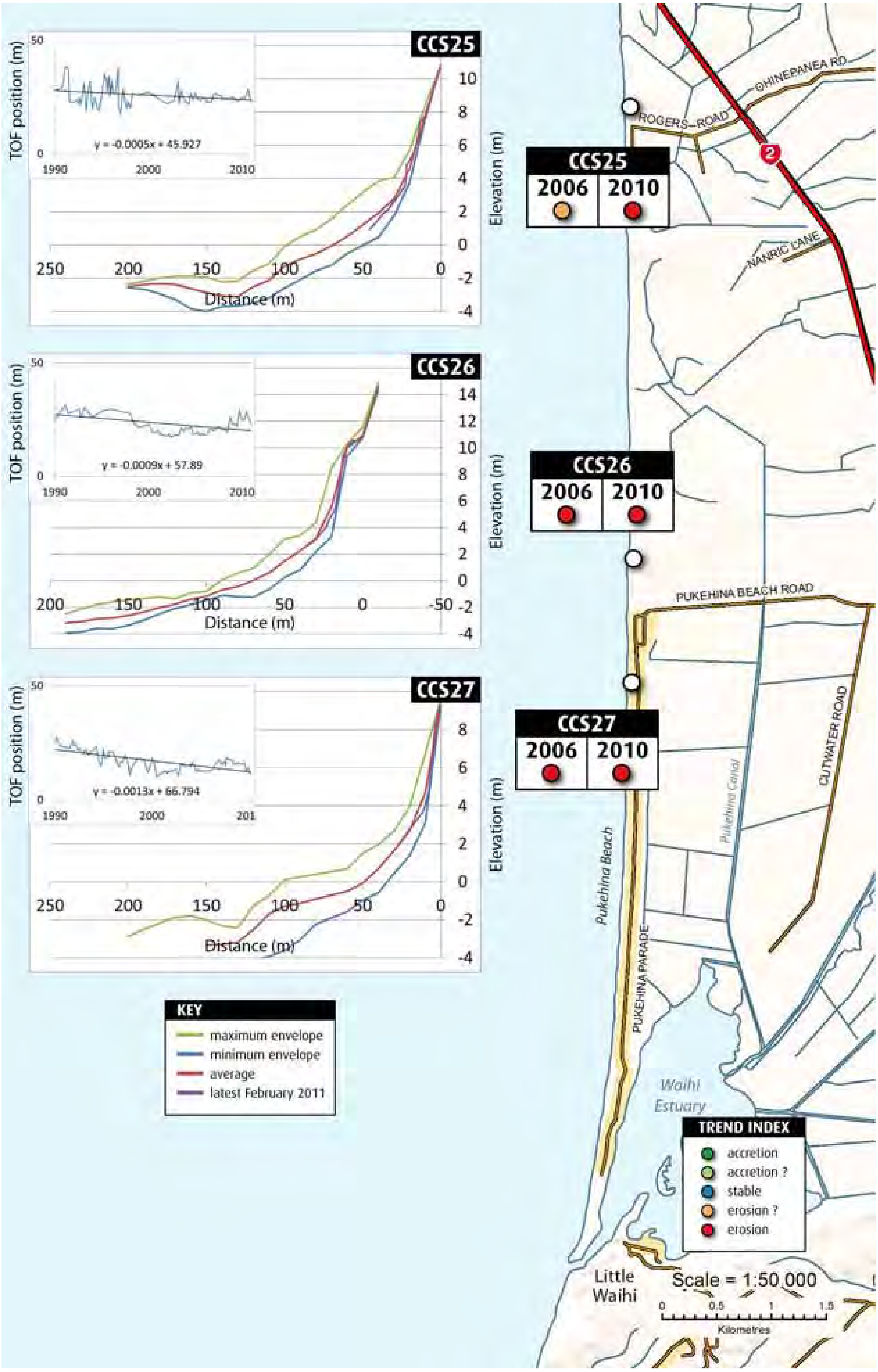

CCS27 - 1978


CCS27 - 2006


CCS27 - 2011

Site CCS27 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.

A common pattern of frontal dune retreat is common for all three sites for the twenty years of record, CCS26 does show a seaward movement of the TOF in the last several years although this is not yet a statistically significant trend change. The February 2011 profile position for the lower beach section was around the long term average position for CCS27. CCS25 was tracking below the average. For all three sites a wide vertical envelope of approximately 3m is common for the position of the lower beach section.


CCS25
TOF position (m)
y = -0.0005x + 45.927
Elevation (m)
Distance (m)
CCS26
y = -0.0009x + 57.89
CCS27
y = -0.0013x + 66.794
KEY
maximum envelope
minimum envelope
average
latest February 2011
CCS25
2006
2010
CCS26
2006
2010
CCS27
2006
2010
OHINEPANEA RD
ROGERS ROAD
NANRIC LANE
PUKEHINA BEACH ROAD
CUTWATER ROAD
Pukehina Canal
Pukehina Beach
PUKEHINA PARADE
Waihi Estuary
Little Waihi
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Scale = 1:50,000
Kilometres

Pukehina Beach section (2)

Site CCS28 is located 2.3km to the east of the Waihi Estuary inlet. Spinifex is 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. For the period of record in this report the trend for CCS28 is one of suspected stability. CCS29 is located 1.3km from the Waihi Estuary entrance, and 250m east from the end of residential development at Pukehina Beach. At this distal end of the spit the beach flattens in the lower profile and a low tide terrace morphodynamic type is predominant. 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. In the 2011 photograph this dune is lost and a scarp exists with overhanging vegetation. 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.

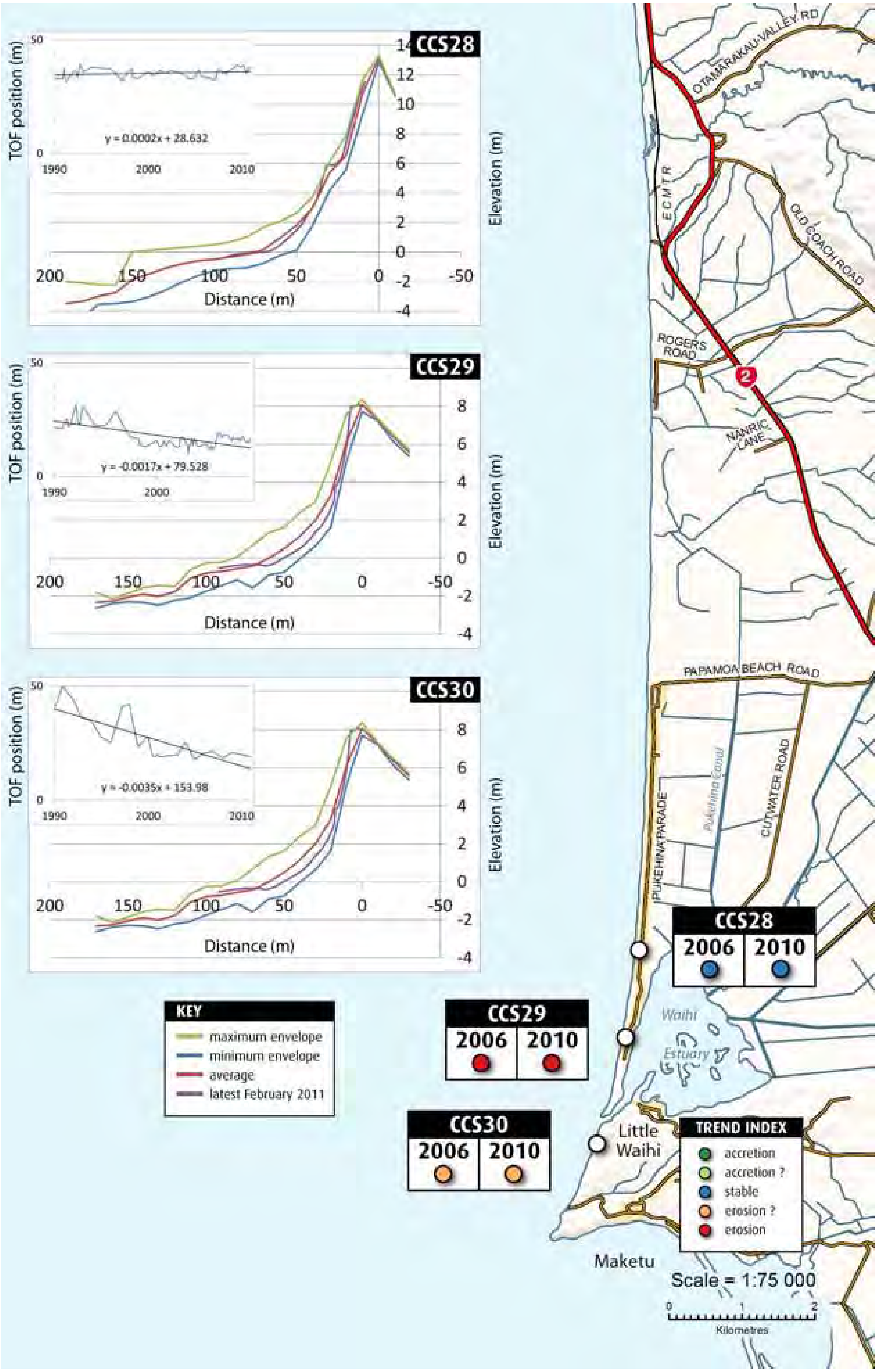
Site CCS30 is located on the western side of the Waihi Estuary entrance, 330m from the inlet. The beach is commonly known as Newdicks Beach (1.2km long), situated on the eastern flank of Okurei Point.

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 is presented in both documents.

