PROCESSES OF COASTAL CHANGE; HIMATANGI TO PAEKAKARIKI

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ABSTRACT

Information is presented on shoreline movement and the causes of coastal change. The physical processes were identified and evaluated along with the influence of man's activities within the coastal system. Data collection included a surf observation programme to record wave data and establishing a beach profile survey network. An Excursion Distance technique analysed the survey data to assess future trends of beach change.

The coastal sediment system is considered to operate as a series of distinct but interrelated subsystems. The principal supplier is longshore transport derived predominantly from the inner continental shelf. Management for stability and hazard avoidance is recognised as essentially a matter of sound foredune maintenance.

INTRODUCTION

Coastal investigations were initiated by the Manawatu Catchment Board in 1982 to provide a study of the coastal processes operating from Paekakarlki to Himatangi. A location map is provided in figure 1. An emphasis was placed on resource management problems to ensure that the Board could formulate planning policies in the future. Information was required about the coastal system from a regional perspective in order for the Board to initiate policies under the 1941 Soil Conservation and Rivers Control and 1967 Water and Soil Conservation Acts. This information will provide technically competent and positive solutions to given problems which can be incorporated into district scheme and regional plan statements at local government level. I The aims of the investigation were to provide:-

1. Information on historical trends of shoreline movement.
2. An understanding of the causes of coastal change.
3. A monitoring network to measure beach change and assess future trends of coastal change.
4. Recommendations for coastal planning including general policy statements for future development and more specific recommendations for existing problem sites.

By accomplishing these aims the study will assist in the wise utilisation of the coastal land resource, and help to avoid the creation of coastal hazards.

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COASTAL DEVELOPMENT

In this investigation the main issue is one of identifying and evaluating the important physical coastal processes, and determining how existing and future development on the coast will influence them. Developments on the coast have taken place with little understanding of the physical forces operating within the coastal zone and the effect man's activities have on these processes and shoreline responses. Mistakes have been made by locating developments on 'hazardous' sites without due consideration for the long term stability of the coastline. These developments, and resulting attempts to protect them, have sometimes accentuated erosion problems.

A strong association has been established between land-use and coastal stability. Coastal problems that have arisen reflect land development practices and examples of this association are illustrated by the following land uses.

1. Waitarere forest

A striking contrast in progradation rates occurs between the forested and non-forested sections of coastline. The maintenance of the foredune by the Forest Service at Waitarere has prevented sand movement inland and encouraged coastal stability. It is estimated that approximately 80 ha has been gained from coastal accretion between the Waitarere lookout tower and the Manawatu River mouth over the past twenty years. This has enabled the Forest Service to advance seaward with their tree planting, converting the previous protective belt of trees into productive forestry.

2. Agricultural land-use

Non-forested sections of coastline which are predominantly backed by farmland have not received the same degree of management or financial support.

In many areas the foredune vegetation cover has been disrupted by man's activities. This has caused blow-outs and foredune instability. Sand blown inland contributes to land use problems, for example: sand migrating onto pasture; blocking drains; engulfing areas of forestry; and threatening settlements. These problems have been particularly severe north of the Manawatu River and to a lesser degree, between Hokio and Waikawa.

Sand loss from the coastal system has resulted in lower rates of progradation.

3. Urbanisation

With the exception of the Kapiti coastline the region has not experienced intensive urban development. Several, beach settlements have arisen and will continue to provide a focus for the future development anticipated along the coastline. These settlements provide access routes to beach amenities which concentrate the public use of the beach and foredunes, usually with detrimental effects on shoreline stability. The resulting disturbance of foredune vegetation has in some cases resulted in severe erosion problems requiring conservation measures. (e.g. North of Foxton Beach).

More intensive urbanisation has occurred along the Kapiti coastline, from Waikanae to Paekakariki. Initial land subdivision took place at Paekakariki in 1903, Raumati Beach in 1911 and Waikanae in 1923. Residential developments have since produced a string of seaside suburbs; the largest of which is Paraparaumu Beach.

