COASTAL SYSTEMS (NZ)
and Associates

Patea Beach Green Waste Management Strategy

Part 1
Coastal change and historical sand stabilization works

Report prepared for the South Taranaki District Council

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Client Report 06/04

July, 2006

1. Background

On 5 September, 2005 the Taranaki Regional Council (TRC) granted resource consent (Discharge Permit) 6088 which allows for the discharge of green waste onto land for stabilization purposes and to discharge leachate and stormwater from that site onto and into land at or about GR: Q22 373 582. This land is located on and about the clifftop to the north of the Patea Rivermouth (Fig 1). This consent has been granted until 1st June, 2007. Special Condition 3 of the permit states that within 6 months of the granting of the consent, a detailed restoration and reinstatement plan is to be completed showing how the site will be left following completion of green waste disposal prior to expiry of the consent. The consent conditions note that the plan should also provide for the maintenance and enhancement (including appropriate planting of dune species) of the foredune between the disposal area and the coastal marine area. It was stated in the (TRC's) Scientist's Report that the regional council do not consider this area to be a long-term green waste disposal site.

On the 10th March, 2006, Coastal Systems was contacted by Mr Steve Robson and Mr Clive Margetts of the South Taranaki District Council (STDC) about implications of ceasing green waste disposal and how the requirements contained within Special Condition 3 could be met. After further discussions and a site inspection, a proposal was compiled and this was accepted on the 5th April. This work consists of two stages. Part 1 (the present report) involves preparing a preliminary report by June/July 2006 that will *background the physical processes and sand stabilization history at the site.* Conclusions will be drawn regarding future sand stability at the site and whether or not green waste needs to be involved. The second stage (Part 2) of the investigation involves *the development of a sand management plan* based on the findings contained in Part 1. This plan will address both the need for sustainability as required under the Resource Management Act 1991, and meet Special Condition 3 of the existing resource consent. This second stage of the programme is to be completed by the end of 2006.

2. Information

I have read the Soil Conservation file (SC4/44) held by the Taranaki Regional Council. This file covers the involvement by the Council's predecessor the Taranaki

Catchment Commission (TCC) in stabilizing unstable dunes on the northwestern side of the Patea Rivermouth between 1976 and 1991. The commission was involved in extensive sand stabilization work in the late 1980s and the file contains a comprehensive record of this work.

The Patea Community Board became involved in the use of green waste to extend this stabilization from about the mid 1990s. I have discussed the development of this work into a district-wide operation with members of the Board. It was the increasing scale of the green waste operation that lead the TRC to require a resource consent, and the need to reassess the green waste operation.

I have read the STDC file 523/03 which relates to the present TRC Discharge Permit. I have also read STDC file 849/04 which relates to the council's efforts to secure a Land Use Consent for the green waste operation. File 849/04 includes the written concerns of several interested parties including the Department of Conservation who consider the nature and scale of the green waste operation has an unacceptable effect on natural character.

I have read a 2005 report by the TRC which considers methods to stabilize and restore the area based on appropriate plantings. While that report provides useful information, future sand management planning also requires a detailed knowledge of coastal dynamics and evolution.

I have read several reports related to general stabilization in the rivermouth area including the 1987 DSIR report relating to erosion in Pipeline Bay (on the inland side of Mana Bay), and the 1990 STDC report relating to the stabilization of Pipeline Bay and Mana Bay. I have also read the recent (2003) Duffill Watts and King report concerning stability of the Patea River Entrance.

I have searched the New Plymouth and Patea Museum archives for historical literature, photos and Harbour Board Plans, and spoken with a range of persons, albeit not exhaustive, with relevant local knowledge.

My understanding of the coastal processes and past sand stabilization works also relied on the inspection and analysis of available vertical and oblique aerial photographs. Vertical aerials have been acquired from 1949 (NZAM), 1962 (NZAM), 1968 (GeoSmart), 1974 (NZAM), 1977 (GeoSmart), 1980 (NZAM), 1988 (GeoSmart), 1993 (GeoSmart)), 1996 (GeoSmart), 2002 (Laurie Cairnes Aerial photography), 2005 (Laurie Cairnes Aerial photography). These photographs were digitized and transformed to map coordinates using standard photogrammetric procedures. This process enables images to be overlain so common features such as the location of shorelines, cliff edges and vegetation boundaries can be directly compared. In addition, stereographic imagery was obtained which enabled 3D viewing; this greatly increased the level of observed detail.

Oblique aerial photographs have been obtained from 1947 (GeoSmart), 1958 (GeoSmart), 1991 (TCC), 1992 (Coastal Systems), and oblique terrestrial photos obtained from 1987, 88, 91 (TCC), and 1990, 2000-2006 (Coastal Systems). While perspective distortion on oblique photos makes quantitative assessment difficult, they still provide useful qualitative detail.

3.0 Coastal change

3.1 The natural rivermouth

Prior to construction of the entrance moles, the coast is well described by the 1879 New Zealand Harbours Plan of Patea depicting the harbour and entrance works as recommended by Sir John Coode and other civil engineers. Hereafter this plan is referred to as the ‘Goode Plan’ part of which is reproduced as Fig 2. In addition, I have also seen several water colour paintings done between 1860 and 1890, which provide further detail of the pre-mole landscape and natural processes.

In the Coode Plan, the river is shown entering the sea along the same southward alignment as evident further upstream. It flowed seaward beneath that area where the south beach dunes now exist and past the South Head (Fig 2) which appears to be little changed today. The northwestern coastline was cliffed with a spit extending from the North Head some 400 m southward to the low tide rivermouth. Ordinary spring high tides are shown reaching the cliff-base along both the northwestern and southeastern coasts. However, an 1865 painting by Edward A. Williams suggests the tides and waves may not have reached the cliff-base for extended periods of time. The inter-tidal beach on the Coode Plan is noted as consisting of “gravels resting upon hard clay”. A boulder bank to the southeast of the entrance is described as having “drift sand covering large boulders”. Interestingly, this is the only mention of sand, although shading and shapes inland of the beach to the north of the rivermouth are indicative of clifftop dunes.

3.2 Entrance Structures

The ~325 m long North Mole and ~450 m long South Mole were constructed in stages between ~1880 and 1921. These structures are very similar to those depicted on the Coode Plan (Fig 2).

The North Mole acted as a sand trap for the predominantly northwest to southeast littoral drift, and the shoreline rapidly moved seaward – a now well recognized response to such structures. Indeed, by the time the first vertical aerial photograph was taken in 1949, the shoreline had adjusted to its present, albeit fluctuating, location as illustrated by the graph in Fig 3.