CCS29 - 1978

CCS29 - 2006

CCS29 - 2011


CCS28
TOF position (m)
y = 0.0002x + 28.632
Elevation (m)
Distance (m)
CCS29
y = -0.0017x + 79.528
CCS30
y = -0.0035x + 153.98
KEY
maximum envelope
minimum envelope
average
latest February 2011
CCS28
2006
2010
CCS29
2006
2010
CCS30
2006
2010
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
OTAMARAKAU VALLEY RD
OLD COACH ROAD
ECMTR
ROGERS ROAD
NANRIC LANE
PAPAMOA BEACH ROAD
PUKEHINA PARADE
Pukehina Canal
CUTWATER ROAD
Waihi Estuary
Little Waihi
Maketu
Scale = 1:75 000
Kilometres

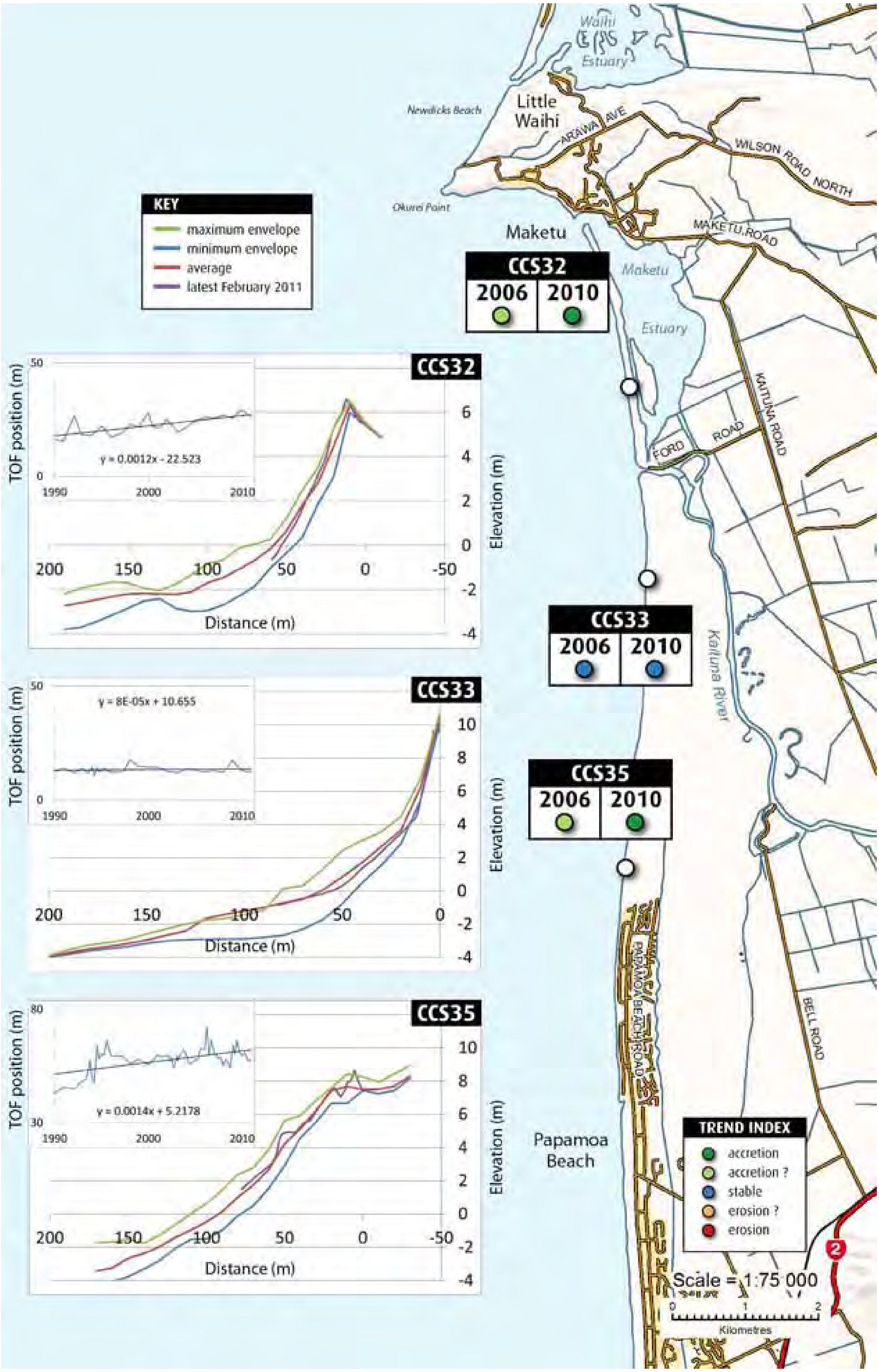
2.9 Kaituna Beach system

Kaituna Beach section

The CCS32 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). Site CCS31, which was located to the east was lost in 1978 when the Maketu Spit was breached. Site CCS33 is located 1.5km to the west of the Kaituna Cut. The site has a heavily scarped frontal dune which is sparsely colonised by spinifex, which has been common since the late 1970's. 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 amount of flucutation in the lower beach section but stability in th upper beach even with the exposed and elevated nature of this section of the beach. Site CCS35 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. Healy (1978) comments that at this time this area around CCS35 was being grazed by cattle.

This section of beach shows stable to accretionary trends. Sediment from the Kaituna River would compliment the supply moving in the littoral system generally in a net easterly direction. Bell et.al. (2006) calculate a 18,000 t/yr sand and gravel contribution from the Kaituna River entering the coastal environment.

CCS35 is monitored quarterly due to its proximity to the Papamoa residential area and future proposed residential development.


KEY
maximum envelope
minimum envelope
average
latest February 2011
CCS32
2006
2010
CCS33
2006
2010
CCS35
2006
2010
TOF position (m)
Elevation (m)
Distance (m)
y = 0.0012x - 22.523
y = 8E-05x + 10.655
y = 0.0014x + 5.2178
Little Waihi
Waihi Estuary
Newdicks Beach
Okurei Point
Maketu
Maketu Estuary
ARAWA AVE
WILSON ROAD NORTH
MAKETU ROAD
KAITUNA ROAD
FORD ROAD
Kaituna River
PAPAMOA BEACH ROAD
BELL ROAD
Papamoa Beach
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Scale = 1:75 000
Kilometres

2.10 Papamoa Beach system

Papamoa Beach section

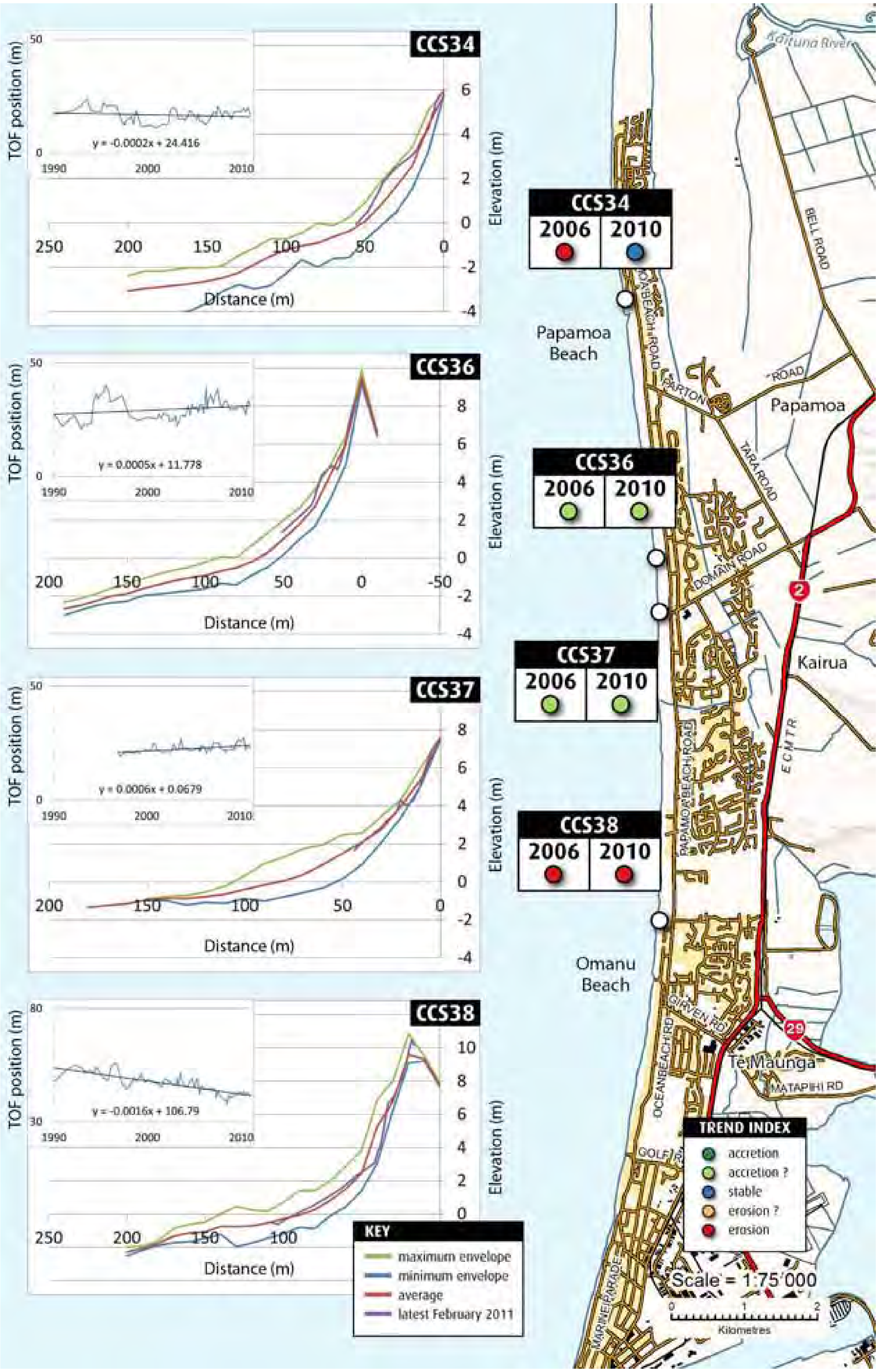
The CCS34 site is located at the western end of Taylor Street, which is at the eastern end of the Papamoa development. The Papamoa Beach system is an 8.8km-long sand beach bordering Holocene coastal plain of sand dunes. The foredune ranges from 30 to 50m in width and 4.7 to 13.0m above MHWS (Gibb, 1994). 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 and 2011 images with a well vegetated incipient frontal dune. Site CCS36 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 CCS37 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 CoastCare programme sites. This section of beach is popular for recreational activities, portions of the frontal dune have been retired from human traffic and exhibit thriving populations of spinifex and pingao.

A mixture of trend patterns are presented for these four sites. With some stability in the foredune position and volume over the last 5-6 years the statisitical test is now returning a stable trend being present. Moderate seaward movement of the foredune has ben recorded at the two central sites. CCS38 continues it's retreating trend of the last 20 years.


