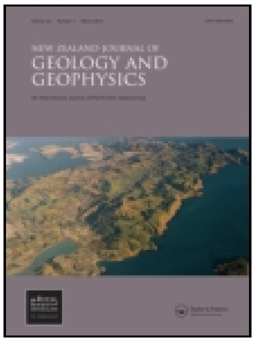

Taylor & Francis
Taylor & Francis Group

New Zealand Journal of Geology and Geophysics

ISSN: 0028-8306 (Print) 1175-8791 (Online) Journal homepage: http://www.tandfonline.com/loi/tnzg20

Seasonal variation in volume and morphology of some western Taranaki beaches

E. R. Matthews

To cite this article: E. R. Matthews (1979) Seasonal variation in volume and morphology of some western Taranaki beaches, New Zealand Journal of Geology and Geophysics, 22:4, 465-472, DOI: 10.1080/00288306.1979.10424154

To link to this article: http://dx.doi.org/10.1080/00288306.1979.10424154

Published online: 06 Feb 2012.

N.Z. Journal of Geology and Geophysics Vol. 22, No. 4 (1979): 465–72

Seasonal variation in volume and morphology of some western Taranaki beaches

E. R. MATTHEWS

*Geology Department, University of Auckland, Auckland, New Zealand**

ABSTRACT

Five beaches (Oakura, Werekino, Harriet, Oaonui, and Okaweu) in western Taranaki were monitored for 15 months and were found to display seasonal variation in beach volume and morphology. This variation may be related to cyclicity in the wave climate and is more pronounced on beaches facing directly into the prevalent swell direction.

INTRODUCTION

Previous studies of beach processes in New Zealand have described the sand and mixed sand/gravel beaches of the east coast of the South Island (McLean 1976). Some of these studies have revealed weak seasonality (e.g., Burgess 1968; Kirk 1969; Dingwall 1974), but a detailed study by Harray & Healy (1978) in the Bay of Plenty (on the east coast of the North Island) demonstrated clearly the lack of any seasonality there. However, profiles surveyed at monthly intervals over three years at three beaches further north, in Hauraki Gulf, revealed some seasonality in beach volume (Schofield 1975).

Few studies have been carried out on the west coast of either island and these have not revealed any seasonal variation in beach morphology, e.g., Mangin (1973) in the southern Karamea Bight, Gibbard (1972) on the west Wellington coast, and Delgrosso (1971) on Auckland's west coast. These studies were based on a survey period of less than one year. Gibb (1978) analysed beach profile data collected over 18 months from Wellington's west coast and found that the beaches responded to particular storm/post-storm events that did not display seasonal variation. The only suggestion of seasonality in either wave climate or beach morphology on the west coast was made by Burgess (1971), who analysed 14 months of measured wave records from Castlecliff, near Wanganui, and found that although there was no clear seasonal difference in wave height, December to March was the period of mildest wave conditions.

The present study, derived from my M.Sc. thesis (Matthews 1977), is based on a longer period of data collection (15 months) than most previous west coast studies. It shows that a weak seasonality does occur on beaches of Taranaki Peninsula (see Fig. 6).

GEOLOGICAL SETTING

Taranaki Peninsula (Fig. 1) is a ringplain surrounding the volcanic centres of Egmont, Pouakai, and Kaitake. It comprises lahar flows, up to several metres thick, containing andesite pebbles and boulders with wood fragments and lumps of peat. Tephras and water-laid sands and gravels also occur. At the coast the onshore ringplain terminates in low cliffs generally less than 10 m high, but up to 40 m high between Oakura and New Plymouth. In cutting these cliffs the sea has left a residual mantle of andesitic boulders extending 5–10 km offshore to depths of 50–75 m (McDougall & Brodie 1967). Where boulder reefs (perhaps remnants of lahar mounds similar to those seen inland) provide protection, shallow accumulations of sand may form beaches, occasionally extending below low tide level. Sidescan sonar records held by Shell, BP, and Todd Oil Services Ltd show that offshore from Oaonui beach there is a sand salient extending more than 1 km seawards to about 10 m depth. Other sandy beaches along the coast probably have similar offshore extensions.

