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LATE QUATERNARY SEDIMENTARY PROCESSES AT OHIWA HARBOUR EASTERN BAY OF PLENTY WITH SPECIAL REFERENCE TO PROPERTY LOSS ON OHIWA SPIT

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LATE QUATERNARY SEDIMENTARY PROCESSES AT OHIWA HARBOUR, EASTERN BAY OF PLENTY WITH SPECIAL REFERENCE TO PROPERTY LOSS ON OHIWA SPIT

Jeremy G. Gibb, Water and Soil Division, Ministry of Works and Development.

ABSTRACT

Ohiwa Harbour represents a drowned river valley system enclosed by two sand spits. The valley system was drowned by the post-glacial rise in sea level between 6,500 and 18,000 years ago to form an embayment open to the wave-fetch of the Bay of Plenty. The bay existed from 2,000 to 6,500 years ago before being enclosed by Ohope and Ohiwa Spits to form Ohiwa Harbour. Over the last 2,000 years a net longshore drift eastward has resulted in Ohope exceeding Ohiwa Spit in length by a ratio of 8:1.

Sedimentation between 1878 and 1976 has reduced the tidal compartment within Ohiwa Harbour by about 36%, and decreased the cross-sectional area of the entrance from 3055 m^2 (1878) to 1950 m^2 (1976). Since 1867 the entrance has migrated 350 m eastward as a consequence of recession of Ohiwa Spit and extension of Ohope Spit. If this trend continues, then the entrance will reach the relatively stable Quaternary marine bench 700 m east. A tentative prediction based on historic recession rates for the life of Ohiwa Spit is given as 80 years, with a lower limit of 60 years and an upper limit of about 200 years.

Since 1886 the seaward shoreline of Ohope Spit has built out at 1.33 m/yr, whereas since 1867 the seaward shoreline of Ohiwa Spit has eroded at 1.28 m/yr. Sand eroded from Ohiwa Spit is mainly deposited within the harbour. The May 1960 Tsunami and the April 1968 "Wahine" storm-surge have accelerated spit recession at Ohiwa. All efforts to prevent erosion and recession by coastal protection have failed. Resettlement of residents elsewhere appears the only reasonable solution.

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CONTENTS

INTRODUCTION

Ohiwa Harbour is located in the eastern Bay of Plenty, North Island, New Zealand, between Whakatane and Opotiki, and lies approximately 10 km east by road from Whakatane. At high tide the harbour is 24 km^2 and it has a land catchment of 172 km^2. The harbour is enclosed by two sand spits with an entrance approximately 350 m wide at high tide. The western Ohope spit exceeds Ohiwa Spit in length by a ratio of 8:1.

Since 1850 Ohiwa Spit has undergone two stages of residential development, the first in the 1860s and the second in the 1950s. In both cases sections were offered for sale by the Crown after subdivision of Crown land by the Lands and Survey Department.

The first subdivision, named Ohiwa Township, was located within the harbour on the end of Ohiwa Spit. This was destroyed by erosion between 1878 and 1920. The second, situated on the open-coast part of the spit, is currently being destroyed by erosion processes. Three houses have fallen into the sea and a number have been moved to safer ground. Today residents are mainly old-age pensioners and holiday bach owners, the former having limited resources at their disposal for resettlement. By contrast Ohope Spit has a history of accretion.

This paper outlines the geologic history and processes of formation of the harbour and both spits, including an examination of historic shoreline changes and erosion processes. A prediction on the life of Ohiwa Spit is made also.

TERMINOLOGY AND METHODS

Terminology

Spit recession is a net decrease in spit length from base to tip, whereas spit extension is a net increase in length. Coastal erosion is a net decrease in spit width, whereas accretion is an increase in width. Both recession and erosion result from the removal of sand, whereas both accretion and extension result from the addition of sand.

Methods

To determine the geologic history and processes of formation of both spits, they have been investigated both in the field and from a study of old survey plans, air photos and reports.

During field investigations tephras (air-fall volcanic ash deposits) and sea rafted pumices were used to define ancient shorelines and determine the age of formation of both spits. On Ohope Spit sea-rafted Taupo pumice (AD 150), Kaharoa ash (AD 1050) and Tarawera ash (AD 1886) were found and mapped by Dr W.A. Pullar (pers. comm. 1976). These same ashes and pumices were identified during field work together with Loisels pumice (AD 1250) on Ohiwa Spit. Seven tephras have been identified in the Holocene coastal plain in the Whakatane district by Pullar and Selby (1971), dating from the Whakatane ash of 3330 B.C. With the assistance of air photos, ancient shorelines have been reconstructed in Fig. 1 by plotting the seaward extent of tephras, and the location of pumice beach ridges.

Historic shoreline changes at Ohiwa Harbour entrance and along Ohiwa Spit have been studied from old survey plans dating from 1867 (SO 2804) and air photos dating from 1945. These records were obtained by courtesy of the district Lands and Survey office Gisborne. Other survey plans compiled by the Poverty Bay Catchment Board, and Ministry of Works residency, Gisborne, have also been used.

Rates of spit erosion, accretion, and recession have been calculated from measuring differences in the plan position of shorelines. The prediction on the life-span of Ohiwa Spit has been based on a study of processes, and regression analyses of spit length plotted against time. Rates of harbour sedimentation have been calculated from survey data collected in 1878 and 1976, using a method described by Heath (1975).

GEOLOGIC HISTORY

At the height of the last major glaciation about 18,000 years ago, "Ohiwa Harbour" existed as a river valley system which was cut down to glacial sea level some 120 m below present day sea level. The post-glacial rise in sea level flooded the old valley system until sea level stabilsed at a level near to that of the present day about 6,500 years ago. Following sea level stabilisation the process of shoreline smoothing in the Bay of Plenty commenced.

The occurrence of sea-rafted Taupo pumice on both spits as the oldest time plane suggests that Ohope and Ohiwa Spits started forming about 2,000 years ago. This indicates that the present harbour must have been a bay open to the seas of the Bay of Plenty for about 4,500 years previously. The lack of any preserved beach ridges at the head of the harbour and the occurrence of peat deposits in the arms, suggests that tectonic subsidence has occurred obliterating evidence of shorelines formed when Ohiwa was a bay. Furthermore, the Whakatane Graben enclosing the Rangitaiki Plains 10 km west of Ohiwa, shows evidence of subsidence (Pullar *et. al.* 1971), at about 1.15mm/yr.