CCS34 - 1978


CCS34 - 2006


CCS34 - 2011



CCS34
TOF position (m)
y = -0.0002x + 24.416
Elevation (m)
Distance (m)
CCS36
y = 0.0005x + 11.778
CCS37
y = 0.0006x + 0.0679
CCS38
y = -0.0016x + 106.79
KEY
maximum envelope
minimum envelope
average
latest February 2011
CCS34 2006 2010
CCS36 2006 2010
CCS37 2006 2010
CCS38 2006 2010
Papamoa Beach
Papamoa
Kairua
Omanu Beach
Te Maunga
Kaituna River
BELL ROAD
PAPAMOA BEACH ROAD
PARTON ROAD
TARA ROAD
DOMAIN ROAD
ECMTR
GIRVEN RD
OCEANBEACH RD
MATAPIHI RD
MARINE PARADE
GOLF RD
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Scale = 1:75 000
Kilometres

2.11 Mount Maunganui Beach system

Mt Maunganui Beach section

Site CCS39 is located 200m to the west of the Tay Street artificial surf reef (see Weppe, 2010), 2.7km east from Mt Maunganui. This section is described as 4.6km-long sand beach bordering Holocene sand dunes forming the Mount Maunganui tombolo (Gibb, 1994). Site CCS39 has undergone a reversal in trend over the last 10 years with a strong seaward movement of the frontal dune after recording the most seaward position within the record during the late 1990's. The CCS40 profile is one of a gently sloping prograding frontal dune with a spinifex vegetative cover with a wide high tide beach. 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. This section of beach is regularly groomed (see patterns in the 2006 photograph) and is replenished by material moving onshore from the harbour dredge spoil dumping sites located several kilometres offshore. The 2011 photograph shows a similar wide upper beach (30-40m in width) as shown in the 2006 image.

The CCS40 profile record shows the development of the "frontal dune". This feature has undergone extensive re-vegetation with native species. The toe of foredune plot shows a position that has fluctuated moderately but is largely stable. The volume plot (included for this site) shows the increase in volume for this section of beach with an approximate 50% increase in the last 20 years of monitoring at this location. An additional site (CCS40a) was installed in 2003 to the west of CCS40 on a line that bisects dune planting works. Several metres of fluctuating seaward movement of the toe of the foredune has been measured at this site.


CCS39
TOF position (m)
y = 0.0006x + 23.434
Elevation (m)
Distance (m)
CCS40
y = -0.0004x + 42.979
CCS 40 Volume (m²/m)
y = 0.0167x - 292.2
KEY
maximum envelope
minimum envelope
average
latest February 2011
CCS39
2006
2010
CCS40
2006
2010
Motuotau Island
Omanu Beach
Omanu
Mt Maunganui
Mauao/ Mt Maunganui
Tauranga Harbour
Tauranga Entrance
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Scale = 1:50 000
Kilometres

2.12 Matakana Beach system

Matakana Beach system (1)

Site CCS41 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. In some places 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, other vegetation species found on the dunes are *Ammiphina arenana* and *Spinifex sericeus* (Muller, 2011). Due to access issues and the lack of residential development on the open coast of the barrier this site has only been profiled annually (in March).


CCS41 -2011


CCS42 - 2011


CCS43 - 2011

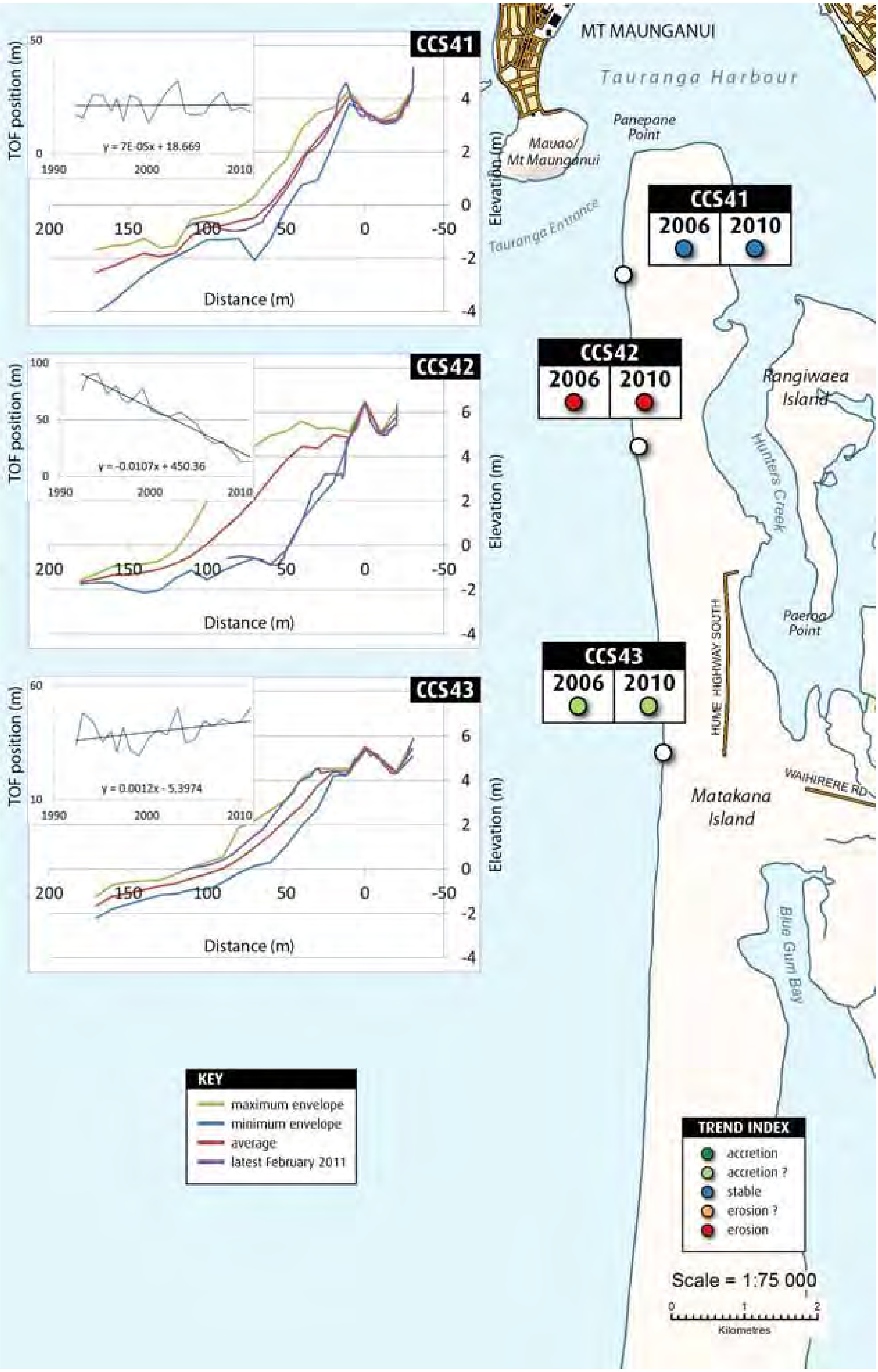
For CCS41 a stable pattern has existed for the foredune position. Significant volumes of sediment move on and off the mid to low beach profile with the maximum and minimum envelopes showing several metres of vertical difference for much of the measured profile.

The CCS42 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 ~80m of landward movement of the foredune. The envelope plots show this section of beach to be in its most landward position for the 20 years of measured record.

Site CCS43 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 2011 profile shows the beach to be it most seaward position in the last 20 years.