Periods of urban development are considered to have initiated phases of shoreline erosion. Pronounced erosion has only been observed from 1930 (Donnelley 1954). Since the 1950's episodes of severe storm activity have been recorded and these have resulted in shoreline erosion along the Kapiti coast. Urban development has the associated effects of increasing drainage and runoff of fine sediments. This causes both higher water tables in sandy beaches and/6r clogging of beach pore spaces with fines. Both factors are conducive to beach erosion by creating impervious surfaces which increase the scouring effect of wave backwash.

More notable storm events in July 1954, October 1957, and September 1976, have initiated beach protection work. Following damage to the Raumati south seawall during 1980 the Kapiti Borough Council opted for a rock revetment protection scheme on the recommendation of their coastal consultants. Presently the Council requires further information on the effects of this form of hard-rock protection on the beach system, and seeks knowledge to develop a rational, predictive base for planning future coastal protection work.

It is concluded that all land-uses have significant patterns of interaction with the purely physical coastal sedimentation processes.

PHYSICAL COASTAL ENVIRONMENT

Recent geological events have provided the primary physical control on the coastal landform system. Dune building phases, supplied by massive amounts of sand, have dominated coastal evolution. Although the supply of sand has decreased, dune building continues under the influence of the prevailing west to northwest wind.

Since the formation of the geological character of the coastline, the shoreline has been evolving towards an equilibrium position and form in response to coastal processes on it.

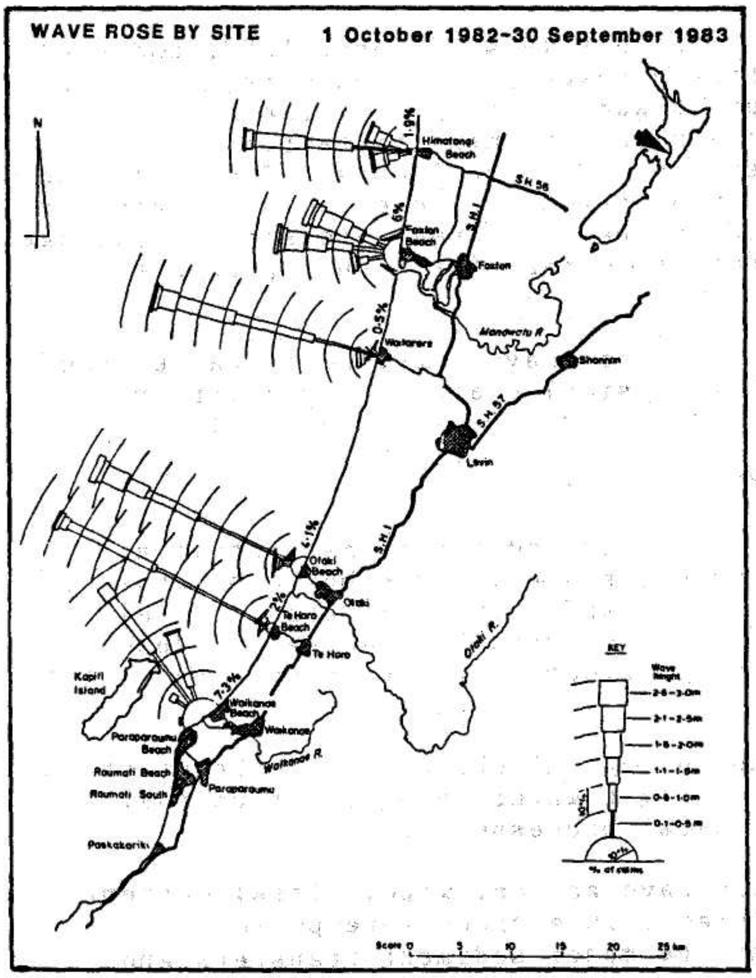
Processes variables include wave action; wind; tides; currents; and sediments. "These interact, in a process-response relationship, to determine the major sediment transfers and shoreline movements.