It is difficult to predict when a stable harbour entrance would have been established but it was probably within the last 500–1,000 years, and may have been located further west of the 1867 entrance (Fig. 3). The harbour entrance was formed by Ohiwa and Ohope Spits growing towards each other until an entrance channel in dynamic equilibrium with the tidal compartment was established.

The geological evolution of Ohiwa Harbour during the late Quaternary is shown in Fig. 1.

Spit Formation and Longshore Drift

Air photos show dune ridges on Ohope Spit with distinctive growth forms strongly implying growth of the spit from west to east (see Fig. 2). By contrast reworked limonitised gravels underlying sand at the end of Ohiwa Spit indicate construction of this spit from east to west. The gravels have been derived from erosion of a Quaternary marine terrace about 1 km to the east.

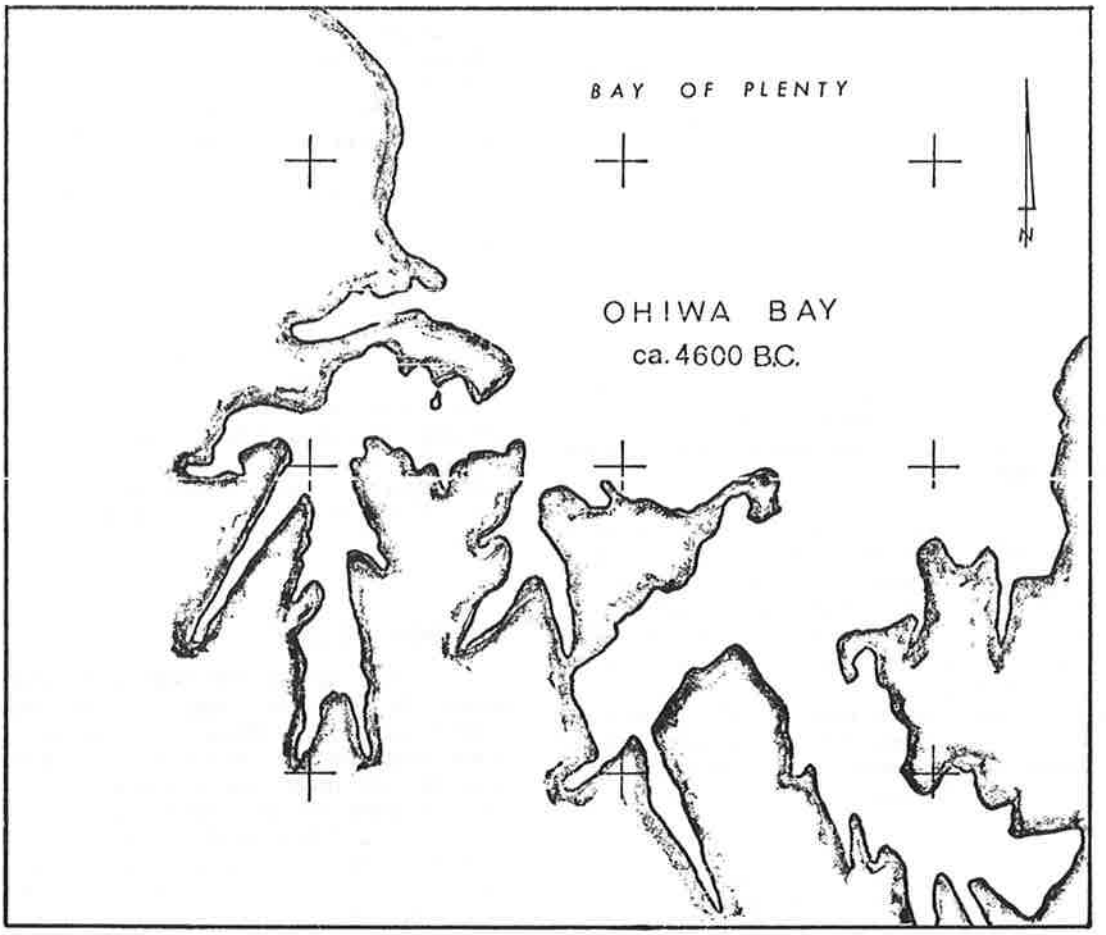

FIGURE 1 (a) "OHIWA BAY" following post glacial drowning of the Ohiwa river Valley system.