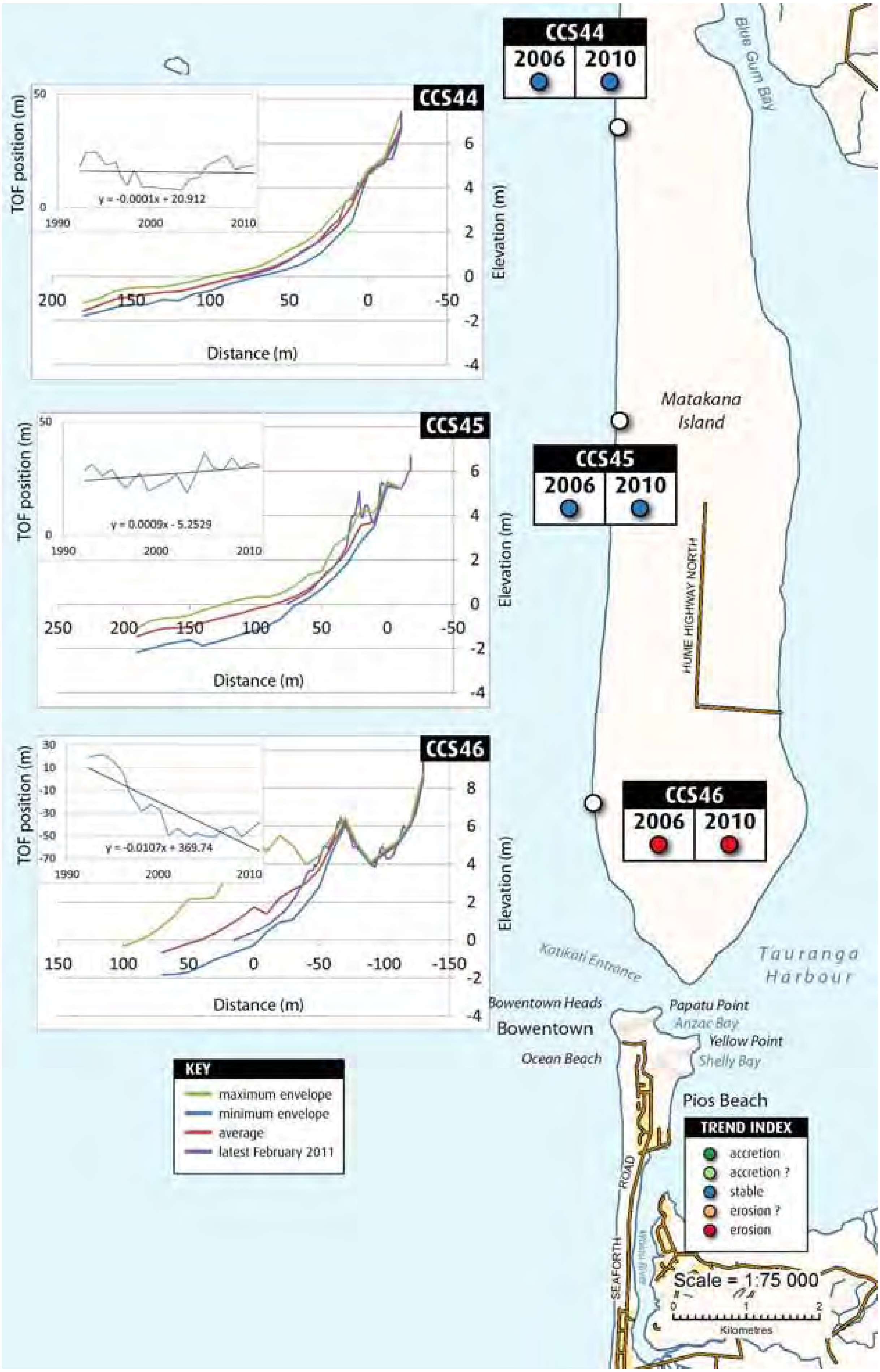


CCS41
TOF position (m)
y = 7E-05x + 18.669
Elevation (m)
Distance (m)
CCS42
y = -0.0107x + 450.36
CCS43
y = 0.0012x - 5.3974
KEY
maximum envelope
minimum envelope
average
latest February 2011
MT MAUNGANUI
Tauranga Harbour
Panepane Point
Mauao/ Mt Maunganui
Tauranga Entrance
CCS41 2006 2010
CCS42 2006 2010
CCS43 2006 2010
Rangiwaea Island
Hunters Creek
Paeroa Point
HUME HIGHWAY SOUTH
WAIHIRERE RD
Matakana Island
Blue Gum Bay
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Scale = 1:75 000
Kilometres

Matakana Beach section (2)

The CCS44 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 2011 profile is located around the average of the recorded dataset. Statistical p-tests and also regression analysis shows that this section of beach is in a stable state. The CCS45 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 2011 profile is located around the average of the recorded dataset. The earlier recorded offshore profiles (se Iremonger, 2007) also reflect this pattern of low variability. All three ofshore profiles converge at -7m. 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. Site CCS46 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 natural barrier and restriction to any movement of the entrance to the northwest. This restriction means often tidal flows are directed towards the monitoring site. The profile history at this site shows a landward retreat of ~70m for the 20 years of measurements.


CCS44
2006
2010
TOF position (m)
y = -0.0001x + 20.912
Elevation (m)
Distance (m)
CCS45
y = 0.0009x - 5.2529
CCS46
y = -0.0107x + 369.74
Matakana Island
HUME HIGHWAY NORTH
Blue Gum Bay
Katikati Entrance
Tauranga Harbour
Bowentown Heads
Bowentown
Ocean Beach
Papatu Point
Anzac Bay
Yellow Point
Shelly Bay
Pios Beach
SEAFORTH ROAD
KEY
maximum envelope
minimum envelope
average
latest February 2011
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Scale = 1:75 000
Kilometres

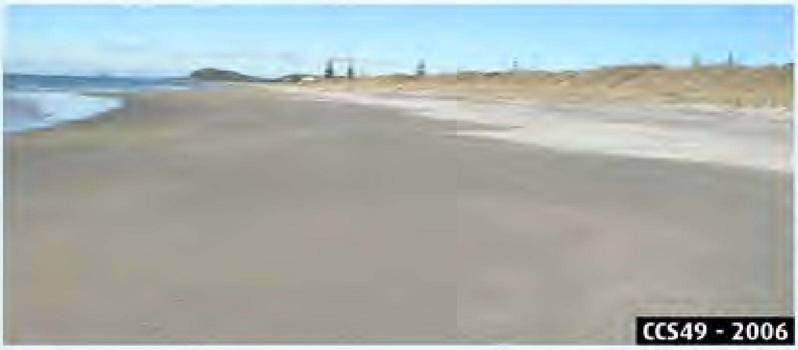
2.13 Waihi Beach system

Waihi East Beach section

Site CCS47 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 patterns caused by 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 9m of duneline progradation between September 1978 and April 1994. The profile history shows a wide band of movement in beach position evidenced by the maximum and minimum envelope location. The 2011 profile is positioned around the long term average.

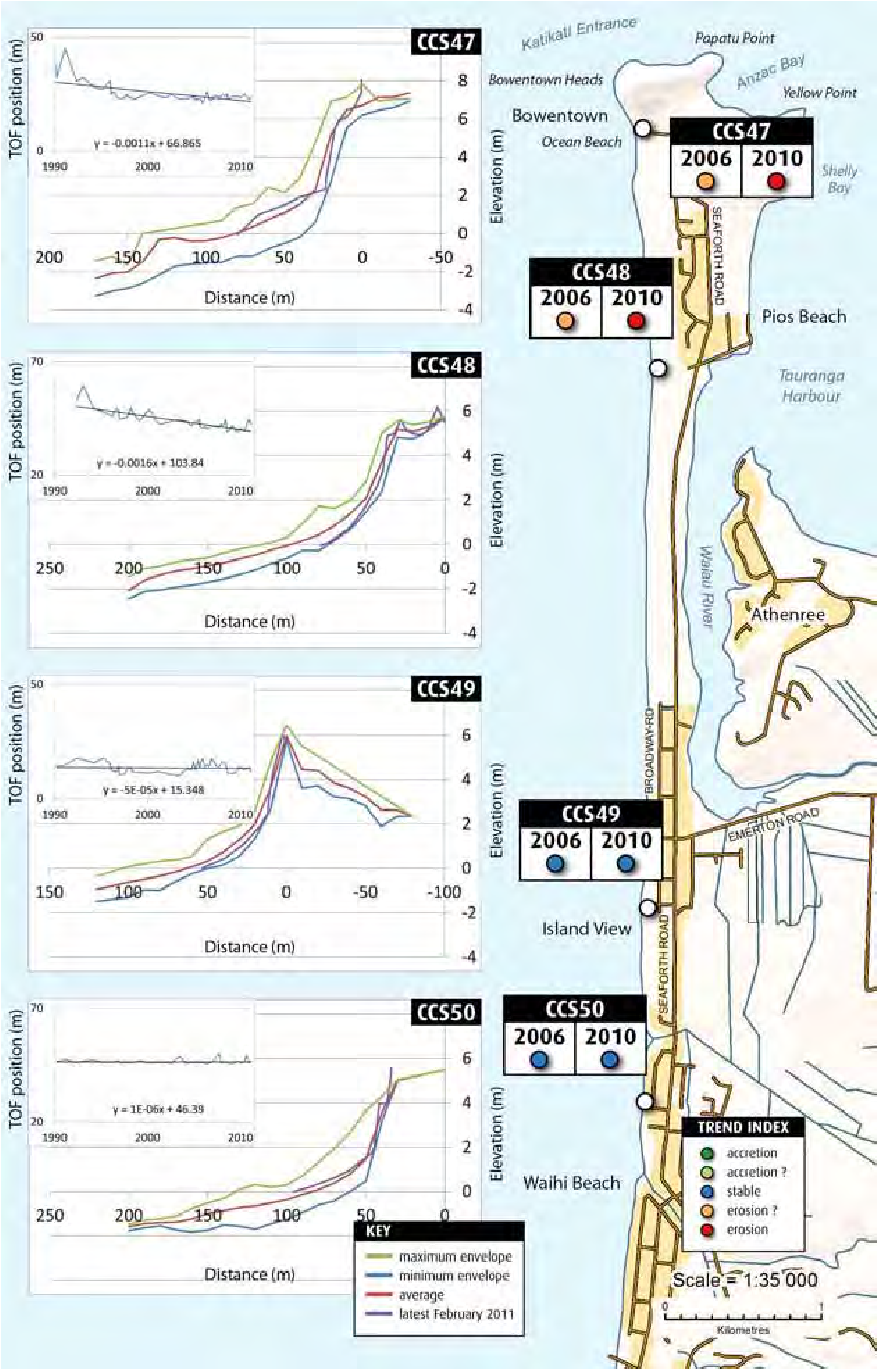
Site CCS48 is located 2km to the northwest of the Bowentown entrance. Gibb (1994) states the section of beach from Ocean Beach to Island View is 4km long sand beach bordering a 250 to 750m wide tombolo of Pleistocene and Holocene dune complexes derived primarily from offshore sources. An erosion trend continues to be recorded at this site.

Site CCS49 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. The 2011 photograph shows the loss of these lower beach features and also a scarp present on the frontal dune face.