While the beach-face location adjusted relatively quickly to altered marine processes associated with mole construction, the consequences of wind-blown sand were both unexpected and far reaching. As soon as the spring high tide line moved seaward from the cliff, wind-blown sand was able to both accumulate within this newly created ‘back-beach’ and be transported across this area to reach the wave basin (Mana Bay). Over time, sand accumulated about plants and the process of dune formation began. In addition, a sand ramp formed against the cliff. These situations are evident in the 1947 oblique aerial photograph shown in Fig 4. Sand was now able to reach the clifftop, pass through a “low point in the cliff” (noted on the Coode Plan, and evident from shading that indicates parabolic dune sidewalls), and present a hazard to the dwellings, occupants and utilities at the beach settlement. This lead to the series of sand stabilization works that continue to this day.

3.3 Early sand stabilization works

The 1958 aerial oblique photo (not reproduced) shows a windbreak fence and possibly conservation plantings. The 1962 aerial photo (Fig 5) clearly depicts this long shore-parallel fence which was constructed of vertically driven and wired mill slabs. These stabilization works resulted in a continuous shore-parallel foredune forming and, for the next 15-20 years, this minimized wind-blown sand from both threatening the settlement and blowing alongshore to reach Mana Bay. The 1977 vertical aerial photograph (Fig 6) illustrates this stable foredune.

Fed by a continual supply of wind-blown sand, the shore-parallel foredune along the central-southern section of the beach increased in volume and height. This situation probably led to increasing wind shear across the crest, desiccation of dune grasses, and the development of erosion guts (blowouts) which rapidly expanded and allowed substantial quantities of sand to move inland**.** This critical situation was reached during 1987 (El Nino), if not somewhat prior to this, and is illustrated by the photos in Fig 7. At that time wind-blown sand was an ongoing nuisance and the leading edge of the sand drift was about to descend upon the beach settlement. A government (NWASCO-subsidized) sand stabilization scheme was designed and coordinated through the TCC. These works and their repercussions will be described in the following section.

To the northwest of the shore-parallel fence, shorter diagonal wind fences were erected during the 1960s and 70s, and evidence of these can be seen in the 1977 aerial photo (Fig 6). However, they did not result in the formation of a significant and continuous foredune as in the centre-south of the beach, possibly due to the fence and planting design, or differences in sand supply and wind strength at the northern end of the beach. This fencing may well have contributed to the development of the discrete dunes orientated diagonally across the beach (and parallel to the prevailing wind) which still characterize this area today.

3.4 Vegetation effects

It is possible that the vegetation type also had some effect on the formation of wind-parallel dunes in the north and the shore-parallel foredune along the central-southern beach.

The effect of different types of sand-binding vegetation on wind flow, dune form and dune stability is well known and has been described in the 2005 TRC report. Plants which grow in clusters such as marram grass (*Ammophila arenaria*) concentrate the air flow between clumps and scouring occurs with sand then depositing in the ‘shadow’ areas near the crest or to the rear. The resulting dunes are hummocky and encourage isolated dune development with *wind-parallel* orientation (e.g. Fig 8A). By contrast, grasses with creeping runners (stolons) such as spinifex (*Spinifex sericeus*) and pingao (*Desmoschoeneus spiralis*) extend laterally across the surface, thereby encouraging sand deposition over a wider area and the formation of more even dome-like dunes. Such dune formation processes tend to result in continuous *shore-parallel* foredunes (e.g. Fig 8B). So, if marram plants had dominated the northern sector and spinnifex/pingao in the central-southern sectors, then this would have encouraged the development of the observed dune forms. However, the clumpy nature of vegetation depicted earlier in the photographic record (e.g. Fig 4), suggests that marram was always dominant.

It should be noted that while marram-dominated dunes encourage blowout development, such instability can also occur with dunes of spinifex/pingao, albeit within a longer time-frame. For example, in situations where the front of the foredune is undercut by wave action, or trail bikes cause localized loss of vegetation cover, wind flow is able to concentrate and erosion guts can develop. Alternatively, if dunes continue to increase in height, then, over time, wind-shear will increase across the crest, desiccating vegetation and increasing the erosion potential.

3.5 Sand stabilization during the late 1980s and early 1990s

The mobile sand problem facing the community by the late 1980s was significant in terms of both the hazard and the effort that would be required to bring it under control. The extent of bare sand, the topography and the wind strength resulted in the TCC having to trial several techniques and this is described in their file. The extreme winds to which this area is subjected are illustrated by the size of sand ripples on the existing back-beach and the degree of wind desiccation of hardy dune grasses (e.g. Fig 9).

Stabilization methods in the central-southern section consisted of blocking the large erosion guts (blowout throats) using pine trees thinned from a nearby plantation. In

1988, wind-break fences were constructed over the sand drifts to the rear, and marram grass was planted between these structures (see Fig 10).

In 1992, wind breaks were constructed across the northern dunes and ramp (Fig 11) and planting carried out. This work was only partially successful and a proposal was put forward for further windbreaks in 1994. However, it appears that this work did not eventuate.

3.6 Recent stand stabilization

By the mid 1990s, the mobile sand problem had been largely contained; however, some unstable areas persisted. Covering the central-southern area with green waste continued and expanded to become a district-wide operation by the late 1990s. The swale between the cliff and original foredune-crest was slowly infilled (see Fig 12) with green waste, wind blown sand and then this was overlain with 'clay'. In addition clay tracks were formed to allow green waste to be placed in areas most affected by erosion or sand drift. In effect a 'green waste platform' has been created that has displaced the original cliff-face seaward by some 50 to 70 m.

In 2000, pingao was planted on the back-beach along the centre-northern sectors. The plants were given green waste protection. A new foredune began to develop and this is described in the following section.

3.7 The present situation

As is evident from the above description, the North Beach and dunes at Patea can be divided into three sectors based on present topography, developmental history and management regime. The longshore extent of these sectors are marked on the 2005 aerial photo in Fig 13, along with features and terminology used henceforth.

The <u>northern sector</u> is characterizesd by the pingao foredune, which is severely blown out in several locations (e.g. Fig 9). Behind the foredune are the discrete and hummocky dunes and erosion troughs aligned with the (topographically steered) prevailing wind. In several instances, foredune blowouts have merged with erosion troughs to the rear which extend up the ramp to the clifftop (see Figs 9 and 13).

The central sector is also characterized by the pingao foredune (Fig 14); however, here it is less blown out indicating less severe winds. Behind this foredune, a swale occurs which broadens and lowers toward the south. To the rear of the swale is the seaward face of the green waste platform. This slope is characterized by patches of green waste and marram interspersed with bare sand. Some of these bare sand areas would rapidly develop into guts if it were not for the platform’s green waste capping. The green waste and marram plants cladding the slope enable it to steepen beyond the angle of repose for dry sand and become more cliff-like.

The southern sector has no continuous foredune, but comprises isolated dune hummocks of pingao located on the seaward side of the broad back-beach area (Fig 15). Behind the back-beach is the over-steepened slope fronting the green waste platform. The slope in the southern sector is also characterized by areas of marram, bare sand and green waste (as depicted in Fig 15); a combination which will facilitate the development of guts on the slope and sand drifts to the rear.