WAVES

Wave Data

Offshore wave data were available from two sources: (1) a waverider buoy installed by Shell, BP, and Todd at Maui-A Tower in 110 m of water (Fig. 1), and (2) ship reports of wave conditions collected by N.Z. Meteorological Service. The waverider buoy records provide data on wave height and period, but not, unfortunately, direction. The available records (August 1976–December 1977) do not cover the entire study period, and ship reports of wave data, in which swell direction was recorded, were used in addition to the waverider buoy records so that the entire study period could be covered. The chief disadvantage of the ship reports is that the wave characters recorded are visual estimates, which introduce a significant operator bias. This has been reduced by averaging the several daily observations made in a relatively large area between 37·0° S–40·7° S and 170·0° N–174·7° N (Fig. 1). An average of 3·8 swell observations were made each day in 1976.

Wave Climate

A recent summary of the wave climate around New Zealand (Pickrill & Mitchell in press) shows that the west coast wave climate is a mixture of locally generated storm waves and longer period swell generated by

Received 23 February 1979, revised 26 March 1979

*Present address: N.Z. Oceanographic Institute, DSIR, Wellington, New Zealand

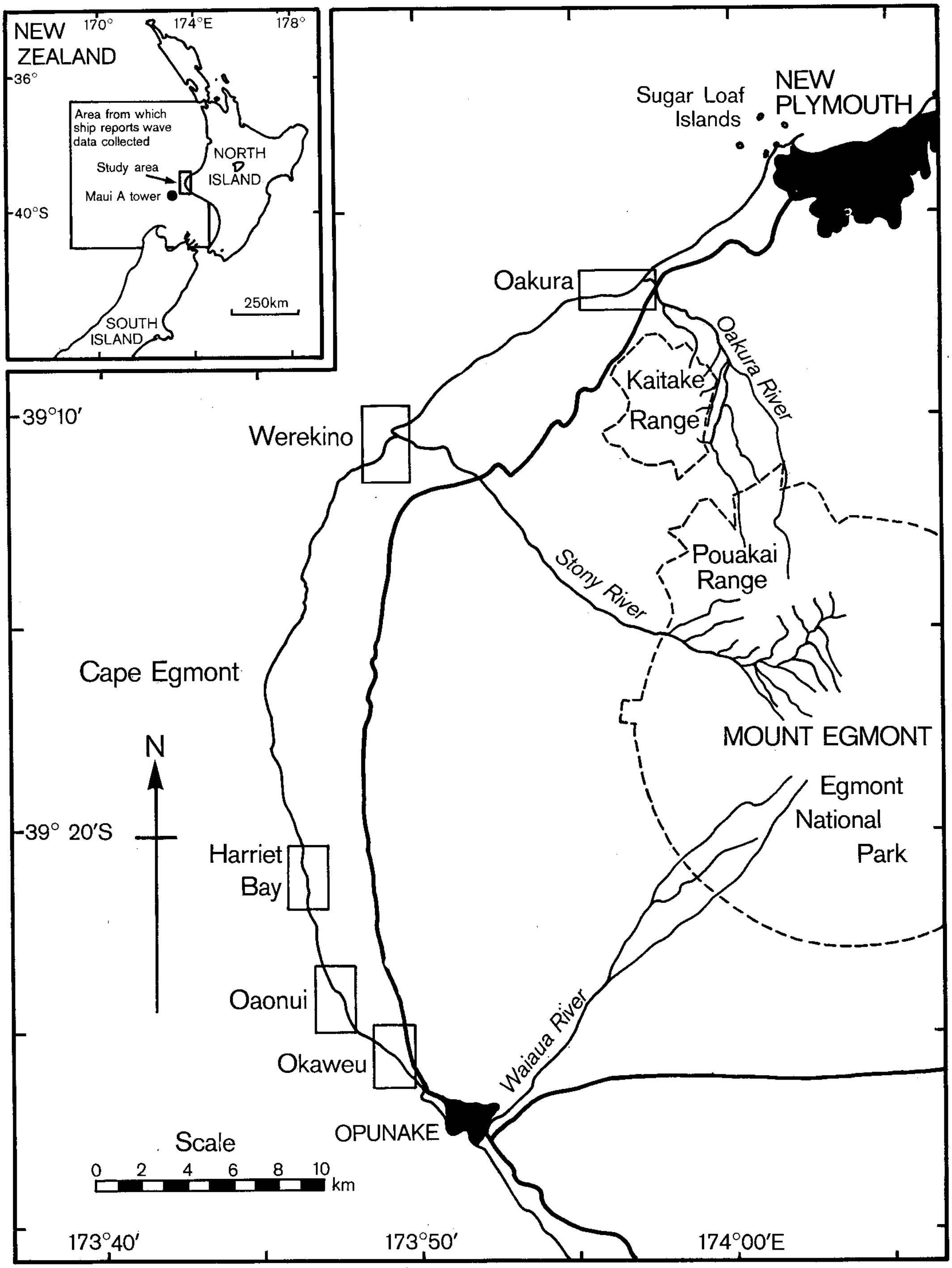

FIG. 1—Location map of the beaches studied in Western Taranaki. *Inset*—Position of Maui-A Tower, and the area from which N.Z. Meteorological Service ship reports of wave data were used.

storms to the south. Pickrill & Mitchell found that ". . . the dominant deep-water wave is south-westerly through to westerly, 1·0–3·0 m high, with a 6–8 s period".