The most important processes in the coastal system concern wave action and the systems of nearshore circulation they create. Changes in wave height and period will result in sand moving onshore or offshore, while the angle of breaking waves to the shoreline usually determines the direction of the longshore component.

Sediment transport is continually adjusting in response to changing wave conditions and this results in a dynamic beach system. As sand is gained or lost the position and form of the shoreline Will fluctuate, programming or retreating accordingly, the steepening or flattening, *to* estimate the balance or imbalance of sediment transfers, the coastal sediment budget concept has been employed, This technique identifies the major sources, losses, and internal transfers of sediment in the coastal system. By determining their state of balance or imbalance, trends of coastal stability are established.

For these reasons much of the data collection summarised in the following sections has been aimed not just at the measurement of shoreline changes but also at preparation of sediment budget estimates.

1. Wave Climate



Detailed reporting on the wave climate was undertaken by a Surf Observation Programme at six localities: Himatangi; Foxton; Waitarere; Otaki; Te Horo; and Waitarere. Wave height and direction of approach are illustrated by the wave roses in figure 1. The results indicate a mixed wave climate, with locally generated storm waves and longer period swell originating from high energy storm centres to the west and southwest. These wave conditions indicate a high potential for sediment transport and although no longshore gradient in wave energy exists, the northern more exposed coastline has higher wave energies.

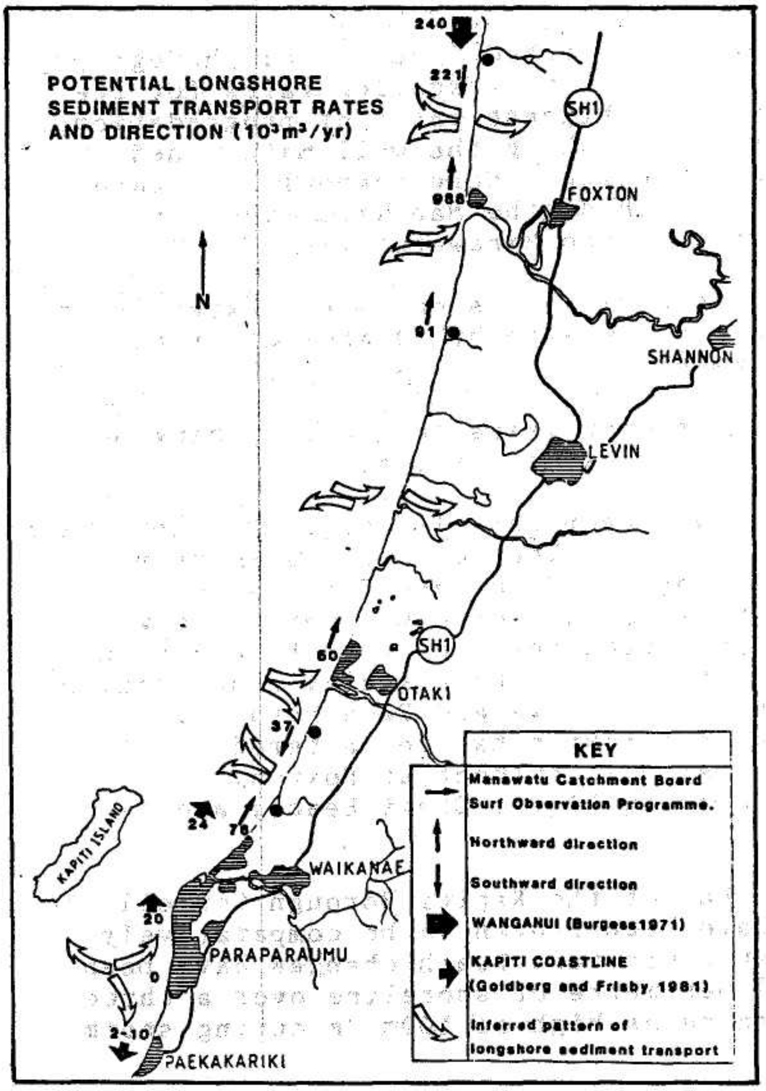
2. Wave Refraction

The process of wave refraction influences the distribution of wave energy along the coastline, setting up longshore currents responsible for sediment transport. Wave refraction occurs as an incoming wave approaches the coast at an angle, and attempts to bend (refract) to align itself with the offshore bathymetric contours. If the refraction process is incomplete the wave will break at an angle to the shoreline and initiate longshore sediment transport.