In contrast to the central sector, in the southern sector, the face of the green waste platform is well landward of the original foredune (see green line in Fig 13 and the dashed line, marking the 1950s fence remnants, in Fig 15). Such retreat in the southern sector is the result of erosion by southerly winds. These fence remnants are also evident in Fig 9A.

4. Discussion

The beach and dune topography of the north beach at Patea is very much a product of man’s activities, firstly at controlling the rivermouth for navigation purposes - which had the side effect of widening the beach and facilitating wind-blown sand - and secondly from the various stabilization works carried out to control this wind-blown sand. The evidence presented in this report shows that while some of the larger scale, more comprehensive schemes were, at least in the shorter-term, successful, many lesser scaled and/or poorer designed works failed.

Ordinarily, sand blowing up and over the cliff then down into the river and thence being washed back out to sea, is not problematic. Indeed, it is a well recognized inlet bypass mechanism. However, this sediment pathway creates a potential hazard for the dwellings and utilities, and a long-term management strategy is required. Indeed, in keeping with the ideals of the RMA, achieving sustainable management should be a primary objective, i.e. in the longer-term, management should not negatively impact on natural processes nor reduce resources and values for present and future generations.

Given the basic understanding of the post-colonial evolution of this beach and the underlying driving processes identified in this report, it will be possible to conceptually design and evaluate a range of alternative management scenarios. It is also possible to project the present situation into the future under the scenario of no further human intervention, i.e. no further green waste or other forms of sand stabilization, and this is done in the following paragraphs:

- The <u>northern sector</u> will continue to develop the discrete, wind-parallel topography, with further blowout development in the pingao fordune and erosion troughs and sand drifts extending from the beach up the ramp to the clifftop from whence 'parabolic dunes' will migrate further inland. This is not a new phenomenon, but is the process by which dunes (now stable) formed across the South Taranaki countryside during previous millennia. In these cases, the pre-requisite beach widening was associated with substantial sediment input, such as from a volcanic eruption, or natural sea-level fluctuations which occur at a time-scale of hundreds of years.

- The <u>central sector</u> is likely to undergo another dune development cycle based on the new pingao foredune. This dune will grow in volume and then as its height increases, blowouts will occur and sand will funnel inland across the swale, up onto the green waste platform and ultimately threaten dwellings and utilities. In addition, erosion guts will develop along the face of the green waste platform independently of the pingao foredune behaviour. These guts will enlarge and the associated sand drifts will also migrate inland. This situation is akin to a natural dunescape where instabilities develop on rear dunes as the sand supply is intercepted by foredune growth and dune grasses on the rear dune are replaced by less wind-resistant plants that have greatly reduced sand binding qualities.

- The future of the southern sector depends on whether or not the isolated patches of dune expand and coalesce. If growth and coalescence do occur, then a similar, albeit lagged, scenario to that for the central section will occur. However, if coalescence does not occur, wind funneling between the existing discrete dunes will result in an unstable topography. In addition, the concentrated wind flow will facilitate the formation of blowouts and erosion guts along the face of the green-waste platform.

The effects of global warming on coastal processes also need to be considered. Sea-level is expected to rise by 0.2 to 0.5 m over the next 100 yrs and in addition, westerly winds are expected to increase by up to 25%. Storm frequency and magnitude are also likely to rise. These changes are expected to increase erosion of the upper inter-tidal beach and foredune; a situation that leads to increased blowout development and wind-blown sand.

The above scenarios for the three sectors will all result in mobile sand creating a hazard for the settlement and utilities. Management will therefore be required to reduce or eliminate this hazard. The nature of this management needs to be carefully considered to ensure that the desired outcomes are achieved while avoiding unexpected repercussion in the longer-term.

Whichever future management regime is adopted, the use of dead organic material (green waste) is likely to be incorporated as past experience in this particularly hostile environment has shown that it can be effective when combined with the more traditional controls such as planting. The nature of the green waste, its manner of usage, along with the scale of the operation, will be determined during Part 2 of the investigation, i.e. the development of a sand management plan.

Coastal processes on Patea's North Beach control the volume of sediment within the inlet, either via wind-blown sand entering Mana Bay, or via surf zone and tidal currents. It may therefore be prudent to also consider the implications of future updrift sand management on inlet dynamics.

Finally, it is noted that a high resolution aerial survey by New Zealand Aerial Mapping Ltd has recently been carried out for the entire Taranaki Coast – funded by the regional and district councils. The scale of the photographs and the accuracy of the ground control points mean that high resolution elevation data can be obtained. Such data can then be used to construct a 3D topographic computer model suitable for use in the development of the sand management plan (stage 2). In addition, this digital terrain model (DTM) will be particularly useful in subsequent landscape planning for those stabilized areas defined in the management plan.

5 Recommendations

1. That the STDC and TRC recognize the need for ongoing sand management at Patea's north beach;

2. That green waste is likely to play a role in future sand management, with the manner and scale yet to be determined, and

3. That the second part of this investigation, namely, *the development of the Patea Beach Sand Management Plan*, proceed forthwith.

Acknowledgements

Dr Mike Shepherd (Massey University) is thanked for reviewing the manuscript, and the Geography Department at Massey University is thanked for use of their photogrammetric equipment. Mr Steve Robson (STDC), Mr Richard Fitzpatrick (TRC) and Mr Terry Tamakehu (South Taranaki District Museum) are thanked for searching and providing archival files and other materials. Cr Ian Ward and the Patea Community Board are thanked for providing background information, and past

Councillor Noel McColl is thanked for providing detailed information on past sand stabilization works.

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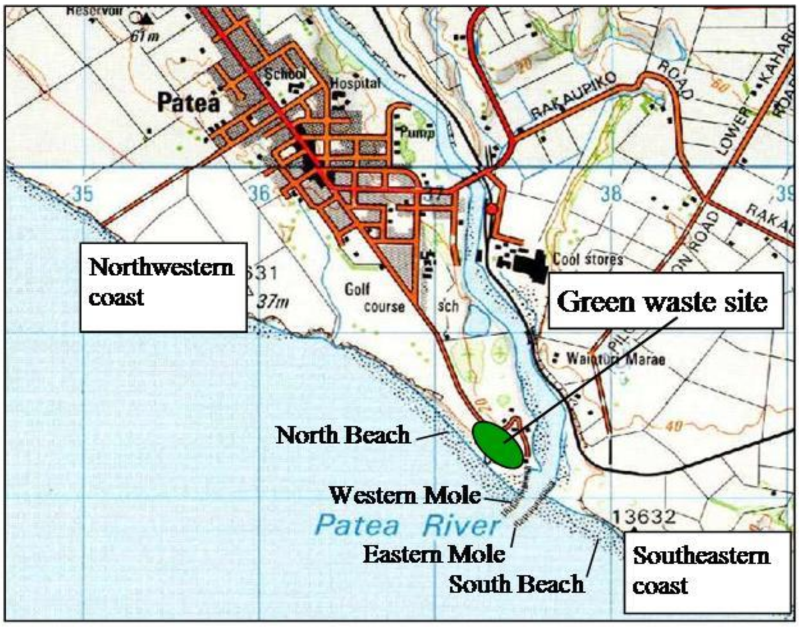