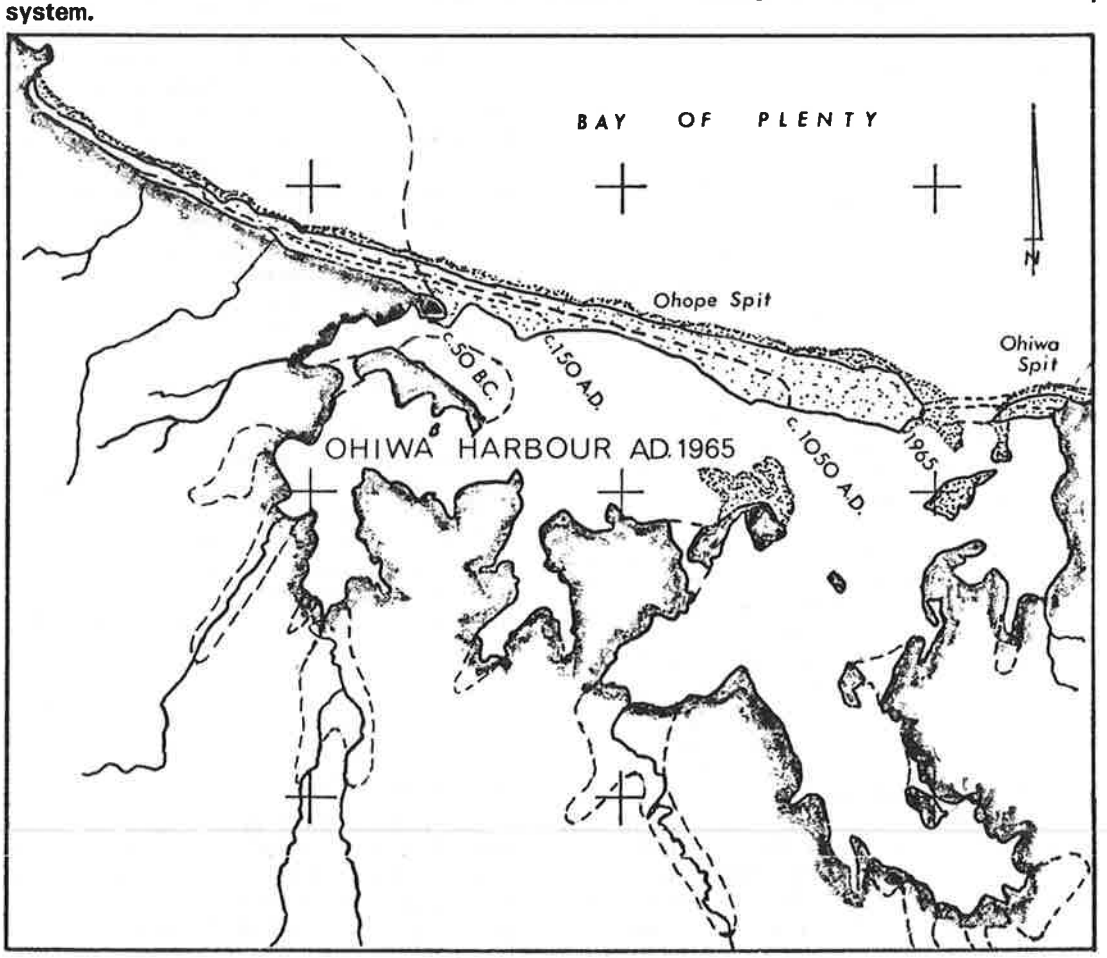

FIGURE 1 (b) The enclosure of the bay by Ohope and Ohiwa Spits to form Ohiwa harbour.

FIGURE 2. Vertical air photograph of Ohiwa Harbour entrance, taken 24 April 1974 (Photo SN 3580, 4524/21). Approximate scale is 1:24,000. Ohope Spit is on the left and Ohiwa on the right. Note the well defined dune ridges on Ohope Spit and the ebb tidal discharge from the harbour bearing against Ohiwa Spit. The photograph was taken by N.Z. Aerial Mapping, Hastings, and made available through courtesy of the Department of Lands and Survey.

Both Ohope and Ohiwa Spits are free-form sand spits of a type that are generally constructed by longshore drift (Zenkovitch, 1967). The existence of two opposing spits indicates an oscillatory longshore drift in this part of the Bay of Plenty. However the fact that Ohope now exceeds Ohiwa Spit in length by a ratio of 8:1 suggests a net longshore drift eastwards. The constant migration of the harbour entrance eastwards since 1878 also supports a net longshore drift in that direction as unstable entrances tend to migrate in the direction of predominant longshore drift (Bruun and Gerritsen, 1960).

Further evidence supporting a net longshore drift eastwards in the eastern Bay of Plenty is provided by driftwood rafted down the Waiaua River being deposited in substantial quantities along 1000 m of adjacent coastline east of the rivermouth, and along only 50 m of coast to the west. This river is located about 35 km east of Whakatane. Along the Rangitaiki Plains coast, Pullar and Selby (1971) suggest a net eastward longshore drift. The prevailing waves in the eastern Bay of Plenty, are from the NW to West quadrant (Mr D. Revington, Chief Engineer, Bay of Plenty Catchment Commission, pers. comm.) which would produce a net eastward longshore drift.

HISTORIC SHORELINES

Historic shorelines for both Ohope and Ohiwa Spits established from survey plans and air photographs are shown in Fig. 2. A list of survey plans and air photographs is given in Table 2 below. Several trends are shown for the harbour entrance and shorelines of both spits:

(a) Since 1867, the seaward shoreline of Ohiwa Spit has shown net erosion but several cycles of accretion and erosion have alternated in the last 110 years. The periodicity of these cycles is between 15 and 40 years.

(b) Since 1886 the seaward shoreline of Ohope Spit has undergone net accretion but some