Wave refraction analysis for the Manawatu-Horowhenua coastline have identified four compartments possessing local wave and current regimes with distinct systems of sediment exchange and erosional status. These were:

A. North of the Manawatu River
B. Manawatu River to Waikanae
C. Waikanae to Paraparaumu
D. Paraparaumu to Paekakariki

3. Theoretical Longshore Sediment Transport



In addition to providing information on the wave climate, the surf observation programme data has been processed to calculate the potential longshore sediment transport, as presented in figure 2. The results have enabled a closer subdivision of the sediment transfers operating within the four broad compartments identified by wave refraction results. A total of eight sub-systems have been identified within the Manawatu-Horowhenua coastal region.

These were:

1. Himatangi to mid-way to Foxton.
2. Mid-way to Foxton to Manawatu River.
3. Manawatu River to Otaki
4. Otaki to South of Te Horo
5. South of Te Horo to Waikanae
6. Waikanae to Paraparaumu
7. Paraparaumu to Raumati South
8. Raumati South to Paekakariki

Although large transfers occur in both north and south directions, a net northward transport has resulted in five of the eight sub-systems.

4. Coastal Change

The existence of these sediment transport sub-systems and the interaction of mans activities in the coastal system have been reflected in the results of shoreline movement. These results show a coastline attempting to evolve towards an equilibrium position with progradation and dune development for most of its length.

Patterns of long term change established from aerial photography analysis have recorded a variety of progradation rates for the four sediment compartments. The highest rates of progradation, of up to 4.0m/year, were recorded along the well maintained foredunes of the Waitarere coastline. More commonly the rates range from 0.1 to 1.5m/year south of the Manawatu River and greater than l.0m/year, north of the Manawatu River.

Long term erosion, up to -O.43m/year, has only been experienced along the Kapiti coastline (in compartment D) and is strongly influenced by urban development.

These trends have altered in recent years reflecting changing patterns of land-use within the coastal system.

A series of beach profiles have been established to monitor beach volume changes on a regular basis, the beach survey improves upon the accuracy of the historical data base for assessing shoreline changes, and provides an on-going monitoring network. The Manawatu Catchment Board survey results over the eighteen months period of data collection have shown steady progradation at Himatangi, Waitarere, Hokio, Waikawa and Peka Peka. The coastline between Himatangi and Foxton has not alteced significantly and slight erosion is evident at Foxtoh; immediately south of the Manawatu River; Otaki Beach; and Te Horo.

From this survey data and that of the Kapiti Borough Council the short term beach changes have been proven to be comparatively large. On the Kapiti coast short term beach changes have been recorded at typically $50m^3$: per metre of shoreline over a three month survey period and can be as high as $100m^3/m$ during storm sequences. Along the Manawatu coastline short term changes are only known at six monthly intervals and range up to $25m^3/m$. These beach fluctuations during periods of erosional activity have a significant influence on the coastal sediment budget and on management of the coastal system.

An Excursion Distance technique has been developed to provide a means of monitoring and predicting beach change from survey data. The technique involves measuring the horizontal distance from a profile bench mark to each beach contour level at half metre vertical intervals, as a function of time.

The analysis is carried out by computer package programmed to firstly render individual profile excursion distances comparable by normalising the results. This standardising technique enables a comparison of results between sites.

Linear Regression is then carried out to obtain the best-fit estimate of the rate of change for a given contour. Correlation co-efficients are calculated for the results to determine the significance of the results. The results are plotted as Excursion Distance Graphs and enable the time gradient of each contour to be produced. This presents the rate of beach change upon which the future trends in shoreline movement are predicted.