Figure 1 Map showing the location of the Patea Beach green waste site and locational terms used in the text

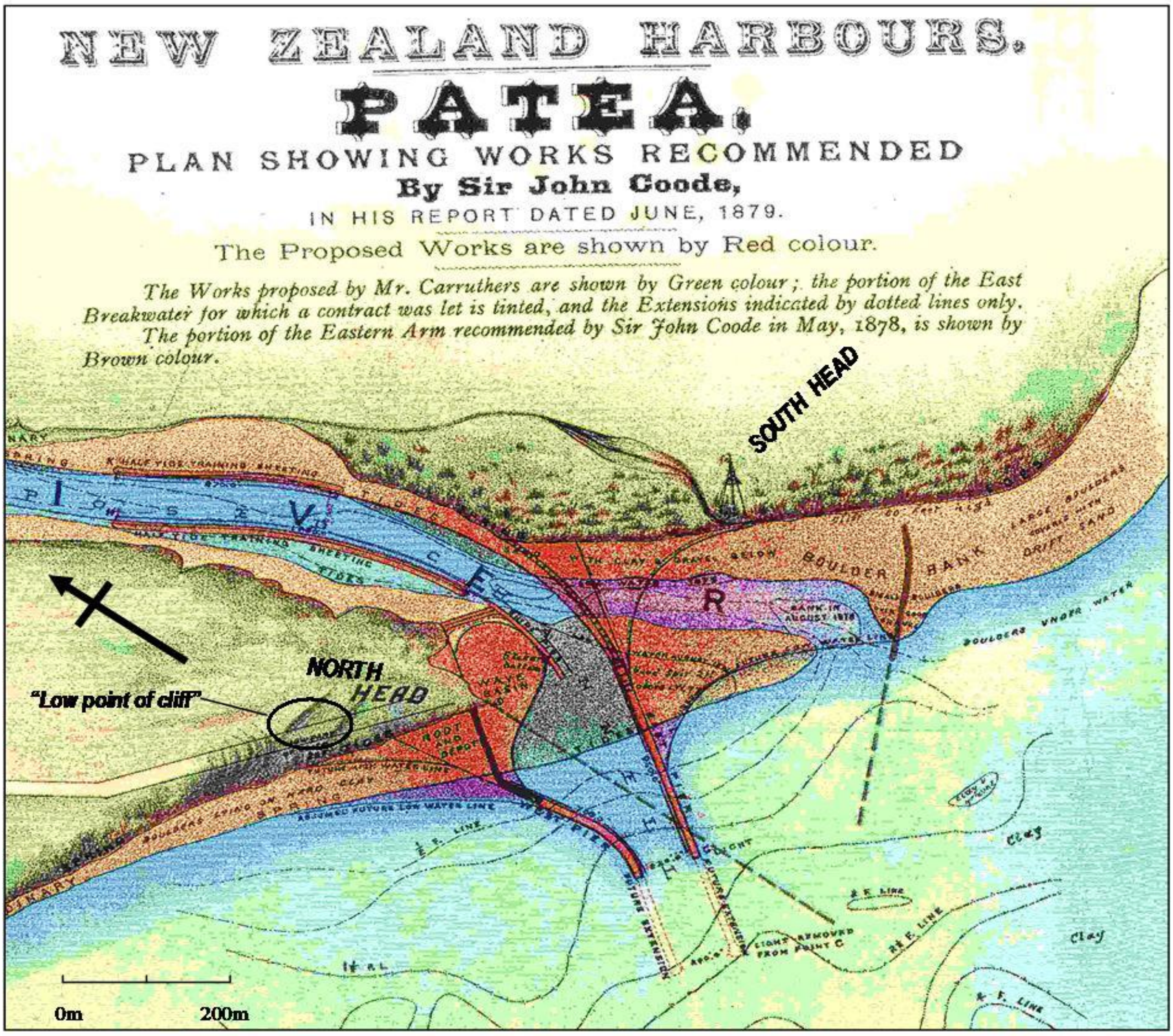

Figure 2 New Zealand Harbours Plan of the Patea Rivermouth area in 1879, depicting the harbour and entrance works recommended by Sir John Coode and others.

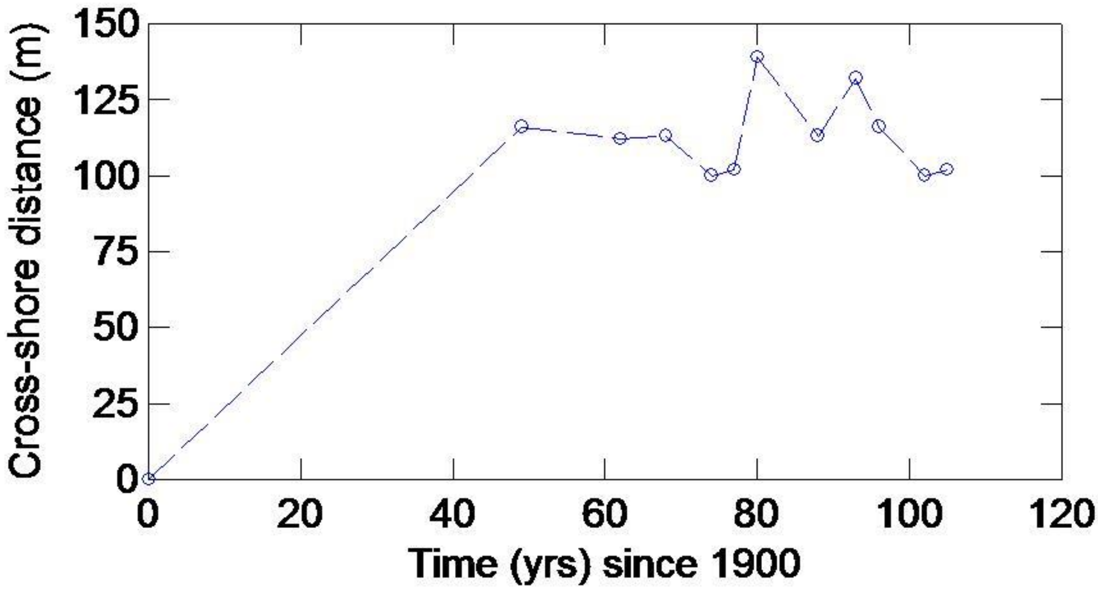

Figure 3 Shoreline change from base of cliff along a transect mid-way along North Beach. The cliff-base was approximated from the first (1949) aerial photo. Data points correspond to years of aerial photography. Shorelines were defined as the upper limit of the inter-tidal beach and this was delineated by intensity changes, with darker areas (heavier minerals or wet sand) denoting the beach face, and lighter areas marking the back-beach.