CCS49 - 2006

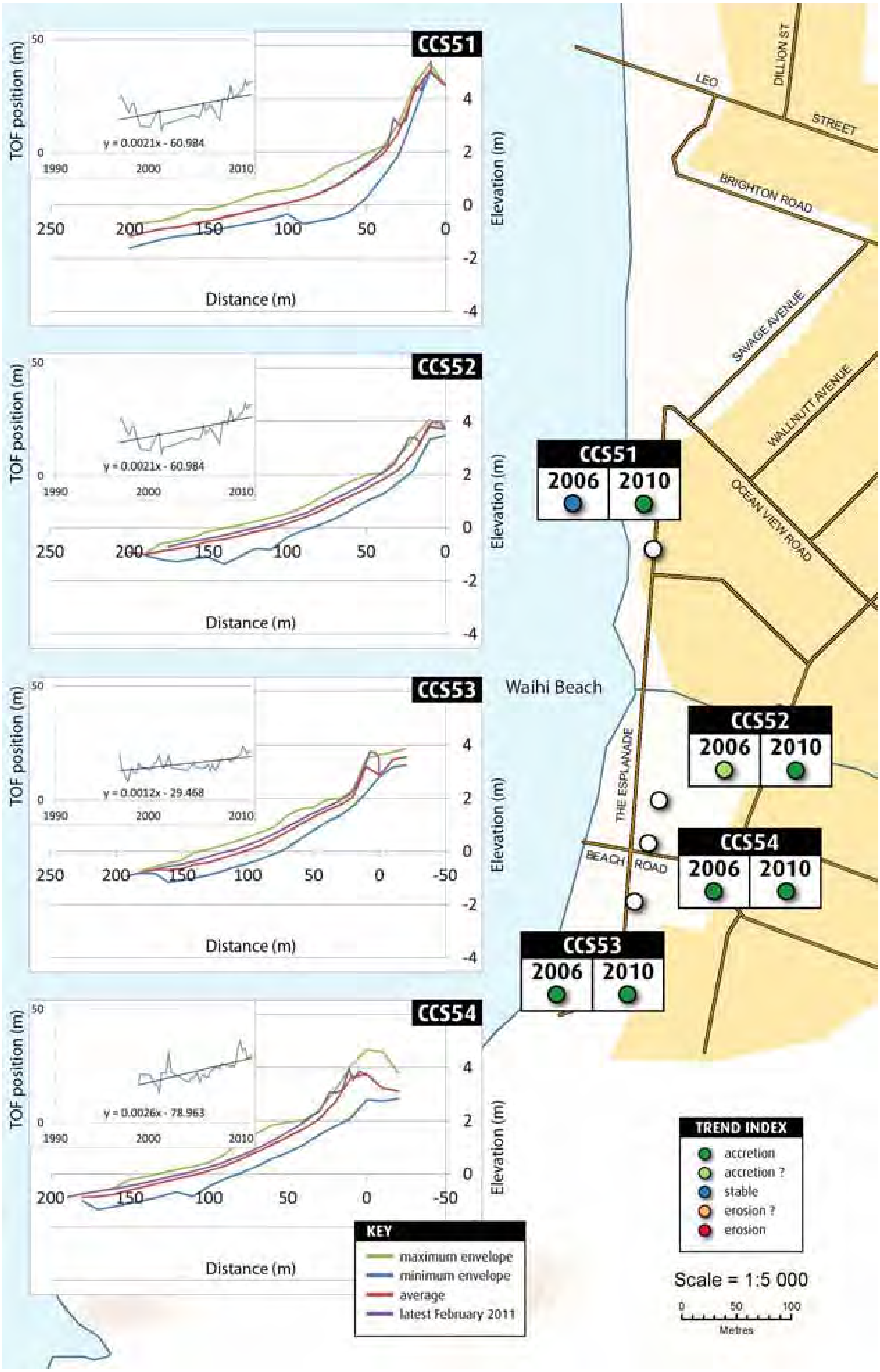

CCS49 - 2011

Site CCS50 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. This section of wall is scheduled for replacement as part of works consented (62912) in 2008. 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.


CCS47
TOF position (m)
y = -0.0011x + 66.865
Elevation (m)
Distance (m)
CCS48
y = -0.0016x + 103.84
CCS49
y = -5E-05x + 15.348
CCS50
y = 1E-06x + 46.39
KEY
maximum envelope
minimum envelope
average
latest February 2011
Katikati Entrance
Papatu Point
Anzac Bay
Bowentown Heads
Yellow Point
Bowentown
Ocean Beach
Shelly Bay
SEAFORTH ROAD
Pios Beach
Tauranga Harbour
Waiau River
Athenree
BROADWAY RD
EMERTON ROAD
Island View
Waihi Beach
2006
2010
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Scale = 1:35 000
Kilometres

Waihi West Beach section

Site CCS51 is located at the southern boundary of the popular Waihi Beach. A 5m 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. Toe of foredune and beach volume data both show trends of accretion for this site. Site CCS52 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 CoastCare 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. Like CCS51 this site is also showing trends of acretion in both the foredune position and the volume of sediment in the upper beach system. Site CCS53 is the western most of the beach profile monitoring sites. (CCS54 is located to the east of this site). The site is located at the western end of The Esplanade on the eastern side of the small stream. Like CCS52 the site origin is located in a CoastCare fenced area planted with native vegetation. Positive trends in both measured parameters are calculated for this site. Site CCS54 is located at the centre of The Esplanade on the eastern side of the small stream. The site is located in a CoastCare fenced area planted with native vegetation. Profile history shows the "earthworks" undertaken to develop a dune at the start of the CoastCare programme. Like 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 in a berm formation at times.


CCS51
TOF position (m)
y = 0.0021x - 60.984
Elevation (m)
Distance (m)
CCS52
y = 0.0021x - 60.984
CCS53
y = 0.0012x - 29.468
CCS54
y = 0.0026x - 78.963
KEY
maximum envelope
minimum envelope
average
latest February 2011
Waihi Beach
CCS51 2006 2010
CCS52 2006 2010
CCS53 2006 2010
CCS54 2006 2010
LEO
DILLION ST
STREET
BRIGHTON ROAD
SAVAGE AVENUE
WALLNUTT AVENUE
OCEAN VIEW ROAD
THE ESPLANADE
BEACH ROAD
TREND INDEX
accretion
accretion ?
stable
erosion ?
erosion
Scale = 1:5 000
Metres

Part 3: Future monitoring schedule

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

At this time some of the Coast Care sites have been retained as there is now a significant length of record at a number of these sites. The Waiotahi Drifts set have been removed as CCS5 and CCS6 either side of this development will be indicative of trends for this section of coastline. No atypical beach behaviour has been identified in the Waiotahi dataset for the 2003 – 2011 measurement period. The Coast Care sites that have been retained will need to be reassessed when long term physical monitoring programmes for Coast Care are determined.

3.1 Monitoring schedule

The following table (Table 1) contains the proposed schedule of profile measurements for the NERMN profiles. The sites chosen for the quarterly programme are sites which front the main residential developments within the region and hence are required datasets for robust coastal natural hazard analysis and zone mapping.

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.

Table 1 Coastal NERMN monitoring schedule for the next five years (2011-2015)

Site	Monitoring frequency
All sites (Total = 57) • CCS1 to CCS54 inclusive. • Coast Care sites at Papamoa (2 sites), Waihi Beach (1 site) and Mt Maunganui (1 site).	Annually
Selected sites (Total = 23) • CCS9 – CCS11 (Ōhope). • CCS25 – CCS29 (Pukehina). • CCS34 – CCS40 (Pāpāmoa/Mount). • CCS47 – CCS54 (Waihī).	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 (see Appendix 1).

The collection of oblique photographs should be scheduled every 5 years to coincide with this report. This dataset would be collected during the annual survey run. This would next be required during the 2016 annual survey. Before this is undertaken discussion should be held with the Environmental Scientist to ensure suitable field of view angles are obtained.

At this time there is no requirement for further offshore profiles to be measured. The majority of the sites now have three offshore surveys measured over a 15 year period. Where more detailed information is required for this offshore area, a specific project could be developed to gather this information.

Part 4: Discussion

Over time changes in the beach morphology along the Bay of Plenty coastline result from "cut and fill" processes. The movement of sediment from this process is dependent 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 north easterlies in the New Zealand region. During El Niño years, where a higher occurrence of south westerlies occurs, wave conditions in the Bay of Plenty are somewhat reduced although episodic extra-tropical cyclones still occur.

Over the period of the physical coastal NERMN (typically 20 years of data to date), 53 sites have been monitored to access changes in beach profile position and beach volume. Figure 2 and Table 2 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 origins 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. Hodges and Deely (1997) state that Gibb (1983) estimated the rate of littoral drift along the Bay of Plenty Coastline as <100,000 m^3/yr. Hicks and Hume (1991) give an estimate of 70,000 m^3/yr for inlets to both the Ohiwa and Tauranga Harbours.

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 5.8 Mt/yr.

Figure 2 Trend overview for the Bay of Plenty (1990-2011)

Table 2 Beach state and trends in foredune position change

Beach system	CCS site	Site Name	Toe of foredune change from 1990 profile to 2011 profile (+ accretion, - erosion)	Beach state from statistical analysis of all profiles.
Hikuwai	1	Opape East	20	Accretion?
	2	Waiaua River West	-8	Erosion
	3	Tirohanga Stream West	-9	Erosion
	4	Hikuwai West	-18	Erosion
	5	Waiotahi Beach East	7	Erosion?
	6	Waiwhakatoitoi	-6	Stable
	7	Waiotahi Spit	44	Accretion
	8	Ohiwa Spit	165	Accretion
Ohope	9	Ohope Spit	-225	Erosion
	10	Ohope	-22	Erosion
	11	West End	-28	Erosion?
Thornton	12	Whakatane Spit	13	Stable
	13	Piripai	16	Accretion
	14	Golf Links Road	-3	Erosion?
	15	Airport	-8	Erosion?
	16	Rangitaiki East	-7	Stable
Matata	17	Rangitaiki West	6	Stable
	18	Lawrences Farm	0	Stable
	19	Tarawera East	-18	Stable
	20	Matata Domain	-4	Stable
	21	Matata	1	Stable
	22	Murphy's Motor Camp	7	Stable
	23	Pikowai Motor Camp	-21	Erosion
	24	Otamarakau	-20	Erosion
Pukehina	25	Rodgers Road	-5	Erosion
	26	Pukehina Trig	-1	Erosion
	27	Pukehina West	-14	Erosion
	28	Pukehina Middle	4	Stable
	29	Pukehina West	-4	Erosion
	30	Makatu Headland	-21	Erosion?
Papamoa	32	Kaituna River East	10	Accretion
	33	Kaituna River West	-1	Stable
	34	Taylor Street	13	Accretion
	35	Papamoa Beach	0	Stable
	36	Papamoa	5	Accretion?
	37	Papamoa Surf Club[1]	2	Accretion?
	38	Te Maunga	-7	Erosion
	39	Mount Maunganui East	11	Accretion?
	40	Mount Maunganui	-9	Accretion?
Matakana	41	Fire Break Road	1	Stable
	42	Bird Sanctuary	-62	Erosion
	43	Tank Road	17	Accretion?
	44	Matakana Island Centre	0	Stable
	45	Dead End Road	2	Stable
	46	Matakana Island North	-57	Erosion
Waihi	47	Waihi Beach South	-15	Erosion
	48	Waihi Beach- Pio's Point	-10	Erosion
	49	Waihi Beach Island View	-3	Stable
	50	Waihi Beach Island Loop	0	Stable
	51	Waihi Beach North	7	Accretion
	52	Waihi Beach Surf Club[1]	8	Accretion
	53	Waihi Beach Stream[1]	1	Accretion
	54	Esplanade Road[1]	12	Accretion

4.1 Hikuwai to Ōhiwa Beach sections

The 21 years of NERMN record for this eastern group of sandy beach profiling sites shows a dominance of erosion patterns being exhibited (Figure 2). The eastern most site at Opape shows signs of stability, possibly a reflection of its 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 the eastern end of Waiotahi Beach all show signs of erosion trends (the site at Waiwhakatoitoi, near the Ōpōtiki Surf Club is stable). 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 Hikuwai would not benefit directly from this Waioeka sediment supply, this deficit would be further exaggerated under La Nina conditions (predominance of north easterly (onshore/alongshore) winds) which would intensify the westward movement.