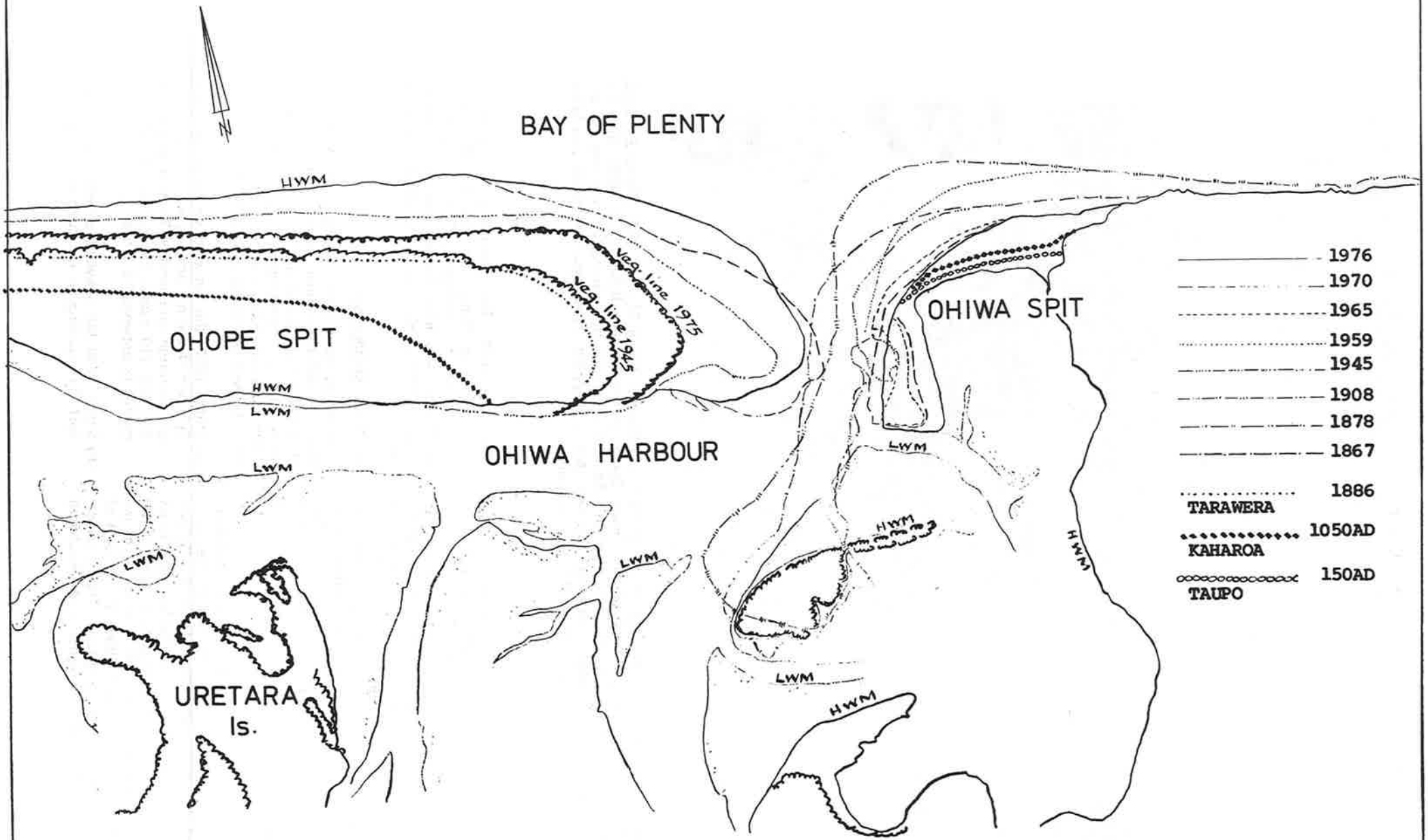

FIGURE 3. Historic Shoreline Changes 1867–1976 (after Gibb, 1976).

erosion has occurred along the harbour shoreline near the end of the spit.

(c) The harbour entrance has migrated steadily eastward since 1867, resulting in net recession of Ohiwa Spit and net extension of Ohope Spit.

Rates of Shoreline Movements

Rates of accretion (+) and erosion (−) have been determined along lines A–B and C–D shown on Fig. 4 for Ohope and Ohiwa Spits respectively. Values are given in Table 1 below. Rates have been calculated by measuring the distance from a stable reference point along the lines for both spits to MHWM, and then dividing this value by the survey time interval.

The values in Table 1 show that since 1867 Ohiwa Spit has lost 140 m width of shoreline by erosion at an average of 1.28 m/yr. Ohope Spit by contrast has gained 120 m width of shoreline since 1886 from accretion, at an average of 1.33 m/yr.

Rates of Entrance Migration

Rates of entrance migration have been established by measuring the length of Ohiwa Spit from each survey, and dividing this value by the time interval between surveys in decimal years. All measurements were made from a reference point at the base of the spit to the vegetation line along line E–F shown on Fig. 4a. Results are given in Table 2.

Values in Table 2 show that the harbour entrance has migrated 346 metres eastward since 1867, at an average of 3.15 m/yr. Since 1959 the recession of Ohiwa Spit has increased exponentially and now exceeds 10 m/yr.

The Entrance Channel

Two cross-sectional surveys have been made of the harbour entrance within the last 100 years, and are shown in Fig. 4b. The first was made on 27 June 1878 (SO 3065), and the second on 6 April 1976 (Freestone, 1976). The mid-tide cross-sectional area was measured on both surveys by planimeter.

The surveys show that the entrance has changed in shape, size and position over the last 100 years. Since 1878 the cross-sectional area of the entrance has decreased from 3.055 x 10^3 m^2 (1878), to 1.950 x 10^3 m^2 (1976). The shape has changed from two symmetrical channels about 12 m deep separated by a bank about 4 m high in the centre, to a single asymmetric channel about 13 m deep bearing against Ohiwa Spit. Ebb and flood tidal discharges in 1878 were probably directed evenly through the channel and not against one bank, whereas the asymmetric channel of 1976 indicates that flows are probably focussed against the eastern (Ohiwa) bank. The eastern bank in the 1976 survey is concave-upwards indicating erosion whereas the western side is convex-upwards indicating deposition. The scouring action of the tides is assisting mouth migration and subsequent recession of Ohiwa Spit.

Line	Time Span (Years)	Distance (Metres)	Rates (m/yr)	+ or −
Ohope Spit A–B	1050–1886 (836)	150	0.18	+
	1886–1945 (59)	50	0.85	+
	1945–1976 (31)	70	2.26	+
Ohiwa Spit C–D	1867–1908 (41)	185	4.51	+
	1908–1945 (37)	200	5.41	−
	1945–1959 (14)	75	5.36	+
	1959–1965 (6)	165	27.5	−
	1965–1970 (5)	25	5.0	−
	1970–1976 (6)	10	1.66	−

TABLE 1. Rates of shoreline accretion (+) and erosion (−) for Ohope and Ohiwa Spits.

Data Source	Survey Date	Spit Length (Metres)	Recession Rates (m/yr)
SO 2804	30. 3.1867	986	
SO 3065	27. 6.1878	925	5.43
SO 3077	26. 4.1909	920	0.16
Air photos	12.10.1945	800	3.29
SO 5159	30. 9.1959	775	1.29
Air photos	1965	740	6.09
Air photos	22. 2.1970	700	8.60
PBCB plan 2974	23. 9.1971	688	7.59
MWD survey	3.1976	640	10.71

TABLE 2. Rates of migration of Ohiwa Harbour entrance. SO plans and air photos were supplied by courtesy of Lands and Survey district office, Gisborne.