Analysis of the wave data used in the present study confirms these results. The mean wave height for the total sea (recorded by waverider buoy) is 2·67 m, whereas the mean swell height (from ship reports) is 2·19 m. The difference is probably due to the influence of locally generated waves (waves with periods of less than 5 s) which have a mean height of 1·19 m (Fig. 2). The wave period data can be interpreted in a similar manner; the mean period for the total area (6·19 s) lies between the mean swell period (8·11 s) and the mean wave period (3·20 s). The swell period is reduced by inclusion of the shorter wave periods

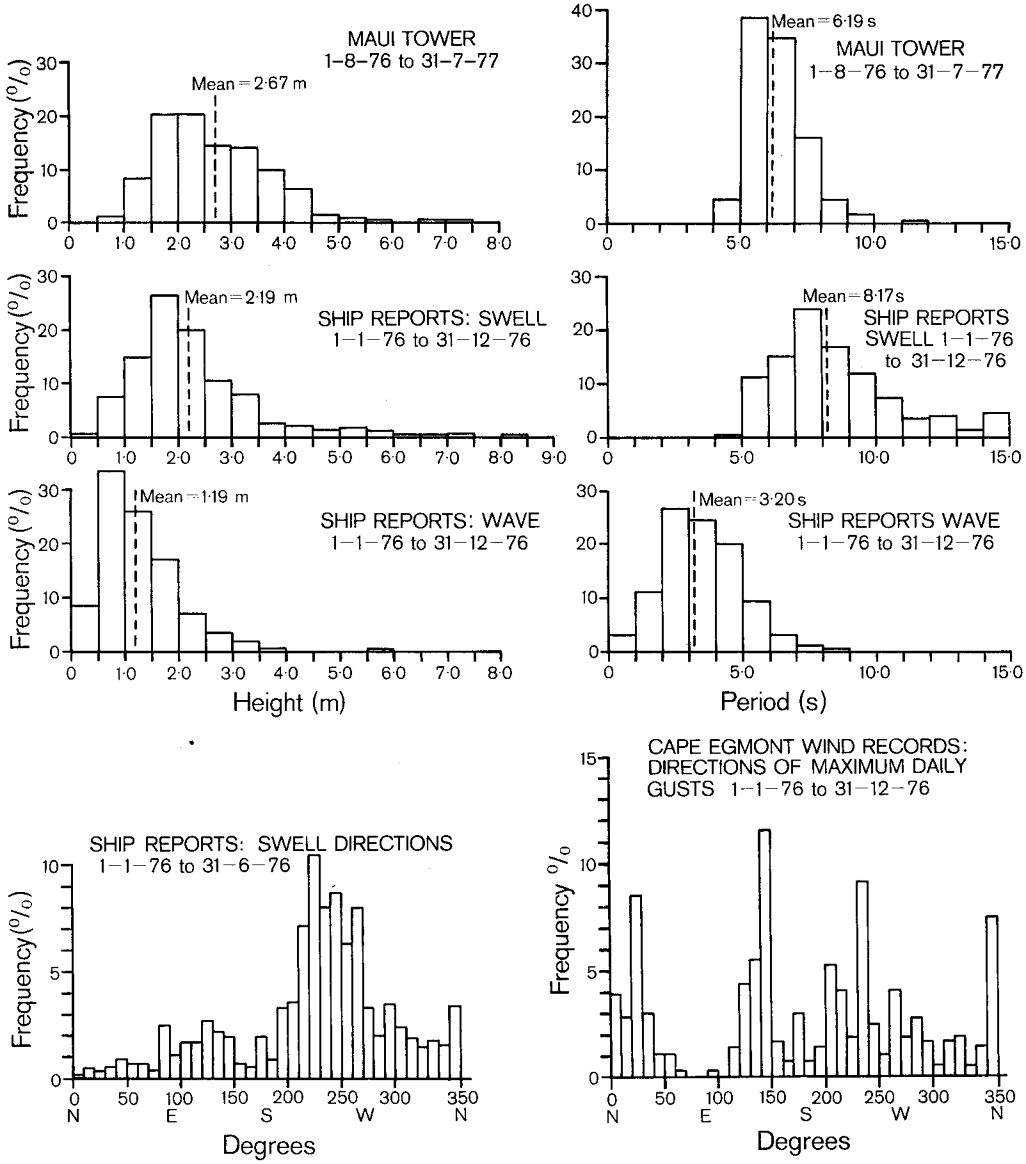

FIG. 2—Wave climate of the Taranaki shelf: frequency distributions of average daily wave height and average daily wave period derived from waverider buoy records at Maui-A Tower and from N.Z. Meteorological Service ship reports in the area 37·0°S to 40·7°S, 170·0°N to 174·7°N (Fig. 1). Frequency distribution of swell direction was calculated from all observations in the ship reports data; frequency distribution of maximum daily wind directions at Cape Egmont derived from N.Z. Meteorological Service weather reports, presented because the direction of locally generated waves parallels the direction of local winds.

when the two are measured together as at Maui-A Tower.

From the ship reports data summarised in Fig. 2, it can be seen that swell arrives predominantly from the south-west. There are no direct observations on the directions of locally generated waves, but it is inferred that these are closely related to wind direction. A plot of the frequencies of directions of maximum daily gusts at Cape Egmont shows that despite orographic effects no one wind direction is prevalent. It is therefore probable that locally generated waves also have no prevalent direction.

Seasonal Variation in Wave Energy

It was shown in the introduction that there are no strong seasonal cycles in the wave climate. Indeed, Pickrill & Mitchell (in press) found that short period rhythmic fluctuations associated with the passage of weather systems across the country were more important. However, it is known that during late summer and early autumn, anticyclones moving eastwards from Australia over New Zealand pass further south than at other times of the year (Garnier 1958) so that one might expect some slight seasonality to exist. Such seasonality would not necessarily be obvious in simple wave height data. However, if wave energy is calculated from the wave height data, any differences will be emphasised (Fig. 3). According to linear wave theory