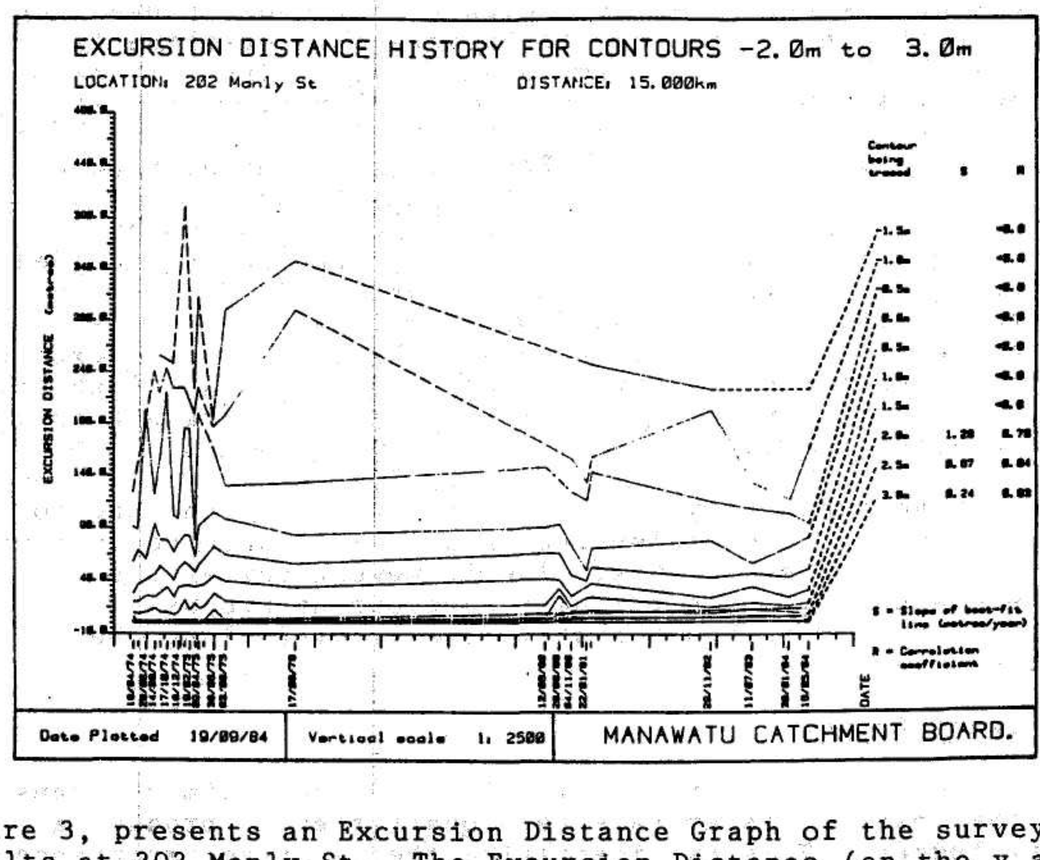


Figure 3, presents an Excursion Distance Graph of the survey results at 202 Manly St. The Excursion Distance (on the y axis), or distance measured from the bench mark to a given contour on the beach profile over time (on the x axis), is indicated by the straight lines on the graph. The corresponding contour levels are labelled to the right. The broken lines on the graph represents the slope of best fit or rate of beach change and are also expressed as rates of change in metres per year (s) to the right of the graph. This information will only appear on the graph if the data has a significant correlation coefficient, (R) that is, greater than 0.6, presented at the far right of the graph.

To interpret the data between survey intervals the negative sloping graphs indicate erosion, as the excursion distances shorten over time, and the positive slope indicate accretion of the beach. Converging lines indicate steepening beach slopes while diverging lines reflect a decrease in foreshore slope angle.

This example shows progradation trends between 1974 and 1984 for the 2.0, 2.5 and 3.0m contours.