Interestingly the profile site at the eastern end of Waiotahi Beach (CCS5) to the west of the Waioeka River exhibits an 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 Waiwhakatoitoi 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 frontal dune has been in the order of ~165 m.

4.2 Ohope Beach section

West End, Ohope receives sediment under normal conditions from material 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 2) have been monitored over the last 21 years as part of the NERMN programme. Within the Ohope Beach system the results for this period show an overall pattern of erosion.

The monitoring site at the end of the Spit (CCS9) 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.

The central beach site also exhibits a significant level of erosion (-22 m).

The West End site also shows patterns of erosion. In particular was the 1996-1997 period where 15 m of retreat occurred mainly as the result of tropical cyclones 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.

4.3 Whakatane to Matata Beach sections

The larger beach system from Whakatāne Spit to Otamarakau (Figure 2) is occupied by 13 monitoring sites and stretches between the Whakatane River and Waitahanui Stream.

For the 21 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.

For the two central Rangitāiki Plains 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 1.54 m/yr have been determined by Gibb (1994). Current rates from the NERMN record show retreat of the frontal dune by ~0.3 m/yr.

The sites adjacent to the Rangitaiki River (CCS16 and 17) both show a trend of stability, which is most likely linked to the increased sediment contribution from the local river system. This pattern of stability is measured at the next five sites which finishes at Murphy's Motor Camp. The effects of human activity are evident in the monitoring record at Ōtamarākau (CCS24) which was a site of historical sand mining. A trend of erosion was determined for both Pikowai (CCS23) and Otamarakau profile sites, for the 1990-2011 period.

4.4 Pukehina Beach section

The 21 years of NERMN data shows predominantly a common trend of erosion for the six beach profile sites within the Pukehina Beach system, the outlier to this pattern is CCS28. This system stretches from Rodgers Road in the east to end at Newdicks Beach on the eastern side of the Maketu Headland (11km in total).

A 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 exhibited on one particular occasion during a short duration storm in September 2005 where up to 8 m of dune retreat was measured in a very confined area (50 m in width) and 100 m 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. These localised effects will be the drivers for the differing time series trend exhibited at CCS28 (i.e. stable).

The MSc 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 15 m 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.

4.5 Kaituna to Mount Maunganui Beach sections

This section of sandy beach between Mount Maunganui and Maketu Estuary are composed of fragile sand dune complexes. The dunes are relatively ancient with the 2000 year old dune complex being less than 80 m 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 Mount 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 NERMN programme for this section of the beach, which starts at the Maketu Estuary in the east and stretches 28 km to the base of Mount Maunganui in the west.

A mixture of trends is present for this section. There appears to be no strong beach wide pattern, 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; and
- 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 (CCS40) 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 12 additional sites funded by Tauranga City Council.

Tonkin & Taylor (2009) were recently commissioned to update the coastal hazard line analysis for much of this section of coastline. Their findings where that the longterm trend component of the setback analysis could be removed as the short term profile record shows the beach to be in a state of dynamic stability.

4.6 Matakana Beach section

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

Erosion patterns are evident at CCS42, which is 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 (CCS46) 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.

4.7 Waihi Beach section

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 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 an 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 is 21 years for the sites from CCS47 to CCS51, the Coast Care sites at the northern end (CCS52-54) have been monitored for the last 13 years. The 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 two to three 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.

Part 5: 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. It is therefore important that storm specific monitoring (as programmed in Part 4) is undertaken in a timely manner and thus increase the value of these datasets when undertaking future coastal erosion hazard investigations and more detailed 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

This pattern has not changed since the last report which summarised data up to 2006.

All of these beaches have been covered recently (within the last five years) by detailed shoreline change investigations.

A number of conclusion items in the last Coastal NERMN data review where highlighted. These are outlined below with comments outlining progress.

Iremonger (2007) conclusions	Comment
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.	Monitoring is ongoing within this NERMN programme (as per the Regional Monitoring and Sustainable Coastal Management programmes as part of the Natural Environment module of the 10 Year Plan - http://www.boprc.govt.nz/media/31196/Plan-090716-TYP05NaturalEnvironment.pdf). A future monitoring schedule has been outlined in Part 3 which will allow for timely and representative coastal profile 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.	Bay of Plenty Regional Council has committed to fund $1.5 million over 10 years for a University of Waikato Chair in Coastal Science. A Memorandum of Agreement between the Council and the university was signed on 11 February 2011. The new Chair will be an integral part of the INTERCOAST programme. INTERCOAST, established by Waikato University and Bremen University in Germany, will be a major centre of marine research excellence, featuring international PhD students.

Iremonger (2007) conclusions	Comment
Maintain the Kohi Point tidal sensor, as this information provides valuable data for erosion causing storm events.	The Kōhi Point tidal/wave sensor continues to collect environmental information. This dataset is currently being reviewed.
Investigate the continued monitoring requirement for the Pukehina wave buoy.	The wave buoy continues to collect environmental information. This dataset is currently being reviewed.
Further develop monitoring linkages with the coast care programme to quantify the benefits of this work.	This work is ongoing and recent collaboration has been strengthened through the development of recontouring trial sites at Ōhope and along the Hikuwai coastline.
Continue to investigate monitoring methods and measurement technology to ensure the profile data is of a high standard and collected efficiently.	This work is ongoing with the Environmental Data Services team. Currently there is a review of software developed by NIWA for the storage and analysis of beach profiles. The surveying team has recently purchased a new RTK GPS and this will improve data capture of alongshore toe of foredune surveys and topographic surveys in the beach environment.

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

1. A continuation of this programme is important in the management regime of this coastal area, this importance is reflected in the Regional Council's 10 year planning document. The information provides a picture of the state of the sandy coastline which feeds into hazard analysis calculation and the determination of erosion hazard zones. The collected information also provides a foundation dataset for analysis into sea level rise effects which will become more important in the future.

2. A close relationship and necessary support should be provided to the INTERCOAST programme, as the open coast PhD research projects get proposed and undertaken within the Bay of Plenty.

3. The future of the wave buoy and Kōhi Point tidal sensor should be regularly reviewed. Some of the summarised wave buoy data has been presented in this document but a full report on both datasets is currently been undertaken. The investigation of computer wave models should also be part of this review as several now exist for the Bay of Plenty region.

4. Linkages with the coast care programme in relation to shoreline monitoring techniques and advice should continue to be developed.

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

The next physical coastal NERMN report is due in 2016.

Part 6: References

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Appendices

Appendix 1 – 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 landforms relevant to the Bay of Plenty.

1.1 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 34 m of water in Katikati inlet and found most waves less than 1 m 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 Bay of Plenty Regional Council’s Triaxys wave buoy located 13 km north of Pukehina Beach in 62 m of water, for the period September 2003 to December 2010 is summarised in Figure 3. Maximum recorded Hmax = 10.3 m, average Hs = 1 m and average Ts = 6.6s.