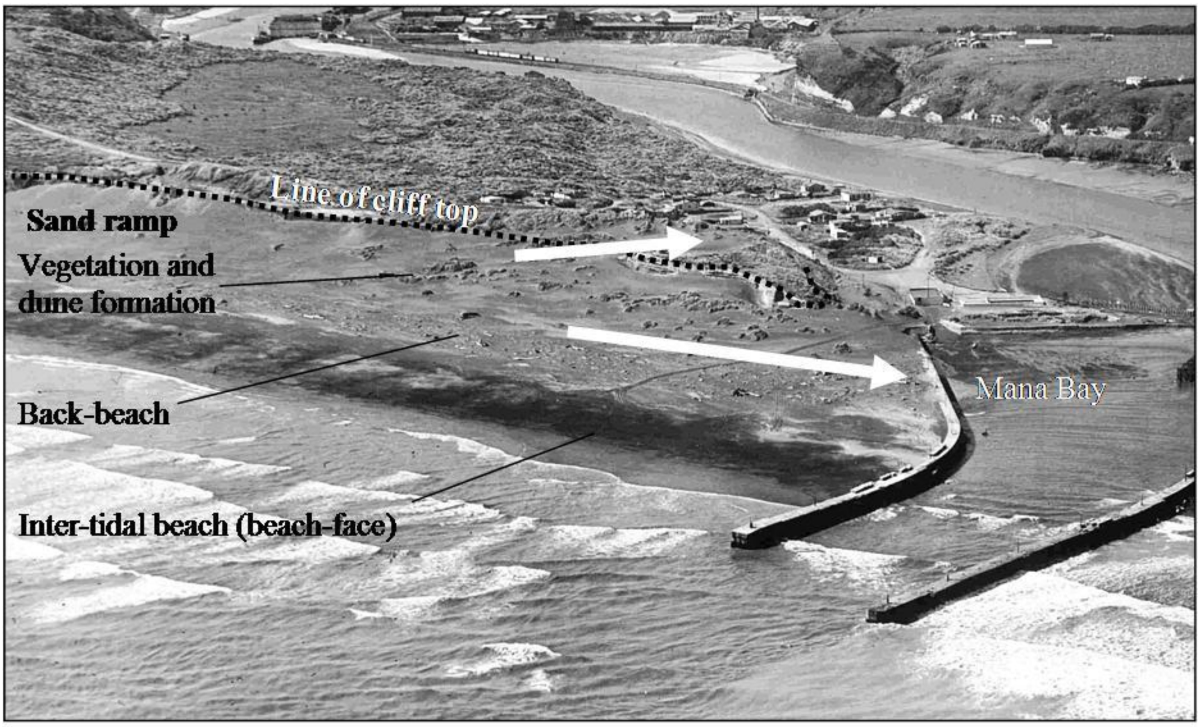

Figure 4 Oblique aerial photo from 1947 depicting the sand ramp up against the cliff together with several other features referred to in the text. Note the arrows denoting the transport route for wind-blow sand across the low point in the cliff line, and also along the back-beach into Mana Bay.

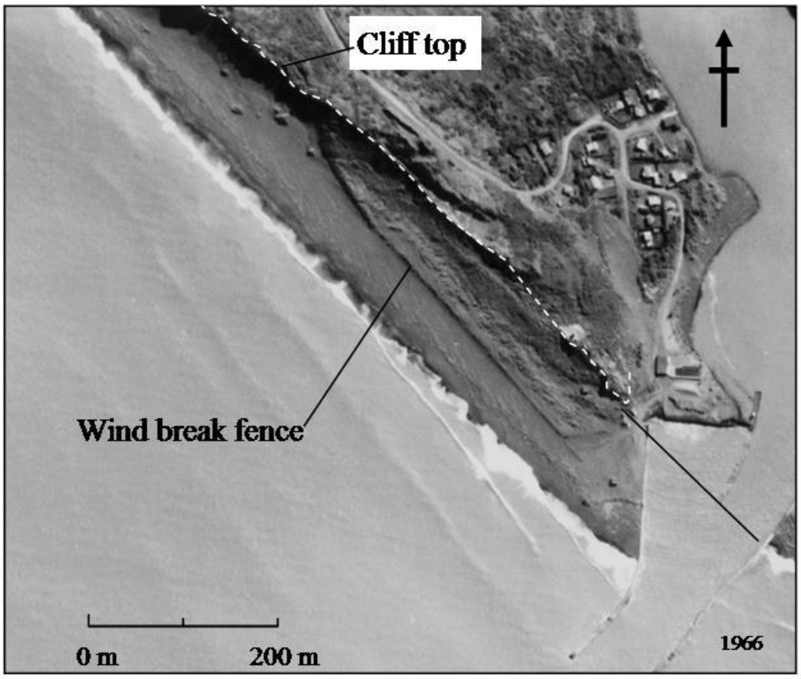

Figure 5 The 1962 aerial photo showing shore-parallel wind-break fence and foredune development between fence and cliff.

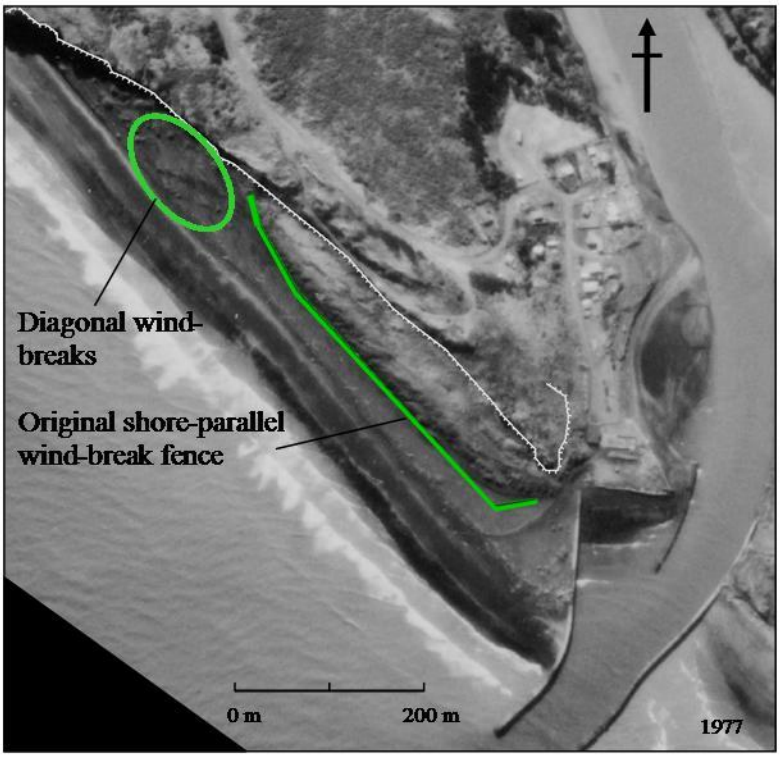

Figure 6 The 1977 aerial photo showing the location of the original shore-parallel wind-break fence (green line) and the well developed stable foredune between the fence and cliff. Note the earlier diagonal wind-break fences (green circle) to the north which were less successful in assisting vegetation establishment and dune formation.