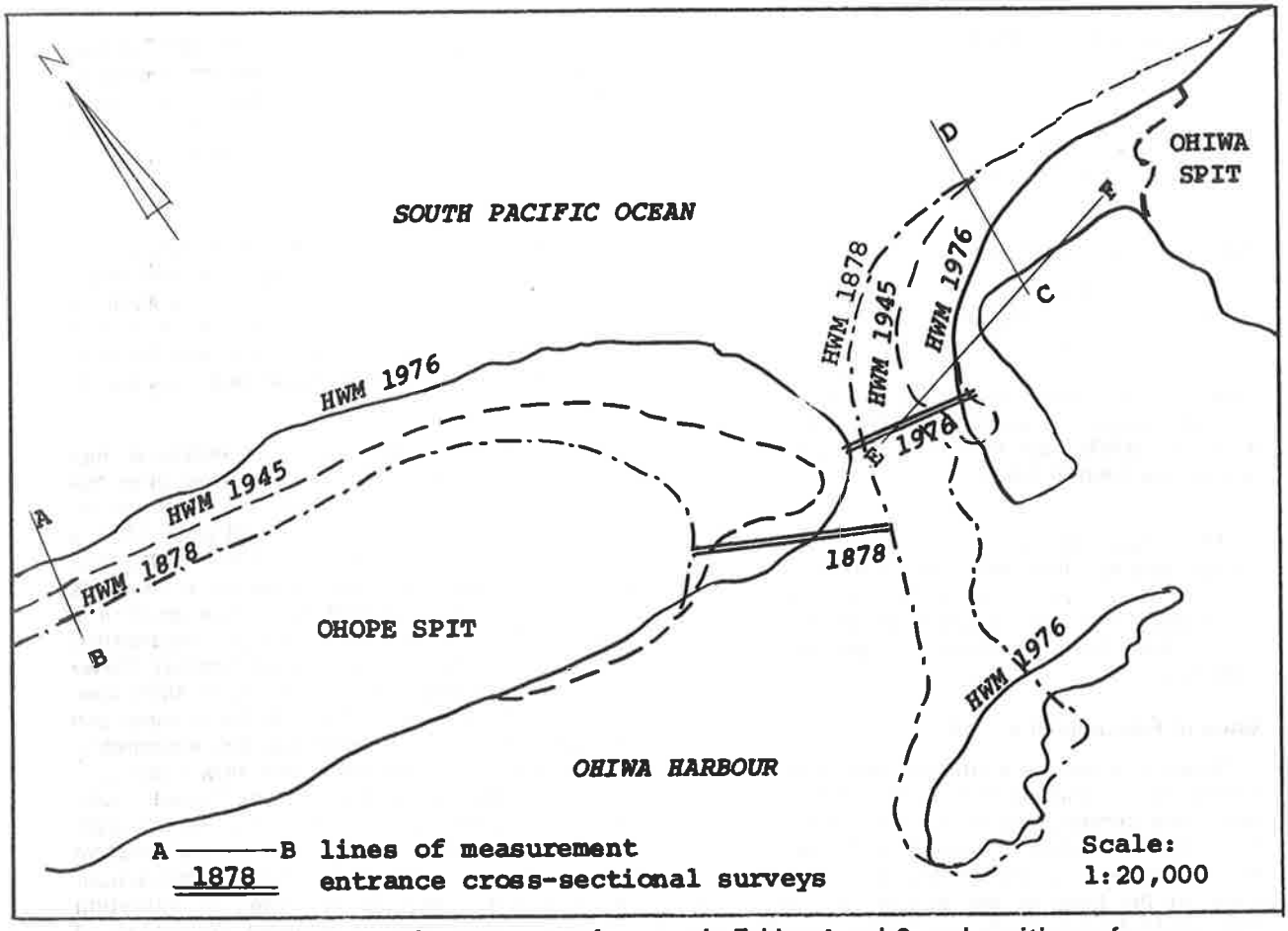

FIGURE 4 (a). Location of lines of measurement for rates in Tables 1 and 2, and positions of cross-sectional surveys in 1878 and 1976.

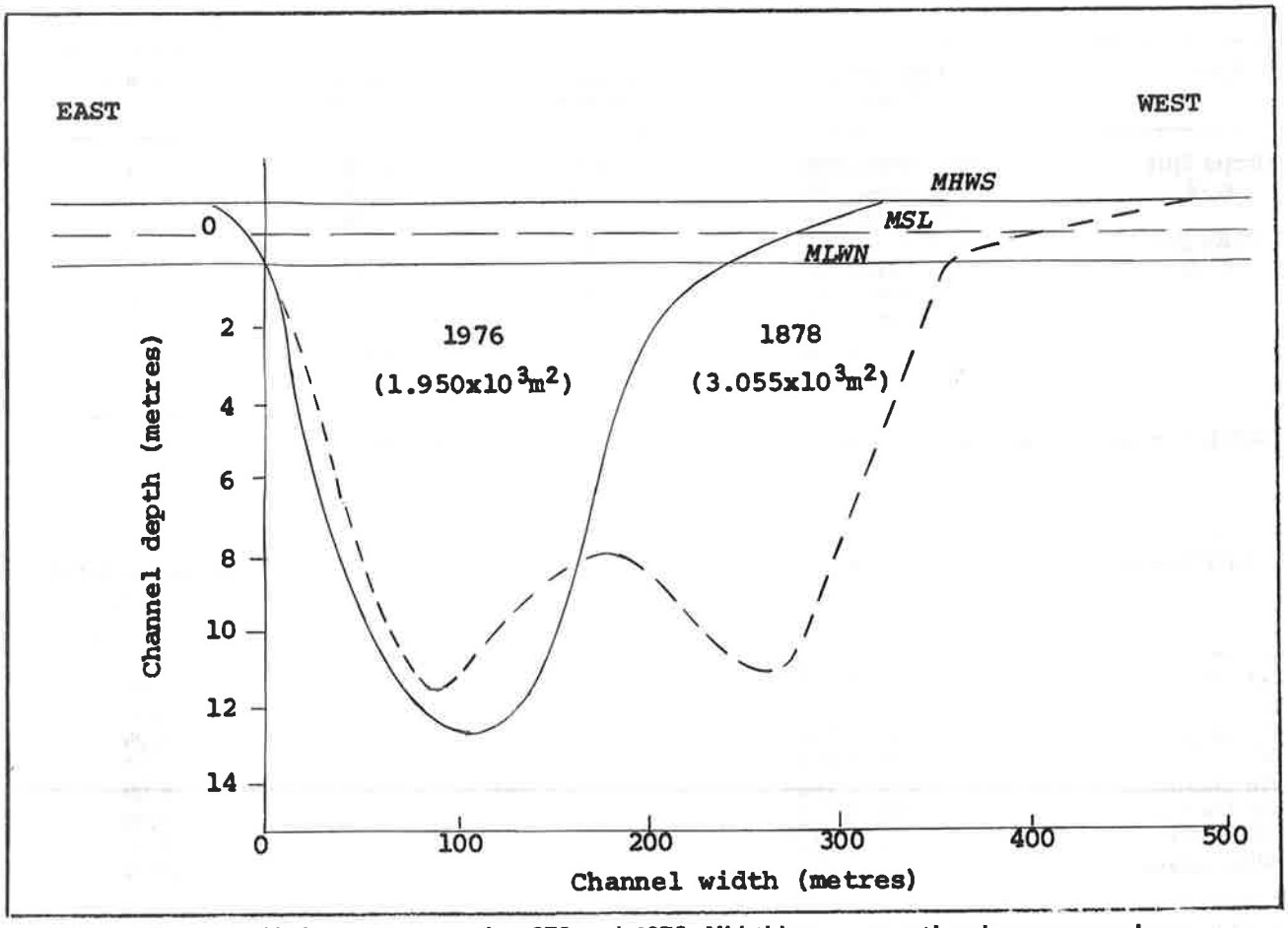

FIGURE 4 (b). Ohiwa Harbour entrances in 1878 and 1976. Mid-tide cross-sectional areas are shown in brackets.