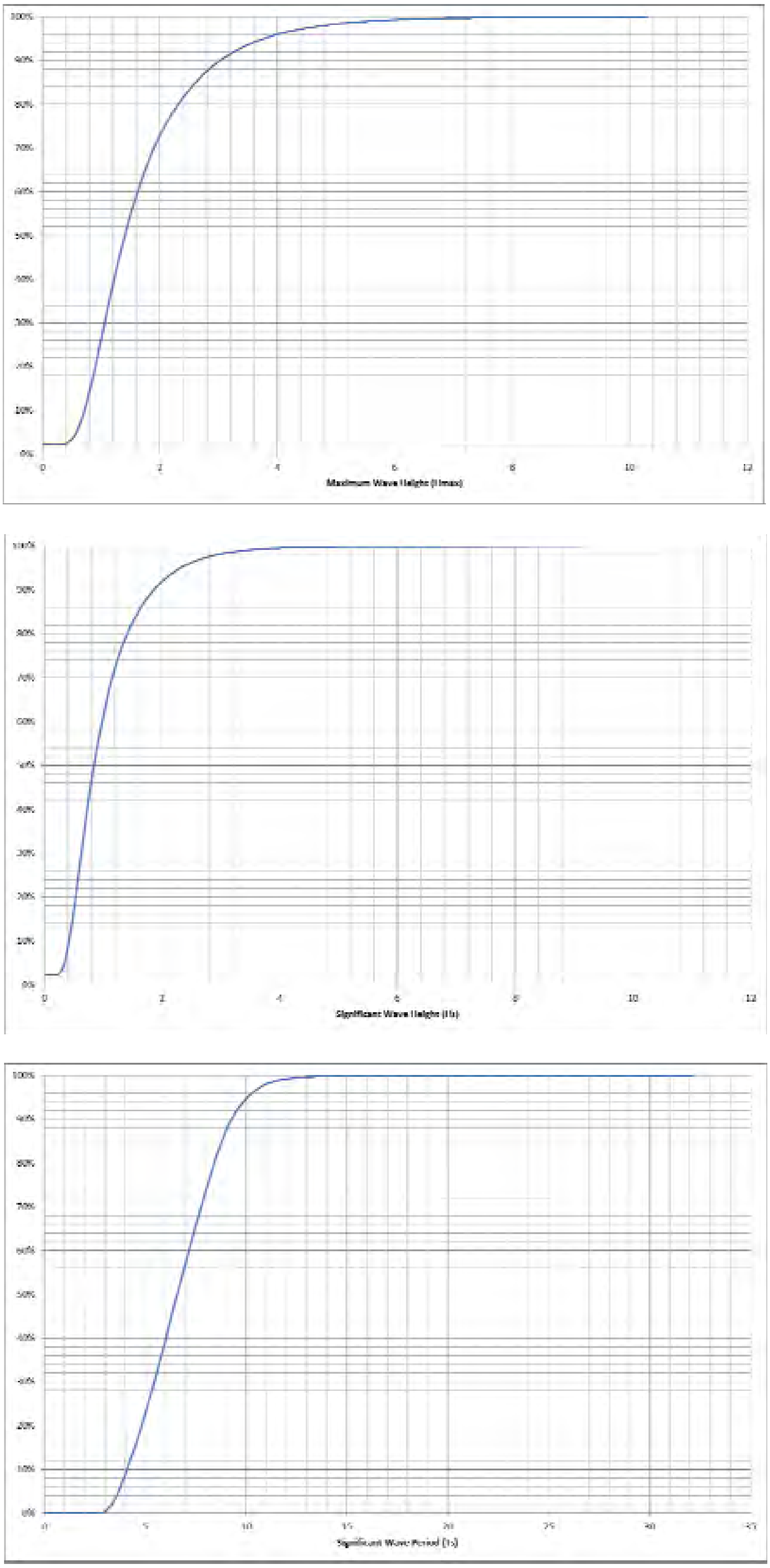
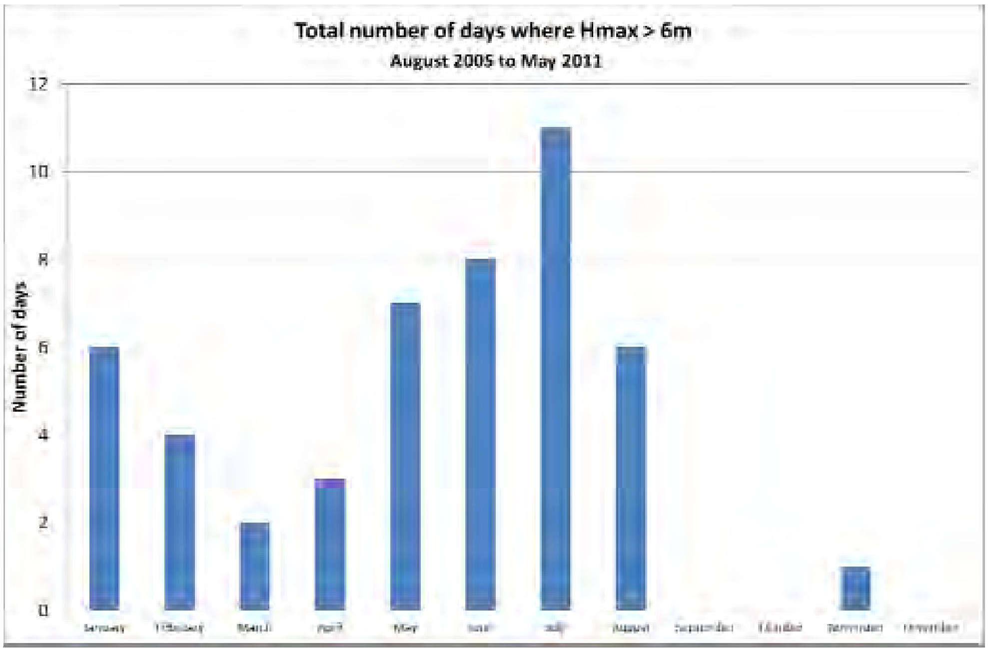


Figure 3 *Wave characteristics recorded at the Bay of Plenty Regional Council wave buoy.*

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 1.5 m dissipate some of their energy over the 20 km of continental shelf arriving in the near shore environment aligned near normal to the shoreline with reduced wave heights of approximately 0.6 - 0.8 m (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.



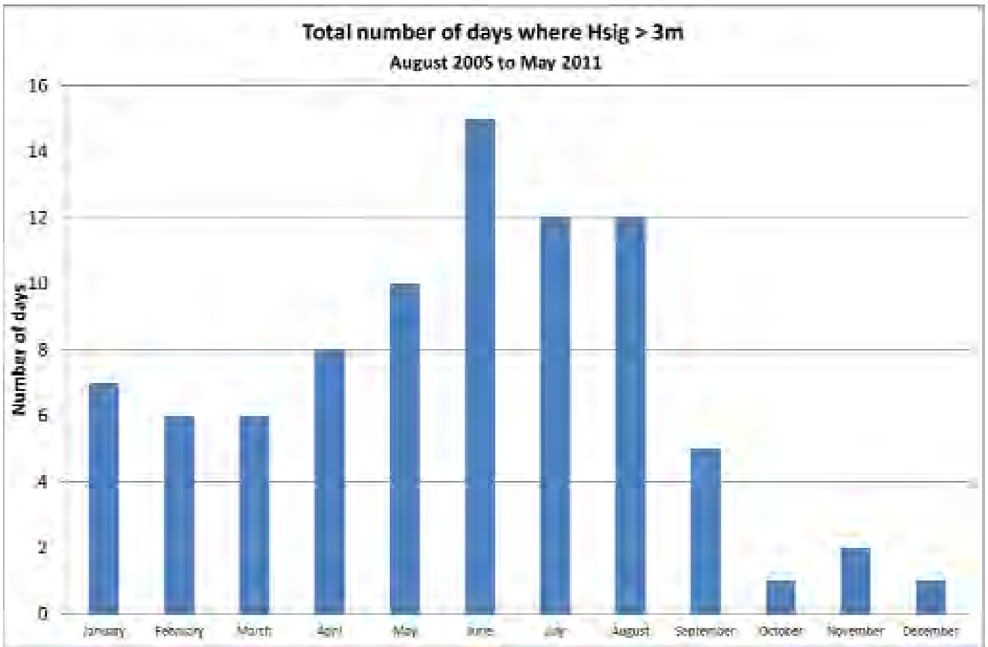


Figure 4 *Seasonal patterns in wave height recorded at the Bay of Plenty Regional Council wave buoy*

Strong winds are more frequent in winter months and during positive ENSO periods (Figure 5). Therefore persistent waves and storm induced erosion are more persistent during warmer La Nina periods (Hay, 1991).

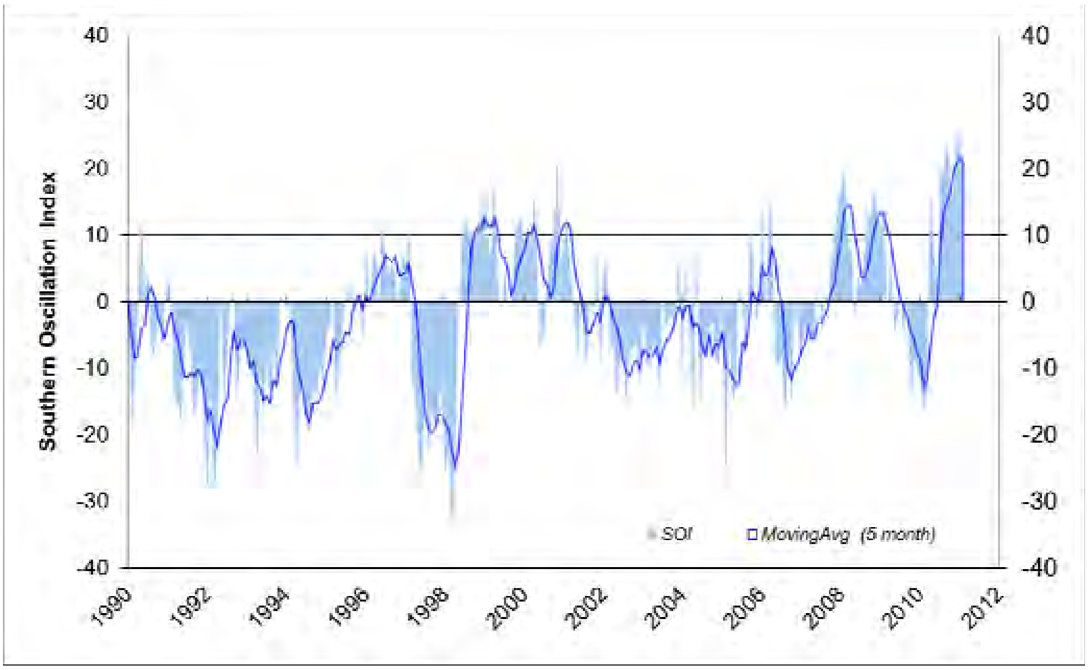


Figure 5 Southern Oscillation Index, 1990 to present

1.2 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. For a more detailed list of events see http://en.wikipedia.org/wiki/Category:South_Pacific_cyclone_seasons.

Table 3 Significant storms during this report period.

Event	Event
March 1988 – Cyclone Bola	29 February 2004 – Cyclone Ivy
July 1992	16 July 2004
September 1993	25 January 2006
24 -25 January 1996	25 April 2006
30-31 December 1996 – Cyclone Fergus	11 July 2007
10-11 January 1997 – Cyclone Drena	17 August 2007
11-13 March 1997 – Cyclone Gavin	21 January 2008 – Cyclone Funa
July & August 1998	30 July 2008
November 1998	13 June 2009
12-14 April 2001 – Cyclone Sose	29 January 2011 – Cyclone Wilma
20-21 June 2002	24 February 2011 – Cyclone Atu
16 April 2003	25 March 2011 - Cyclone Bune

Storm paths show marked variation and not all pass directly into or through the Bay of Plenty, and example of this is shown in Figure 6 where the path for these two recent event varies as well the effect on wave formation and wave size recorded at the Bay of Plenty Regional Council wave buoy.