$$E = 1/8 \, \rho \, g \, H^2$$

where E = wave energy (J/m^2 of sea surface), ρ = density of water (taken to be $1{\cdot}0265\ g/cm^3$), g = acceleration of gravity ($9{\cdot}81\ m/s^2$), and H = wave height (m).

Short-period fluctuations in wave energy related to individual storm events can occur at almost any time. However, during February and March of both years, wave energy was always at a low level; calm periods occurred in other months, but were not as prolonged as in February and March, nor were they repeated in both years. From wave data collected at Wanganui, Burgess (1971) observed that the period of mildest conditions was from December to March. This distinction between late summer–early autumn and the rest of the year would become more obvious if the distribution of wave energies throughout the year were calculated.

BEACHES

Description

The beaches studied are composed of sand derived from lahar and ash deposits of the ringplain. Andesite rock fragments are the dominant constituent, often comprising more than half of the sand. Plagioclase feldspar and augite are next in importance, with titanomagnetite and hornblende in generally smaller, but widely varying, amounts. Skeletal carbonate grains are a minor constituent.

Gow (1967) studied the mineralogy of beach sands at Hawera, not far south of the present study area. He found that heavy minerals (titanomagnetite, augite, and hornblende) are concentrated on the upper part of the beach by swash action. The same phenomenon was observed in the course of the present study. It was also found that the mean grain size of the sand is largely controlled by the heavy mineral content (Fig. 4). At Werekino, Harriet, and Okaweu the texture of sediments low on the beach is affected by the presence of gravel modes which are presumably derived from the adjacent inter- and sub-tidal boulder mantle.

Tidal range at New Plymouth varies between 3·1 m (during spring tides) and 1·7 m (during neap tides). This tide is semi-diurnal and hardly varies over the coast are less than those between predicted and ob- study area; differences in time and height around the served tides.

The height of the beach face above chart datum at Port Taranaki ranges between five and six metres at each of the beaches studied. The gradient, ranging from 2° to 8°, is at least partly controlled by the grain size of the sediment (Fig. 5). All beaches are backed by small semi-fixed dune fields except at Oakura where these dunes have been levelled to accommodate urban development.