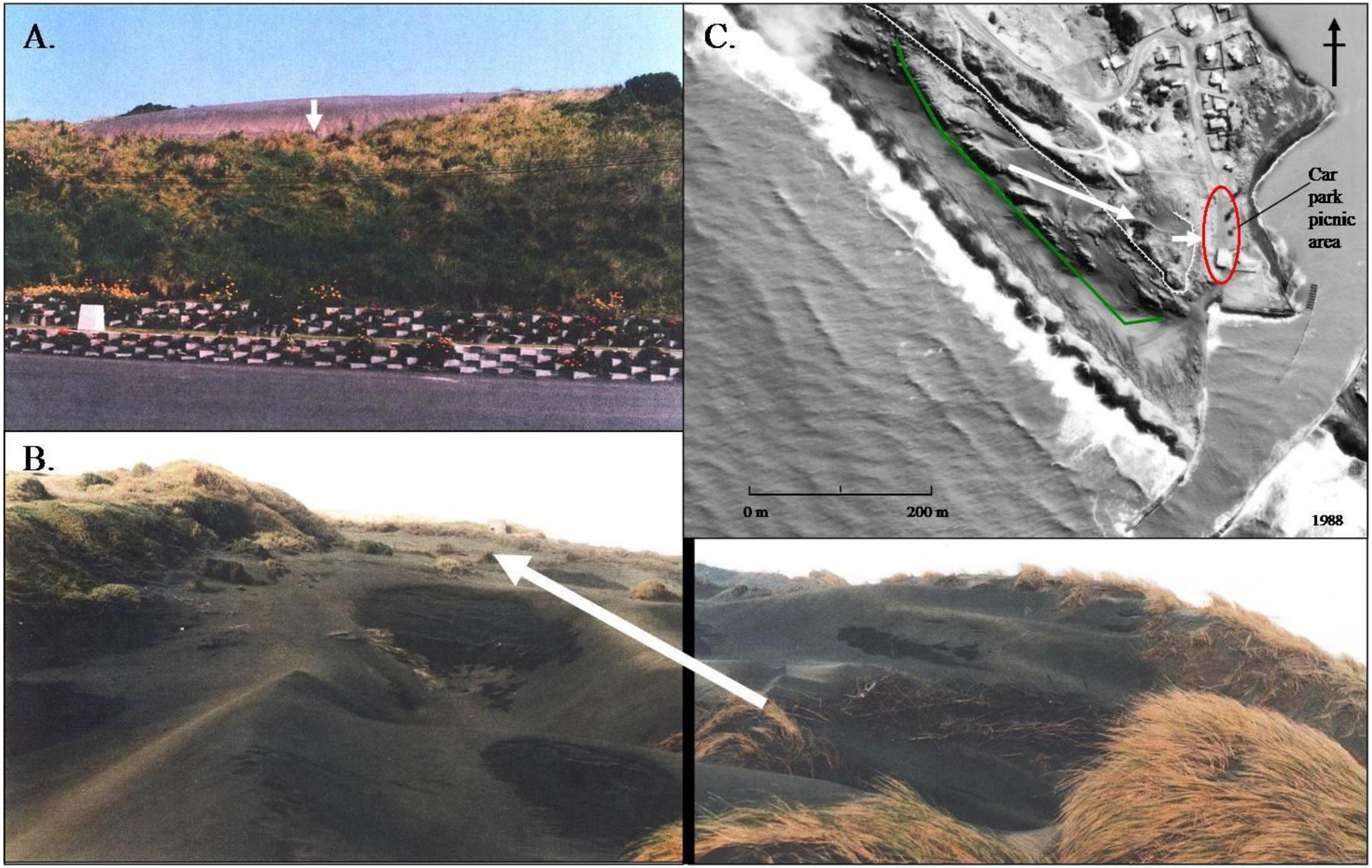

Figure 7 Sand drift (A) about to reach the car park-picnic area in 1987, and moving in indicated direction across top of cliff (B) in 1988. The 1988 aerial photo (C) also illustrates these sand drifts. The location of the arrows in A and B are depicted in C. By 1987/88, the entire foredune behind the original conservation fence (green line in C) was highly unstable. Note earlier (unsuccessful) windbreak fences across the path of the arrow in C.