Along the Kapiti coast, where up to ten years of survey records have been collected, this technique enables a comparison of survey information with the long term record of coastal change as established from aerial photographic analysis.

The Excursion Distance results indicate no trends in beach change along the northern section of the Paekakariki coastline in contrast with the long term erosional record. The QEII park coastline has shown a slightly erosional trend in contrast to low rates of progradation recorded in the long term. Survey profiles at Tiromoana and Takitimu Road (Raumati South) have shown erosion trends before protection work was carried out and no trends afterwards. This contrasts with the long term trends of progradation. Finally the Excursion Distance trends recorded at Wharemauku Road, Ocean Road/Marine Parade and 81 Manly Street (Paraparaumu) indicate progradation from 1974-84 which is consistent with the long term record. These trends are expected to continue under the present coastal conditions, although large changes in beach volume will occur in the short term due to storm erosion events.

The predictive capability of this technique will continue to improve as survey records lengthen and include data collection under a variety of sea-states. The framework now exists to make reliable evaluations of particular development proposals and structures within the beach system at any point along the coastline.

5. Sediment Budget

Based on the results of this investigation the sediment transfers within the coastal system have been quantified to produce a sediment budget. This has identified the relative importance of various elements in influencing coastal stability, and determines the erosional status of sections of shoreline.

The budget calculations have been presented according to the four sediment compartments operating within the coastal system.

In summarising the main points of the sediment budget analysis it must be recognised that the results are highly dependent on the accuracy of the data base. However, while many points of the budget analysis may be debateable, several points are well supported by the evidence presented in this report.

Firstly, no evidence exists for a single, unified, sustained southward sediment transportation. Instead the coast functions as a series of distinct but interrelated dynamic compartments. Each bears a different relationship between sediment supply and coastal stability especially dune stability.

Secondly, the principle supplier to any point on shore is longshore transport within a compartment. Supply to the longshore system must be derived predominantly from the inner continental shelf and inshore sea-bed as the rivers are presently supplying only a small proportion of the total quantities fed to the dunes. Most of the supply occurs from the sea-bed in Compartment B.

Thirdly, the short term beach changes are a high proportion of the budgets in any compartment, and therefore an important influence in dune supply. In this case, the budget has established compartments A, B and C in surplus and compartment D in deficit.

Finally, the long term future is considered to be for sea-bed supply to continue until an equilibrium shoreline is established, provided that dunes can form. If the sand is not trapped in dunes, for example permitted to blow inland and lost from the system, the onshore transport will be unable to keep pace and coastal erosion would result with corresponding adjustments to longshore transport regimes.

CONCLUSIONS

General recommendations have been made to provide planning guidelines which can be incorporated into existing planning structures. The recommendations are designed to avoid the creation of coastal hazards from ill-advised landuse while providing for the maximum use of the coastal land resources.

These are:

1. That the coastal sediment system be treated as a series of interrelated, dynamic compartments as identified in this report.

2. That management and planning be based firmly on the recognition of the interaction, demonstrated for both urban and rural areas, between land-use and coastal stability. Hazard zones should be identified and managed on this basis rather than on purely physical criteria.

3. That management for stability and hazard avoidance on the Manawatu-Horowhenua coast be recognised as essentially a matter of sound foredune maintenance, except at Te Horo-Otaki where the interrelationships with mining activities in the river are significant.

The prime purpose of foredune should be recognised as sand storers, and both coastal instability and inland sand transport hazards are direct functions of loss of foredune sand trapping efficiency.

Following these recommendations it is considered that development within the foredune area will impede the natural function of the system and should be avoided.

4. That monitoring of the Beach Survey Network and evaluation of this survey data by Excursion Distance Analysis be an ongoing feature of coastal management.

5. That a management plan be prepared, based on the information presented to this investigation, to provide a range of management alternatives.

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HOLLAND, ,L.D. (1985) "Processes of Coastal Change: Manawatu-Horowhenua". Manawatu Catchment Board and Regional Water Board Unpublished report No. 66, 192pp. Palmerston North.