Beach Profile Surveys

In February 1976 one profile was established at each of the Oakura, Werekino, Harriet, Oaonui, and Okaweu Beaches (Fig. 1). These were resurveyed at three-month intervals until February 1977 when three or four additional profiles at each beach were established. During January–February 1977 all profiles were surveyed four times at weekly intervals, and in May 1977 they were all surveyed once more. The monitoring of profiles at Oaonui and Oakura was continued and they are still being resurveyed at three-month intervals as part of Maui Environmental Study Phase II which is being undertaken by The University of Auckland.

Profiles were surveyed using plane table, alidade, stadia rod, and tape, measuring from a fixed reference at the top of each profile. Repeated surveys showed this method to be accurate to within ±5 cm vertical distance over a horizontal distance of 60 m.

Volumetric Changes

Areas of change between initial and subsequent profiles were measured, and the volume changes contained in a one-metre-wide strip of beach were calculated (Fig. 6). In May, August, and November the beaches lost material, whereas accretion occurred in January and February.

Morphologic Changes

Time-space contour maps (Fig. 7) were drawn from the series of profiles surveyed during 1976 and 1977. The general trend is for the construction of a wide flat berm at the top of the beach with an associated steep beach face in January and February. During winter (May and August), and also in November, the berm retreated while the lower beach prograded, so that the beaches became more evenly graded and planar. The maps for the profiles at Oaonui and Okaweu show these trends particularly well. These beaches, facing

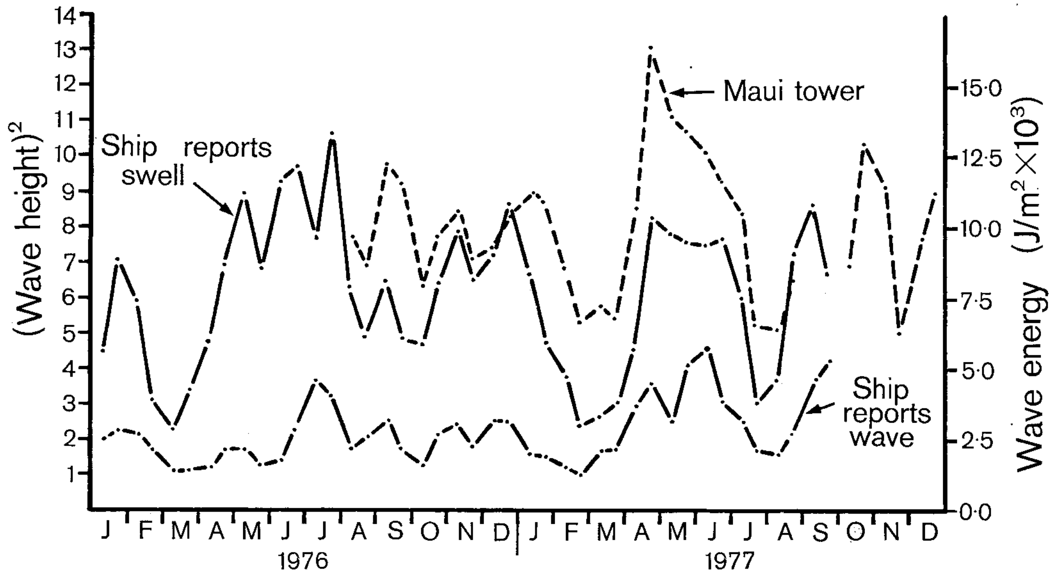

FIG. 3—Seasonal variation in wave energy on the Taranaki shelf 1976–77. Daily values of wave energy calculated from average daily wave height data in Fig. 2. Curve is smoothed by calculating a running mean twice each month on a one-month base.