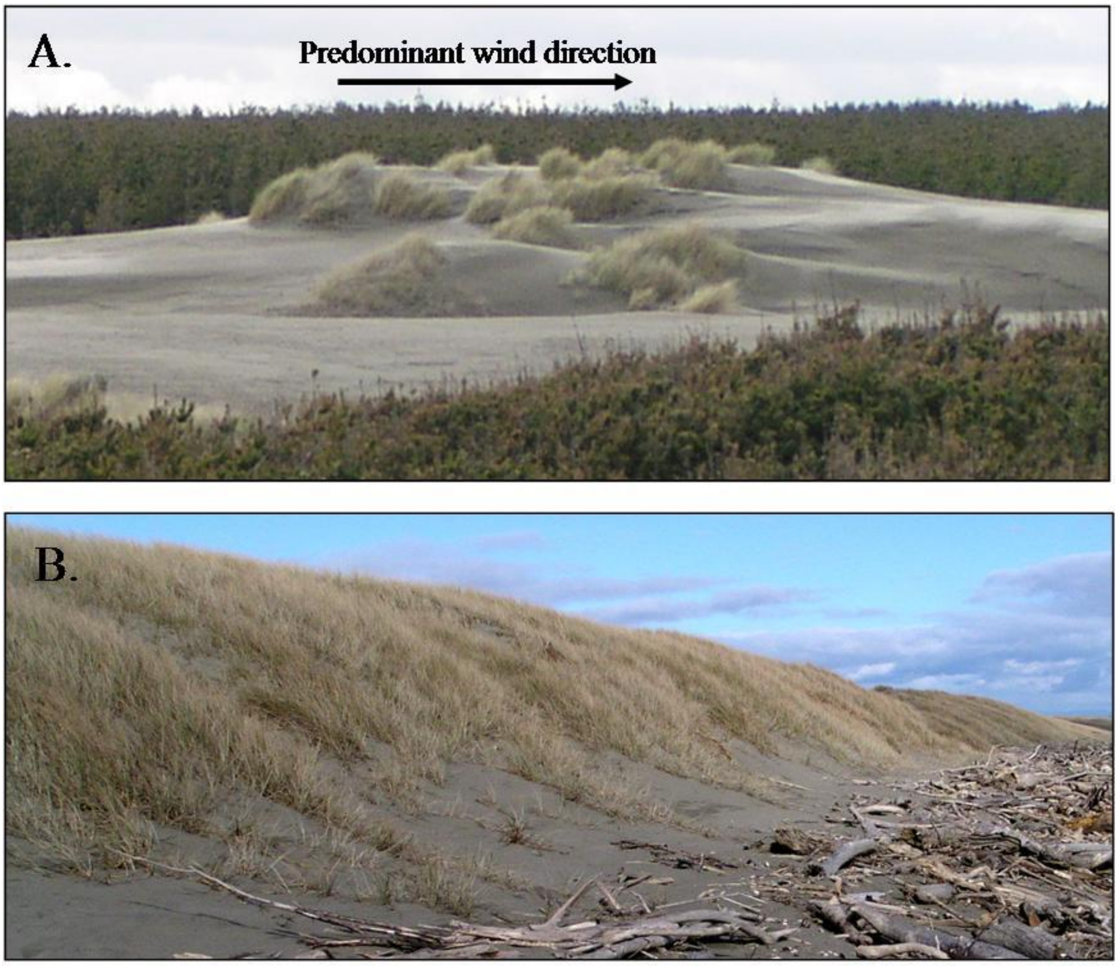

Figure 8 Hummocky dunes dominated by marram (A) compared with more uniform foredunes dominated by spinifex or pingao (B).

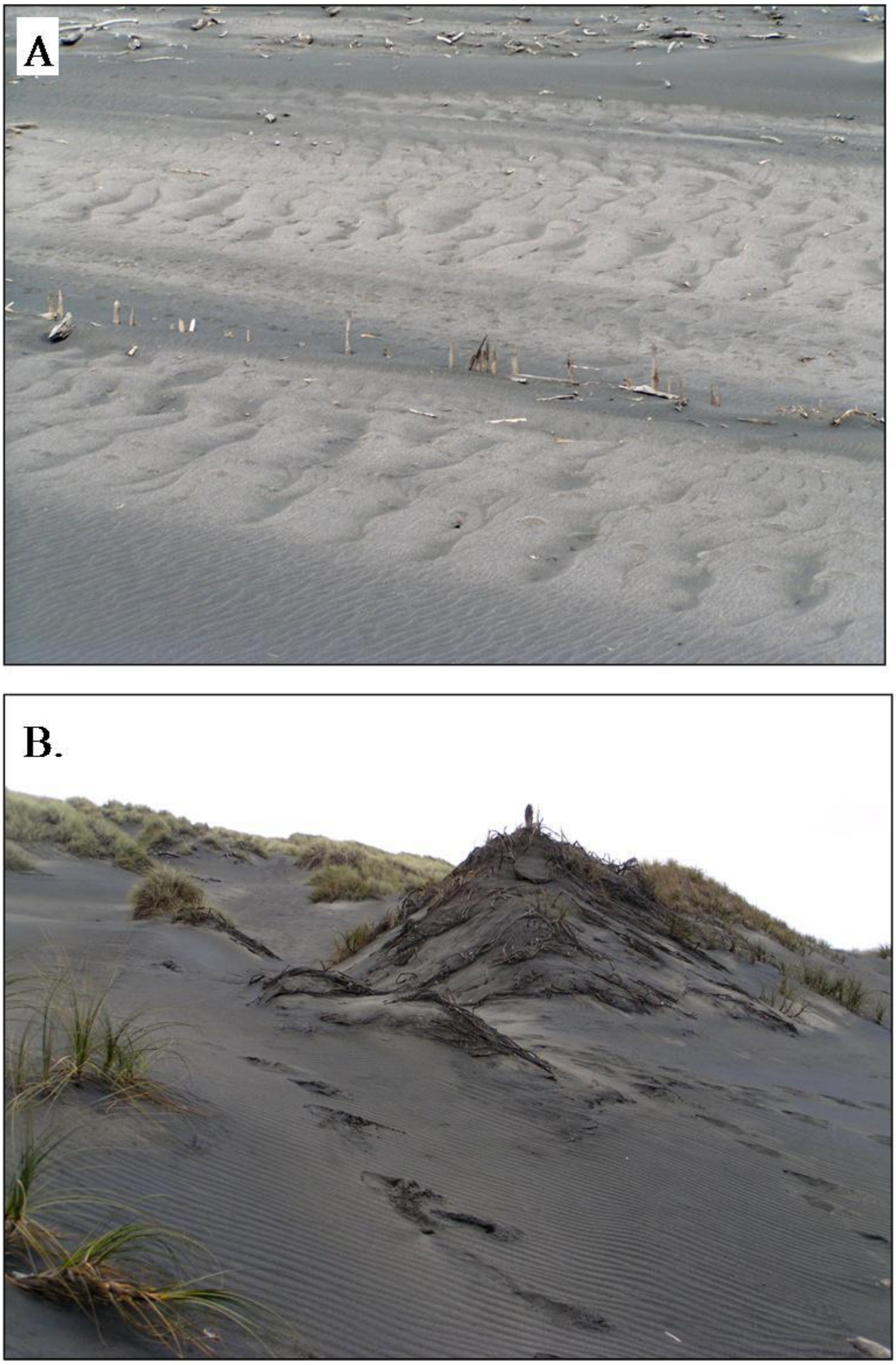

Figure 9 **Evidence of wind severity. Mega ripples (A) on the southern back-beach area, and wind burn (desiccation) of pingao on foredune blow-outs(B) at the northern end of the beach.**

Fig 10 Sand stabilization works carried out in 1988. Pine thinnings were placed in guts and across the path of the prevailing wind (see arrow), with marram planted within the intervening spaces.

Figure 11 This 1992 aerial photo shows the just completed windbreak fencing at the northwestern end of the beach.