SEDIMENTATION

There is indirect evidence that Ohiwa Harbour has been reduced in area and depth by deposition of sediments over the last century and more direct evidence for sedimentation on the seaward shoreline of Ohope Spit and periodically along Ohiwa Spit.

Harbour Sedimentation

Furkert (1947) found that the tidal compartment (α) (the volume of water entering the harbour during flood tide) and the entrance cross-sectional area (A) were simply related, with the parameters when plotted on logarithmic paper lying approximately on a straight line. Heath (1975) found that 16 New Zealand tidal inlets conformed to the same relationship, which gave:

$$\text{Log } \alpha = 0.98 \text{ Log } A + 4.21$$

$$\text{or, } \alpha = A^{0.98}\ 10^{4.21} \quad \text{...(Heath, 1975 p.451.)}$$

The equation established by Heath may be used to calculate the tidal compartment in 1878, given the parameters for 1976 and the entrance cross-sectional area for 1878.

Given: $A_{1976} = 1.950 \times 10^{3} m^{2}$

$A_{1878} = 3.055 \times 10^{3} m^{2}$

$\alpha_{1976} = 2.319 \times 10^{7} m^{3}$

Then: $\alpha_{1878} = 3.055^{0.98} \times 10^{4.21}$

$= 4.222 \times 10^{7} m^{3}$

As the 1976 parameters plot almost exactly on the straight line established by Heath (1975), the 1878 tidal compartment may be assumed to lie on the line also. If this assumption is correct then the percent reduction in the tidal compartment between 1878 and 1976 may be calculated as follows:

$$\frac{\alpha_{1976}}{\alpha_{1878}} = \left(\frac{1.950}{3.055}\right)^{0.98}$$

$$= 0.644$$

Therefore

Reduction = (1–0.644) x 100 = 35.6%

The tidal compartment in Ohiwa Harbour has been reduced by approximately 36% between 1878 and 1976. Sedimentation within the harbour from catchment erosion and littoral drift passing through the entrance, has probably caused this significant reduction over the last 100 years.

Beach Sediment Budget

A sediment budget for the open coast beaches of Ohope and Ohiwa Spits and the harbour bank connected to Ohiwa Spit has been calculated for the period from 1945 to 1970. A general trend of erosion has occurred along the Ohiwa coastline and accretion along the Ohope coastline during this 25 year period.

For convenience 2 km of coast along each spit was measured from the end of each spit. The harbour bank was measured separately as this did not represent the open coast beaches. Surface areas between the vegetation lines in 1945 and 1970 were measured by planimeter from aerial mosaics (1:10,000) compiled from air photos taken in 1945 and 1970. Volumes were calculated by multiplying each area by 1.8 m the estimated average height of the dunes above MHWM. Results are given in Table 3, including the net rate of erosion (–) and accretion (+) along each 2 km beach-length in $m^3/m/yr$ above MHWM.

Values in Table 3 show that the beach sediment budget for Ohope and Ohiwa coasts does not balance. During periods of erosion along the shoreface of Ohiwa Spit, sand has been observed to be transported along with other debris and deposited on the harbour bank attached to the spit. A trend of net growth of the bank supports this observation. However, this still leaves a net loss of 82600 m^3 of sand to be accounted for. A 36% decrease in the tidal compartment since 1878 suggests that part of this sand could have been deposited within the harbour. Equally, it could have been stored in the harbour channels and flushed seaward during ebb tides and deposited on the tip of Ohope Spit. If the latter condition prevailed, then this still leaves a balance of 312,100 m^3 of dunes along Ohope Spit to be accounted for. It is most likely that these dunes have been formed from sand transported by the net eastward longshore drift. This indicates that the main sources for sand are to the west. The rivers discharging from the Rangitaiki Plains would be likely sources.

EROSION PROCESSES

On-site observations of significant erosion events have been made by MWD personnel, local residents, the Poverty Bay Catchment Board and the Bay of Plenty Catchment Commission. The severity of erosion along Ohiwa Spit is shown in Fig. 5 during a bad storm in April 1976.

Location	Ohiwa Coast	Ohope Coast
	1945–1970	
	m^3	m^3
Harbour bank	+105400	
1st km	–141600	+226400
2nd km	– 46400	+168300
Net	– 82600	+394700
Net rate ($m^3/m/yr$)	– 3.8	+ 7.9

TABLE 3. Beach sediment budget from 1945 to 1970 for consecutive 2 km lengths of coastline along Ohope and Ohiwa Spits. The harbour bank adjoins Ohiwa Spit and is dry at high tide.

FIGURE 5. Ohiwa Spit looking west towards the entrance with Ohope in the background. Attack by heavy seas on 18–21 April 1976 caused severe erosion resulting in this house collapsing into the sea. Note the line of rails in the sea. These were placed along the dune toe in 1970 as coastal protection. Photo taken 21 April 1976 by R.K. Smith.

Waves

On 18–21 April 1976 heavy seas from the NNE coupled with equinoctial spring tides attacked the spit and a number of observations were made by MWD personnel (Smith, 1976). During this event, for three hours either side of high water sand was being actively eroded from Ohiwa Spit by heavy seas and carried into Ohiwa Harbour to be added in part to the bank attached to the spit. Sand was being transported by a westward longshore current generated by oblique wave attack from the NNE and assisted by a flooding tide. Breaking wave characteristics were:

T_b = 10 sec — Where; T = Breaking wave Period.