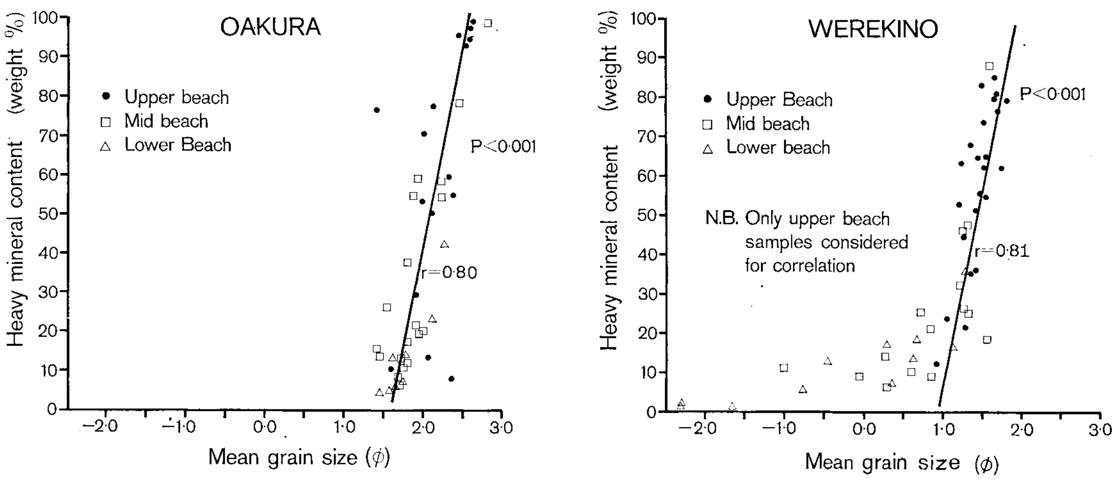

FIG. 4—Relationship between mean grain size and heavy mineral content at Oakura and Werekino beaches. At Werekino only samples from the upper beach were used to calculate the correlation coefficient. Grain size of samples from middle and lower parts of this beach is influenced by coarser gravel modes.

directly into the prevalent direction of incoming energy, show the effects of seasonal variation in wave energy more clearly than the other beaches to the north.

DISCUSSION

It has been inferred above that the variation in wave energy causes the variation in beach morphology. In testing this hypothesis it was found that the correlation between mean intersurvey wave energy and beach gradient or volume (both were tested) at Oaonui is not significant. Since the length of the intersurvey period could be the cause of this poor correlation, the mean wave energy for the two weeks preceding the survey was used instead of the mean for the full intersurvey period. The resulting correlation was still not significant.

These poor correlations may be partly due to insufficient data points (only eight), but probably also to the influence of other factors. Certainly wave energy is

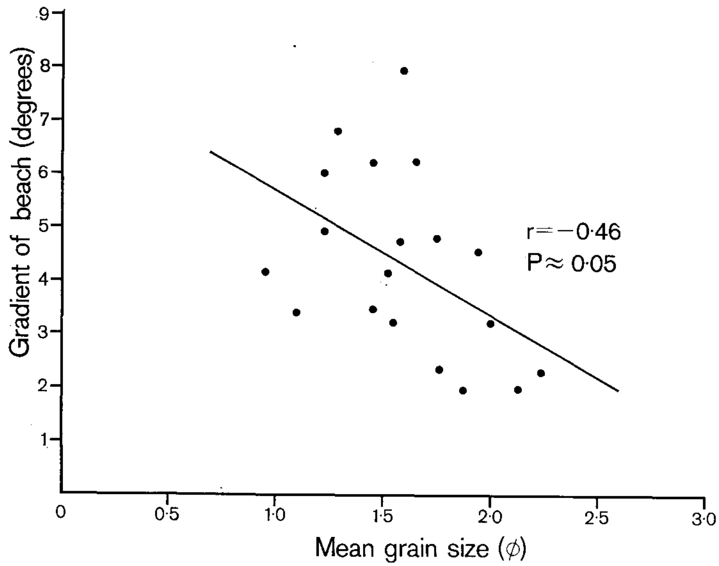

FIG. 5—Relationship of grain size to beach gradient. Results from eight surveys each at Oakura and Werekino and one survey each at Harriet, Oaonui, and Okeweu.

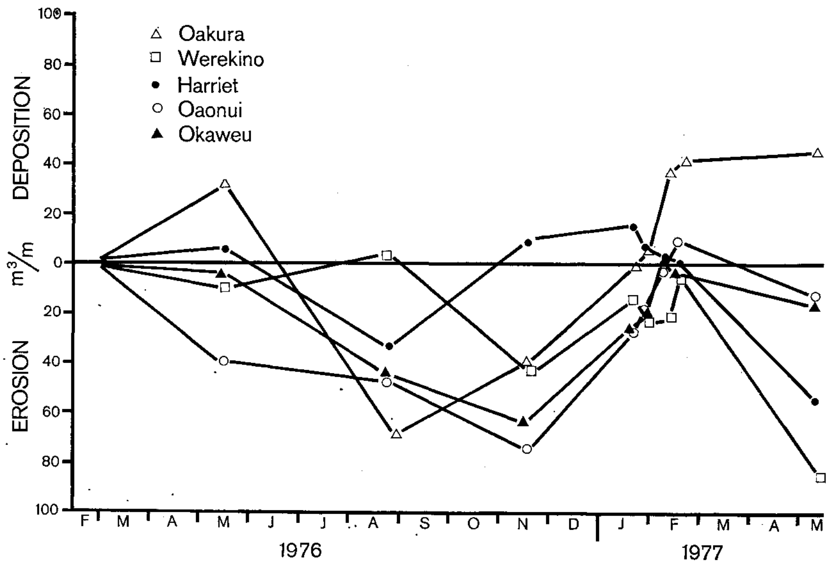

FIG. 6—Seasonal variation in beach volume in western Taranaki 1976–77. Volume changes with respect to the first survey calculated assuming a one-metre-wide strip for one profile at each beach.

important, but variation in sediment supply, wave direction, and wave steepness may also be significant. Schofield (1975) has demonstrated the importance of wind strength and direction.