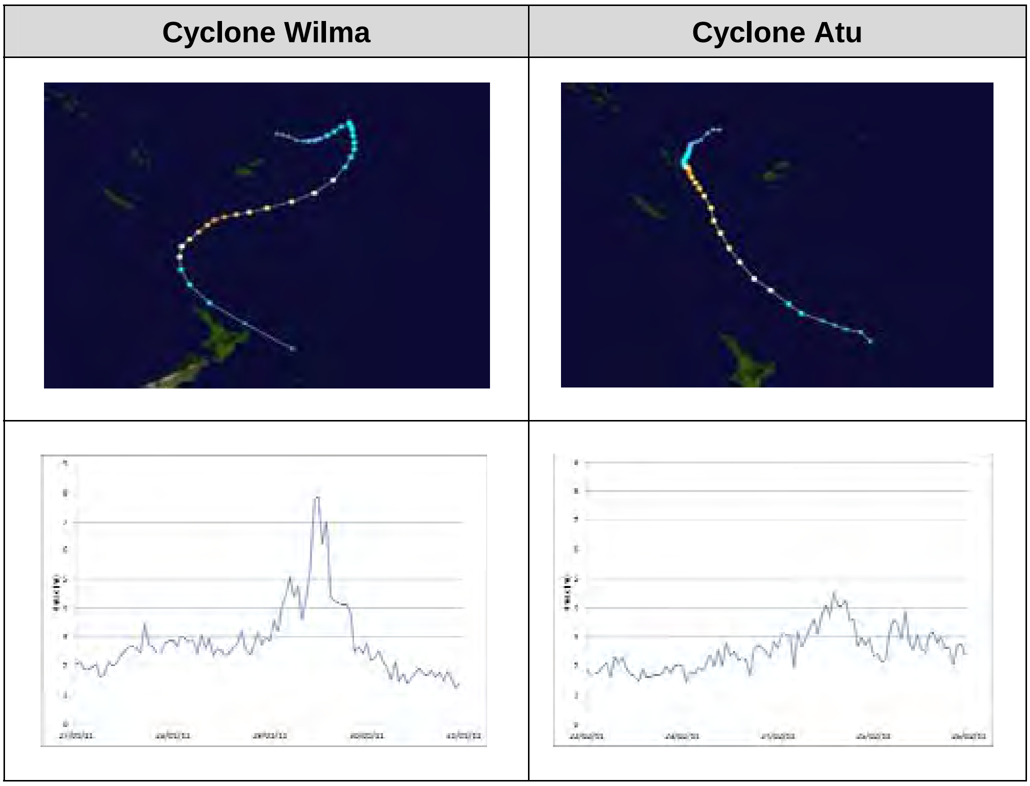


Figure 6 Travel paths for Cyclones Wilma and Atu, along with associated Hmax values recorded at the Bay of Plenty Regional Council wave buoy

1.3 Coastal landforms

1.3.1 Cliffs and shore platforms

In some areas of the Bay of Plenty (Matata, Te Kaha area) 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.

1.3.2 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 7).

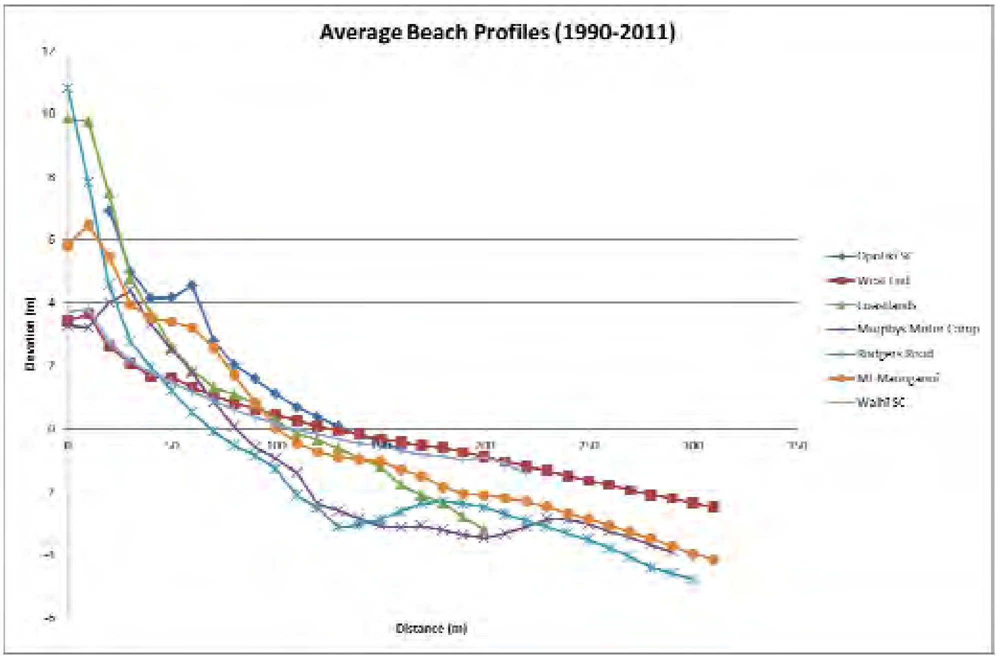


Figure 7 Average beach profile variation throughout the Bay of Plenty Regional Council sandy coastline

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 sub-tropical 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).

1.3.3 **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.

1.3.4 **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. Several documents outline the processes at the Ōhiwa Harbour entrance in more detail, see Murdoch (2005), Julian (2006) and Gibb (2006).

1.3.5 **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.

Dunes in the Bay of Plenty are a significant part of the region's character. At a national level it is estimated that only 11.6% of the original extent of sand dunes remains (Leathwick et al, unpublished report – cited in Ministry for the Environment and Department of Conservation, 2007). In the Bay of Plenty, based on the current mapping, approximately 26% of the historic sand dune landform remains undeveloped. However, undeveloped only means that they are not built-up (housing, roading or other infrastructure), or in agriculture or horticulture. It does not reflect the current state of the remaining undeveloped dunes, some of which are far from their original state with many modifications that are likely to be irreversible (Willems, 2010).

Vegetation cover over the mapped historic dunes landform shows a rapid and significant decline in dune vegetation, with 74% of the original cover lost to developments including urban, agricultural and horticultural activities. Of the remaining vegetation, over half the vegetation types were characterised by exotic species. The transects showed an average of 30% estimated pest plant cover on the transects mapped, with some areas recording over 50% pest plant cover. Higher levels of overall cover were not necessarily associated with housing as might be expected. Very few pest plant species showed a pattern of distribution in the region, with most spread across the full extent from Waihī to Cape Runaway, although with varying density across the transects (Willems, 2010).

Appendix 2 – Monitoring methods

1.1 Overview of monitoring

The Bay of Plenty Regional Council 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.[1]

1.1.1 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 50 m, but does vary due to local circumstances.

During installation the benchmarks are surveyed to Moturiki Datum 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.

1.1.2 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 Bay of Plenty Regional Council 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 3 m tape. The poles are 1.5 m long, graduated in centimetres, with a collar and spike at one end (Figure 8). The poles are place vertically in the ground with the collars at ground level at 3 m spacings, or at each noticeable change in slope. The horizontal distance is measured by the attached tape, with 3 m being the maximum spacing possible. Vertical 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.

[1] 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.

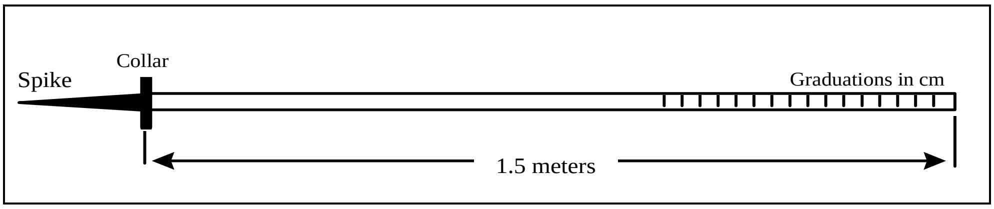


Figure 8 Emery Pole construction

In the case of measurement of a down slope the first pole (Pole 1) is at a higher elevation than Pole 2 (Figure 9). 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 10). 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.

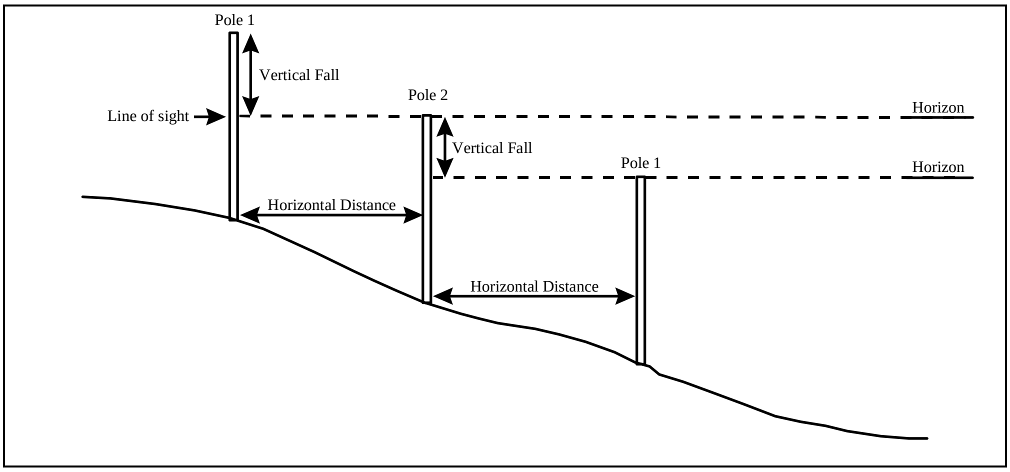


Figure 9 Measurement downslope using Emery Pole technique

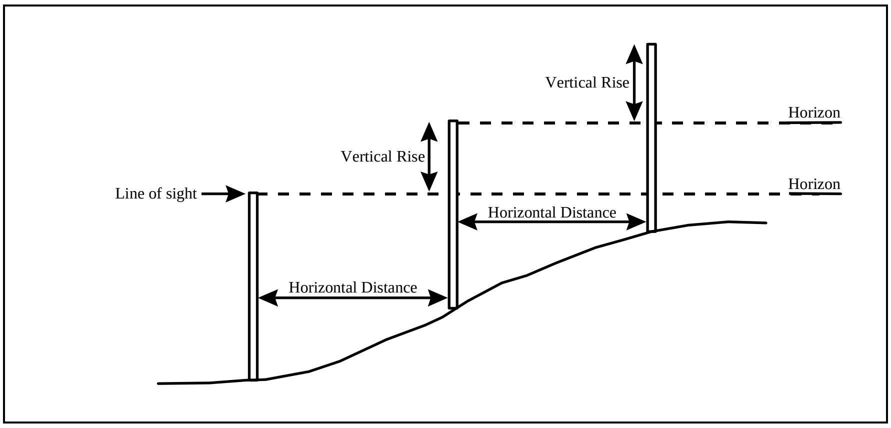


Figure 10 Measurement upslope using Emery Pole technique

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 used less frequently and a Total Station surveying instrument has been utilised for measuring the shape of the beach and performing the levelling quality control checks between the two benchmarks at each site.