H_b = 2.0–2.5 m — H = Breaking wave Height.

Wave $\angle$ = 5–15° from NNE

Another significant factor recorded was a surf-beat of 1.5 to 2 minutes periodicity producing surges into the eroding toe of the foredune. The surf-beat was probably responsible for continual erosion of the dune for three hours either side of high water.

Storm-Surges and Tsunamis

Rates in Table 2 indicate a rapid increase in the recession of Ohiwa Spit between 1959 and 1976. It was during this period that the Tsunami of May 1960 generated by the Chilean earthquake and a storm-surge produced by the "Wahine" storm in April 1968 occurred.

Both the Tsunami of 23–29 May 1960 and the storm surge of 9–10 April 1968 were recorded on the tide gauge in Tauranga Harbour by the Bay of Plenty Harbour Board. The Bay of Plenty Catchment Commission also made level records of the latter event inside rivermouths along the coast.

In Tauranga Harbour the Tsunami superimposed tidal waves of 1–2 hour periodicity with an amplitude of 0.3–0.9 m upon the normal tidal curve. The tidal waves lasted from 23–25 May before levels steadily returned to normal on 29 May 1960. These same conditions were observed by Ohiwa residents within Ohiwa Harbour during this period and reportedly caused considerable changes to channel configurations and banks within the harbour.

Storm-surge heights generated by the "Wahine" storm at localities in the Bay of Plenty are listed from west to east in Table 4. Heavy seas accompanying the storm-surge threw debris and logs 5.0 m above MHWM at the Whakatane Heads and the Rangitaiki Rivermouth, and caused up to 30 m erosion along parts of the Bay of Plenty coastline over 2 days.

The 1960 Tsunami increased the tidal volume in Ohiwa Harbour between 3.04 and 4.48 x 10^7 m^3, and the "Wahine" storm of 1968 between 5.92 and 7.32 x 10^7 m^3. As the normal tidal compartment is about 2.32 x 10^7 m^3 (Freestone, 1976), the volume of water forced into the harbour was almost doubled at high tide by the Tsunami and tripled by the "Wahine" storm.

The effect on the harbour entrance, which is set between two sand spits, leaves little to the imagination. The tremendous volume of water escaping through the entrance during ebb tide would have caused massive scour, accelerating the eastward migration of the entrance. Rates in Table 2 show that the recession of Ohiwa Spit increased dramatically between 1959 and 1965 suggesting the 1960 Tsunami was a contributing

Locality	Surge Height (Metres)	Data Source
Tauranga Harbour Wharf	0.66	BOPHB
Mount Maunganui Wharf	1.14	BOPHB
Kaituna Rivermouth	1.37	BOPCC
Rangitaiki Rivermouth	2.07	BOPCC
Whakatane Heads	2.01	BOPCC
Ohiwa Harbour	1.5 to 2.1	Local residents

TABLE 4. Storm surge heights above MHWM from the "Wahine" storm of 9–10 April 1968. Bay of Plenty.

factor, and also between 1965 and 1970 suggesting that the "Wahine" storm of 1968 was also significant.

PREDICTIONS

The trend of migration of the harbour entrance eastwards and net erosion along the seaward shoreline of Ohiwa Spit over the last 110 years suggests that Ohiwa Spit will eventually be destroyed and that the harbour entrance will reach the relative stability of the Quaternary marine terrace about 700 m to the east.

An attempt at predicting the life of Ohiwa Spit has been made using rates given in Table 2. The past trend of spit recession has also been examined by plotting spit length against time in Fig. 6 and extending lines of best fit to the data to find the year when spit length is zero.

If the 1971–76 rate of spit recession of 10.71 m/yr is used, then the period of time to reduce the remaining 640 m length of spit to zero will be 60 years. If the 1867–1976 average of 3.15 m/yr is used then the time will be about 200 years.