Distinct seasonality in beach morphology on the west coast of New Zealand is not apparent probably because: (1) most studies have covered a period of less than one year (e.g., Mangin (1973), Gibbard (1972), Delgrosso (1971)), and (2) of variation in exposure. In the present study it was found that the beaches facing directly into the prevalent wave direction were more clearly seasonal in form than those facing in other directions. This could explain Gibb's (1978) result; the west Wellington coast is a lee shore, sheltered by the South Island and by Kapiti Island.

These observations and the evidence of weak seasonality in the wave climate combine to indicate that the seasonality described in this paper is of a rather weak character and not as clearly defined as it is on beaches in the Northern Hemisphere (Shepard 1950; Burgess 1975). If seasonality were strong in New Zealand, the short periods of observation and slight variations in exposure would not have prevented its detection until now.

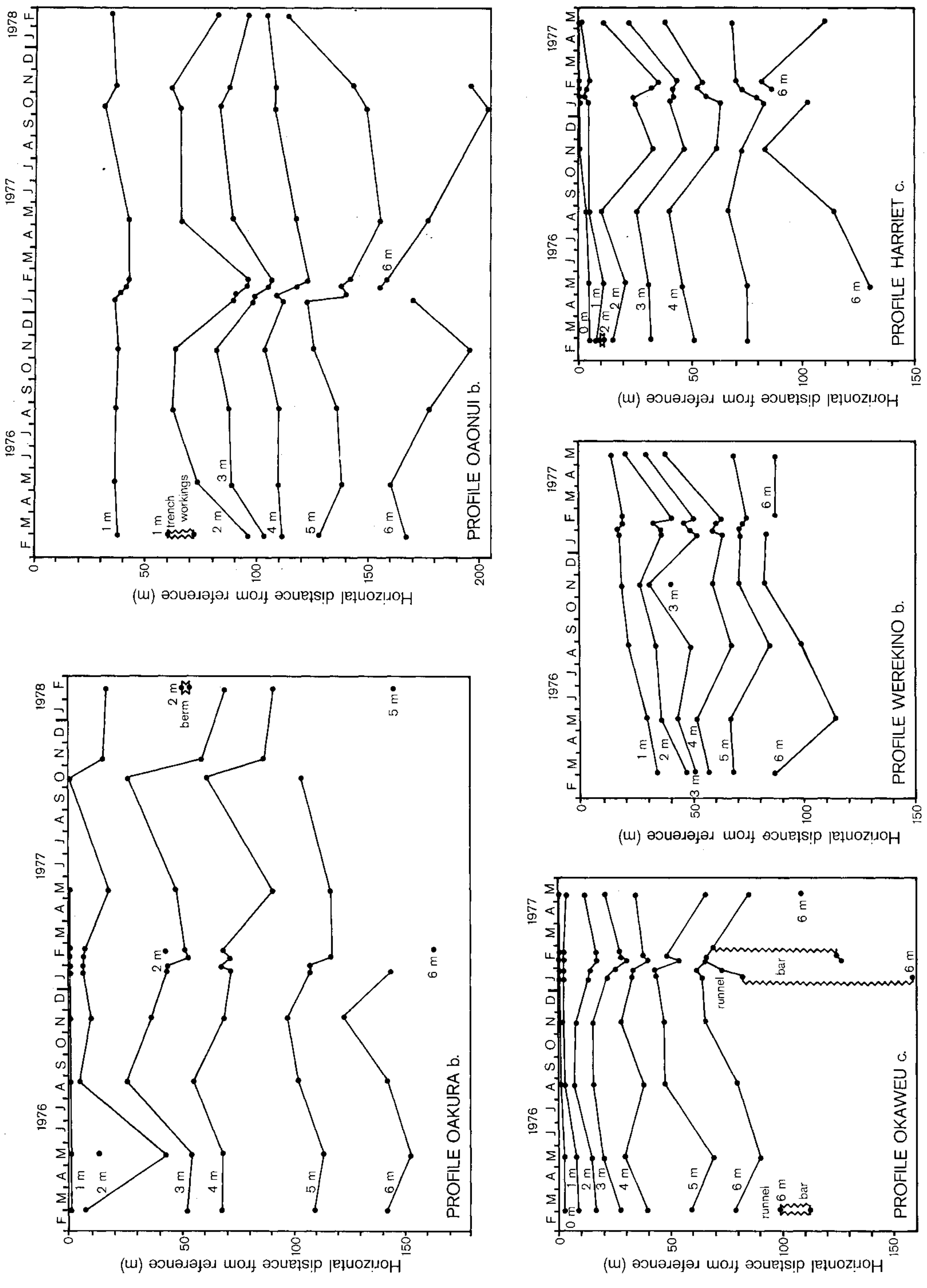

FIG. 7—Seasonal variation in beach morphology in western Taranaki 1976–77. Contours in metres below an arbitrary reference 6·42 m above chart datum at New Plymouth.

ACKNOWLEDGMENTS

Most of this research was carried out as part of a M.Sc. study at The University of Auckland. The study formed part of Maui Environmental Study Phase II which was commissioned by Shell, B.P., and Todd Oil Services Ltd on behalf of Maui Development. I wish to thank Dr M. R. Gregory for his guidance during the initial project and Drs R. F. McLean and R. A. Pickrill for their advice and criticism.

REFERENCES

BURGESS, J. S. 1968: Seasonal beach changes in southern Pegasus Bay. *N.Z. Geographical Society Record 46*: 15–6.

——— 1971: "Coastline change at Wanganui, New Zealand." (Unpublished Ph.D. thesis, lodged in the Library, University of Canterbury.) 99 p.

——— 1975: Beach change—a vital factor in coastal erosion control. *Soil and Water 12 (1)*: 25 & 31.