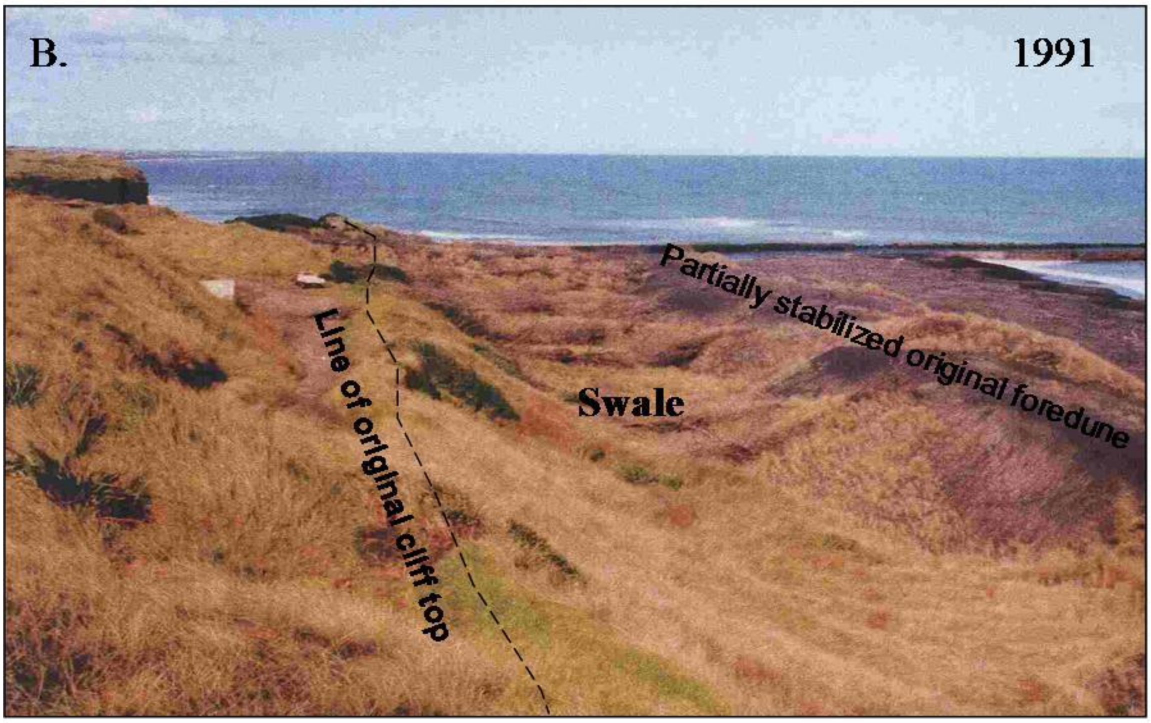

Figure 12 By 2006, a green waste 'platform' had been created (A) by infilling the swale between the original cliff and the crest of the original foredune (B). Note drift-sand at northern margin (in foreground) of green waste platform in A.

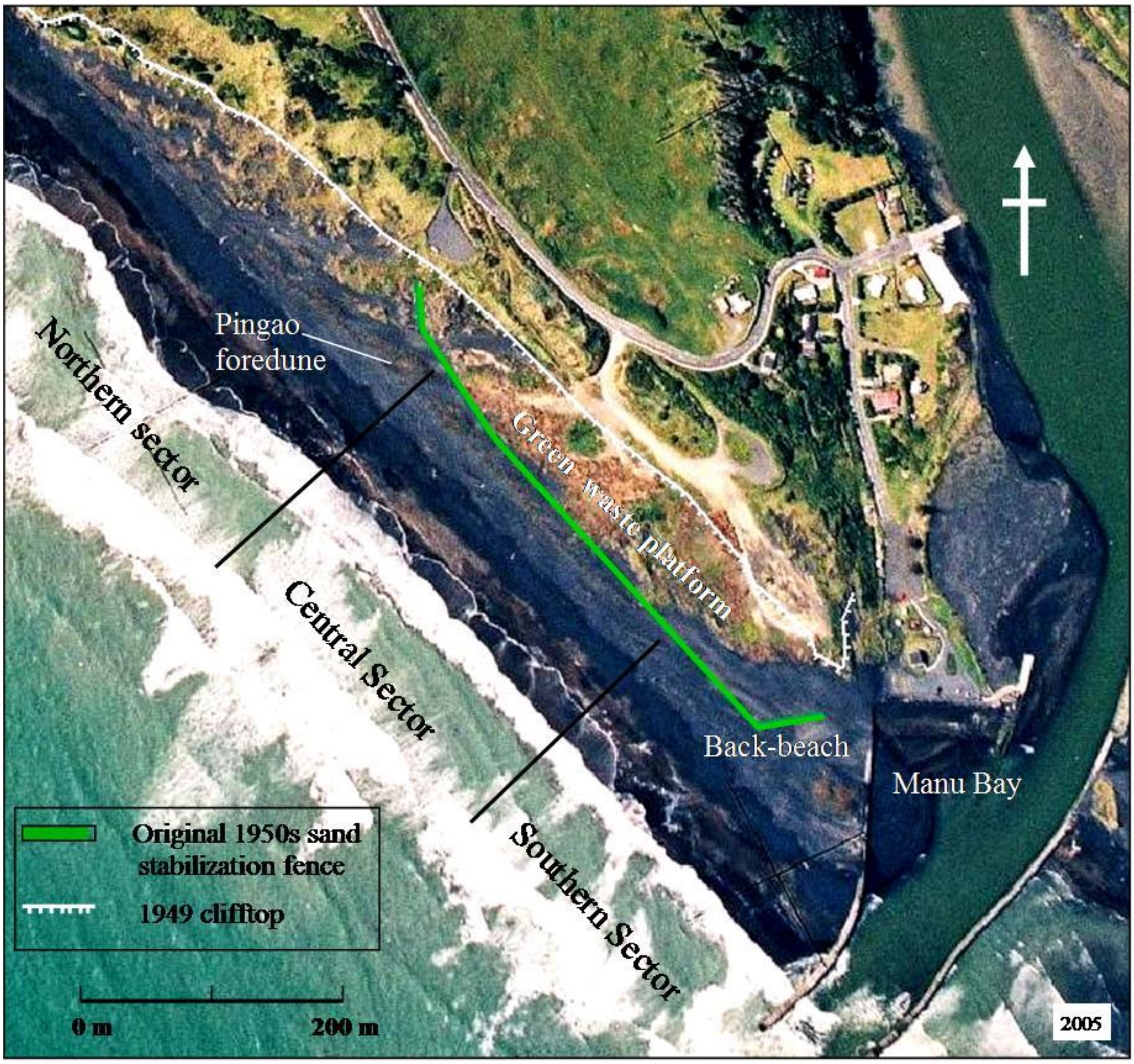

Figure 13 The 2005 vertical aerial photograph showing the three sectors of coast based on physical characteristics and management regimes. Several important physical features are marked.

Figure 14 This photo is taken of the central sector. On the seaward side is the pingao foredune. Note the green waste in the lower left, remnants of the wind-break used to shelter the pingao during its establishment. The slope up to the green waste platform is marked, along with the intervening swale.

Figure 15 Southern sector characterised by isolated pingao hummocks to seaward, and the broad back-beach. On the left hand side is the slope up to the green waste platform. Wind-blown sand transport pathways (arrowed) along the back-beach and into Mana Bay are inferred by the ripples on the lighter sand streaks—see Fig 9A for greater detail. The dashed line locates remnants of the original wind-break fence of the 1950s (see Fig 9A for detail).