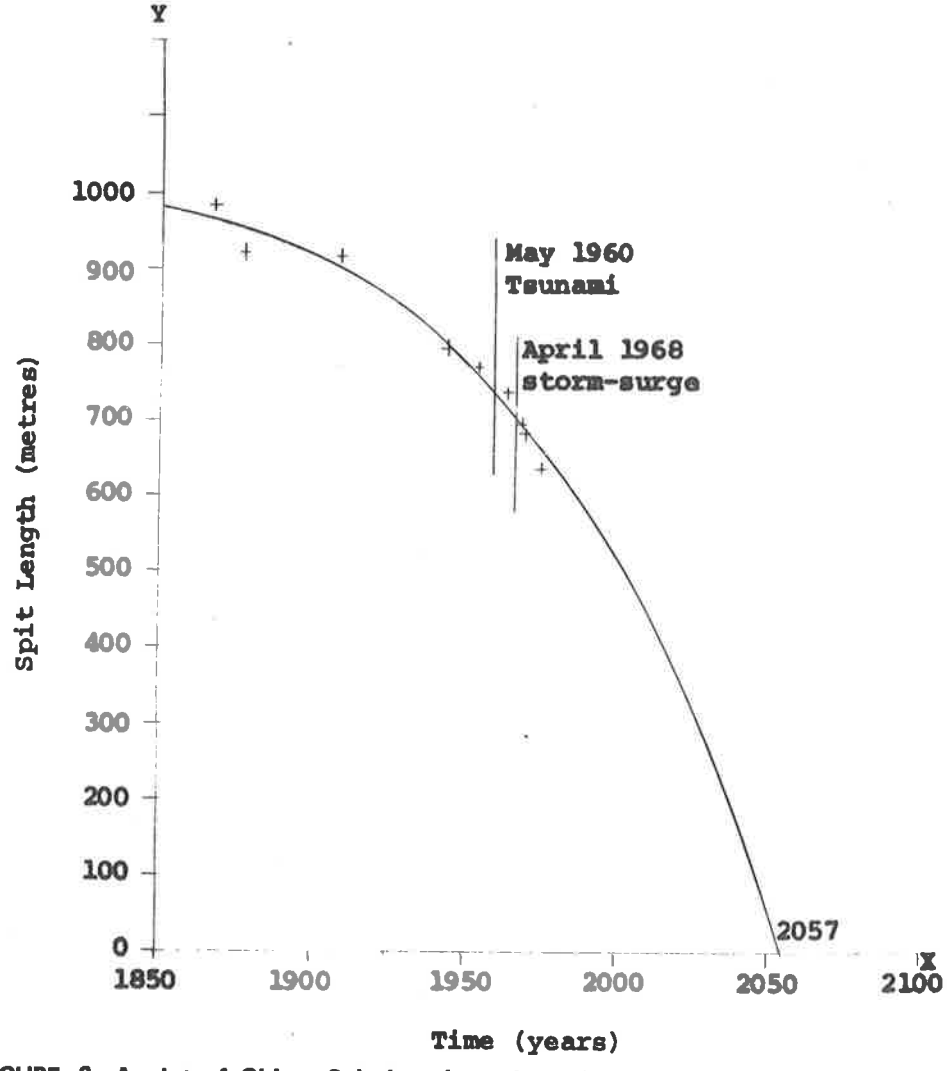

FIGURE 6. A plot of Ohiwa Spit length against time. The curve has been fitted to the 9 data points by cubic regression, and cuts the X axis at 2057 years. Values are from Table 2.

When analysing the past trend of recession, then it is obvious that the 1960 Tsunami and 1968 storm-surge have triggered a sustained increase in the rate of recession between 1959 and 1976. Taking this into consideration straight lines were fitted by eye to the data from 1867 to 1960 and from 1960 to 1976. When the latter was extended to cut the X axis in Fig. 6 a life of approximately 80 years was derived for the spit.

If regression analysis is carried out on the total data points in Fig. 6 then a curved line fitted by cubic regression follows the natural trend and provides the best fit. The curve, when extended, cuts the X axis in Fig. 6 at the year 2057 which also predicts a life of 80 years. Cubic regression provides an equation which is highly significant statistically, with a correlation coefficient of 0.99. The equation is:

$$L = 986.5 - 0.5824 \times 10^{-4}(Y-1800)^3$$

where L = spit length
Y = time in years.

Based on these methods a tentative prediction of 80 years is given for the life of Ohiwa Spit, with a lower limit of 60 years and an upper limit of about 200 years. If the rate of spit recession continues to accelerate then the life of Ohiwa Spit will be less than 60 years.

DISCUSSION

Observations indicate that changes at the harbour entrance and along shorelines of both spits are caused by a complex interaction of unusual events with the day to day action of wind, waves and tides.

Erosion Processes

The destruction of Ohiwa Spit is being effected by a combination of the eastward migration of the harbour entrance and net erosion along the seaward shoreline. The massive increase in the tidal volume produced by the 1960 Tsunami and 1968 storm-surge has accelerated erosion processes to a point where the life of Ohiwa Spit now appears limited.

Most of the sand that is eroded from Ohiwa Spit is deposited within the harbour and therefore is no longer available for rebuilding the shoreline under the normal beach erosion-accretion cycle. Ohope by contrast has tended to build in length and breadth owing to a net eastward littoral drift feeding the beaches. If the volume of littoral drift was reduced in any way by reductions in sediment input from the Rangitaiki Plains rivers, then the shoreline of Ohope Spit could revert to net erosion.

Most of the Ohiwa catchment has been stabilised by pasture and scrub so that sedimentation rates within the harbour from soil erosion will probably decline. It is possible, however, that sand is being deposited within the harbour close to the entrance from littoral drift moving through the entrance during flood tides. If this is so then the cross-sectional area of the entrance will continue to decrease with time which in itself could alter the rate of mouth migration eastwards.

During migration of the entrance, the seaward shoreline of Ohiwa Spit can be expected to move in and out as it has done in the past, but with an increasing possibility of breaching occurring as the present height of the foredune is lowered by coastal erosion. Breaching would accelerate the destruction of the spit and threaten houses on the harbour side.

Solutions

Harbour entrances have been stabilised in the past but at great cost: c.f. Westport, Greymouth, Wanganui. It is possible that a wall approximately 700 m long constructed from individual sheet piles as long as 30 m, along the east side of the entrance could arrest the migration of the mouth. The costs of such a structure, however, would far exceed the amount that could justifiably be spent on protecting the limited property assets at stake on Ohiwa Spit.

The car bodies that have been dumped in front of the eroding foredune since 1970 have been completely ineffective. Many have sunk into the sand within months of being dumped. They have made the beach unsightly and dangerous owing to smashed windscreens and sharp metal protruding from the sand.

The rail and brush protection work constructed by the Poverty Bay Catchment Board in 1969–70 has been outflanked by spit recession and now sits in the tide as a hazard to navigation.

It would appear that the only permanent solution for home owners is to resettle within the immediate future away from the eroding spit. Future development of any kind on Ohiwa Spit should be discouraged as the consequences will obviously be disastrous.

CONCLUSIONS

(1) The growth rate of Ohope Spit has exceeded that of Ohiwa by a ratio of 8:1 over the last 2000 years, due largely to a net longshore drift eastwards in the eastern Bay of Plenty.

(2) The recession of Ohiwa Spit was first recorded by survey plans in 1867 and 1878, and has continued intermittently since that time. Tentative predictions suggest that the spit could be destroyed in 80 years from today with upper and lower limits of 200 and 60 years.

(3) The storm-surge of 9–10 April 1968, and the Tsunami of 23–29 May 1960 have accelerated the destruction of Ohiwa Spit by increasing scour along the eastern bank of the entrance.

(4) The entrance will continue migrating eastwards until it is hard up against the Quaternary marine terrace 700 m to the east.

(5) Alternating accretion and erosion of the seaward shoreline of Ohiwa Spit can be

expected during spit recession with the likelihood of breaching occurring which will accelerate the rate of destruction.

(6) The tidal compartment in Ohiwa Harbour has been reduced by approximately 36% between 1878 and 1976 by sedimentation within the harbour.

(7) Most of the sand eroded from the seaward shoreline of Ohiwa Spit has been deposited on the harbour bank attached to the spit. The remainder has either been deposited within Ohiwa Harbour or on the end of Ohope Spit.

(8) Ohope Spit has probably received most of its sand from the rivers discharging from the Rangitaiki Plains, the sediment having been transported by a net eastward longshore drift.

(9) Although it may be possible to stabilise Ohiwa Harbour entrance the project is too uncertain and expensive to be justified.

(10) No residential development should be permitted on Ohiwa Spit.

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