DELGROSSO, R. F. 1971: "Some aspects of beach morphology and sediments at Bethells and Piha, Auckland west coast". (Unpublished M.A. thesis, lodged in the Library, University of Auckland.)

DINGWALL, P. R. 1974: Bay-head beaches of Banks Peninsula, New Zealand. *New Zealand Oceanographic Institute Memoir 15*. 63 p.

GARNIER, B. J. 1958: "The Climate of New Zealand". Arnold, London. 191 p.

GIBB, J. G. 1978: The problem of coastal erosion along the "Golden Coast", western Wellington, New Zealand. *Water and Soil Technical Publication 10*. 19 p.

GIBBARD, R. G. 1972: "Beach morphology and sediments of the west Wellington coast. Wanganui to Paekakariki". (Unpublished M.Sc. thesis, lodged in the Library, Massey University.)

GOW, A. J. 1967: Petrographic studies of ironsand and associated sediments near Hawera, South Taranaki. *N.Z. Journal of Geology and Geophysics 10 (3)*: 675–96.

HARRAY, K. G.; HEALY, T. R. 1978: Beach erosion at Waihi Beach, Bay of Plenty, New Zealand. *N.Z. Journal of Marine and Freshwater Research 12 (2)*: 99–107.

KIRK, R. M. 1969: Beach erosion and coastal development in the Canterbury Bight. *N.Z. Geographer 25*: 23–5.

MCDOUGALL, J. C.; BRODIE, J. W. 1967: Sediments of the western shelf, North Island, New Zealand. *N.Z. Oceanographic Institute Memoir 40*. 55 p.

MCLEAN, R. F. 1976: Coastal research in New Zealand. *Geoscience and Man 14*: 135–44.

MANGIN, C. M. 1973: "Coastal processes and development in the southern Karamea Bight". (Unpublished M.A. thesis, lodged in the Library, University of Canterbury.) 112 p.

MATTHEWS, E. R. 1977: "The movement of sand on some western Taranaki beaches". (Unpublished M.Sc. thesis, lodged in the Library, University of Auckland.) 135 p.

PICKRILL, R. A.; MITCHELL, J. S. (in press): The wave climate around New Zealand. *N.Z. Journal of Marine and Freshwater Research*.

SCHOFIELD, J. C. 1975: Beach changes in the Hauraki Gulf, 1965–68: effect of wind, sea-level change, and offshore dredging. *N.Z. Journal of Geology and Geophysics 18 (1)*: 109–27.

SHEPARD, F. P. 1950: Beach cycles in southern California. *U.S. Army Corps of Engineers Beach Erosion Board Technical Memorandum 20*. 26 p.