Formation, landforms and palaeoenvironment of Matakana Island and implications for archaeology

Formation, landforms and palaeoenvironment of Matakana Island and implications for archaeology

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Frontispiece: oblique photograph of Matakana Island. View to the northwest with Mount Maunganui in the foreground.

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Abstract

Matakana Island, in the western Bay of Plenty, is a barrier island which encloses Tauranga Harbour. It comprises two distinct parts: an older area of tephra-covered Pleistocene terraces and, to seaward, a large Holocene sand barrier. Vestiges of shore-parallel relict foredunes indicate that the lowest Pleistocene terrace originated as a prograding coastal plain,

The Holocene sand barrier initially formed in at least two separate parts about 6000 cal (calendar years) BP. Its environmental history was determined by means of geomorphological, sedimentological, tephrochronological, pedological and palynological techniques, together with radiocarbon dating. The northwestern part of the Holocene barrier originated as a migrating washover ridge, whereas the southeastern part abutted the cliffed edge of the lowest Pleistocene terrace.

The barrier grew by means of southeasterly spit extension, the accretion of successive foredune ridges along the ocean shoreline, and progradation along the harbour shoreline. By about 3500 cal BP the tidal inlet which separated the two parts had closed. During the past 600 years the ends of the Holocene barrier adjacent to the present tidal inlets have been particularly dynamic features which extended rapidly as the harbour entrances narrowed.

The Holocene barrier has undergone major environmental change throughout its history. Parts of the relict foredune topography of the Holocene barrier were modified by migrating dunes. Parabolic and blowout dunes developed prior to human settlement and a variety of dunes has developed since. Since 600 cal BP natural changes have been augmented by human impact, including modification of the vegetation and soil by Maori and, more recently, farming and plantation forestry. Future planning and management decisions should take into account the dynamic nature of the island.

1. Introduction

Matakana Island forms part of a wave-dominated sedimentary coast located at the western end of the Bay of Plenty (Fig. 1). The older part of the island, which we call *Matakana Core* (Fig. 1), is composed mainly of Pleistocene sands mantled by thick tephra deposits. It adjoins the younger *Matakana Barrier* which is composed mainly of Holocene sands with minimal tephra cover. Rangiwaea Island, which lies to the southeast of Matakana Core (Fig. 1), has a similar geological structure to Matakana Island and a closely associated geological history.

Matakana Island is 24 km long and is New Zealand's largest barrier island. Its development, together with that of the tombolos adjoining Mount Maunganui and Bowentown Heads, formed Tauranga Harbour, a *c*. 200 km^2 estuarine lagoon.

Matakana Island has a Bay of Plenty climate which is mild and sunny, with a moderate rainfall of *c.* 1300 mm/year (Quayle 1984). It is very favourable for human settlement, and suitable for Maori gardening which was based on subtropical plants. The climate is complemented on Matakana Core by friable, easily-worked volcanic loams, on Matakana Barrier by light, sandy soils, and in the adjacent harbour and ocean by abundant fish and shellfish.

The island was extensively occupied in pre-European tunes. Its favourable environment is reflected in the large number of archaeological sites, especially fortifications, on Matakana Core, and in old garden soils and large numbers of shell middens on Matakana Barrier (Marshall *et al.* 1994). Radiocarbon dates indicate a history of occupation from at least 500 years ago. Moa bones found in the sandhills on Matakana Island in 1885 along with other archaeological remains (Bay of Plenty Times, 17 Jan 1885) suggest that initial occupation may have occurred before moa became extinct.

Since the 1920s the barrier has been used almost entirely for exotic forestry, which has had a detrimental effect on the archaeological sites and has modified the barrier soils, topography and drainage. Concern within the local Maori community for their heritage resulted in an approach to the Department of Conservation for information about the barrier history, which led to this interdisciplinary palaeoenvironmental and archaeological study.

Palaeoenvironmental studies are important for two reasons. Firstly, they provide an environmental context for archaeology; secondly, they provide an understanding of barrier landforms and the evolution of the barrier itself. Past studies have covered aspects of the geological, geomorphological, and environmental history of the Bay of Plenty (e.g., Kear and Waterhouse 1961, Wallingford Hydraulics Research Station 1963, Chappell 1974, Davies-Colley 1976, Healy *et al.* 1977, Dahm 1983, and Pullar and Cowie 1967) but Matakana Barrier has received comparatively little attention. This study was carried out between 1992 and 1995.

The objectives of the study are:

1. To map the landforms of the barrier.
2. To carry out geomorphological, sedimentological and stratigraphic studies in order to explain the origin of the barrier and its landforms.
3. To establish a time-frame for barrier development.
4. To determine the nature of the barrier and its environment before and after human settlement.
5. To determine the interrelationships between human activities and the barrier environment and their implications for the archaeological study of the barrier.

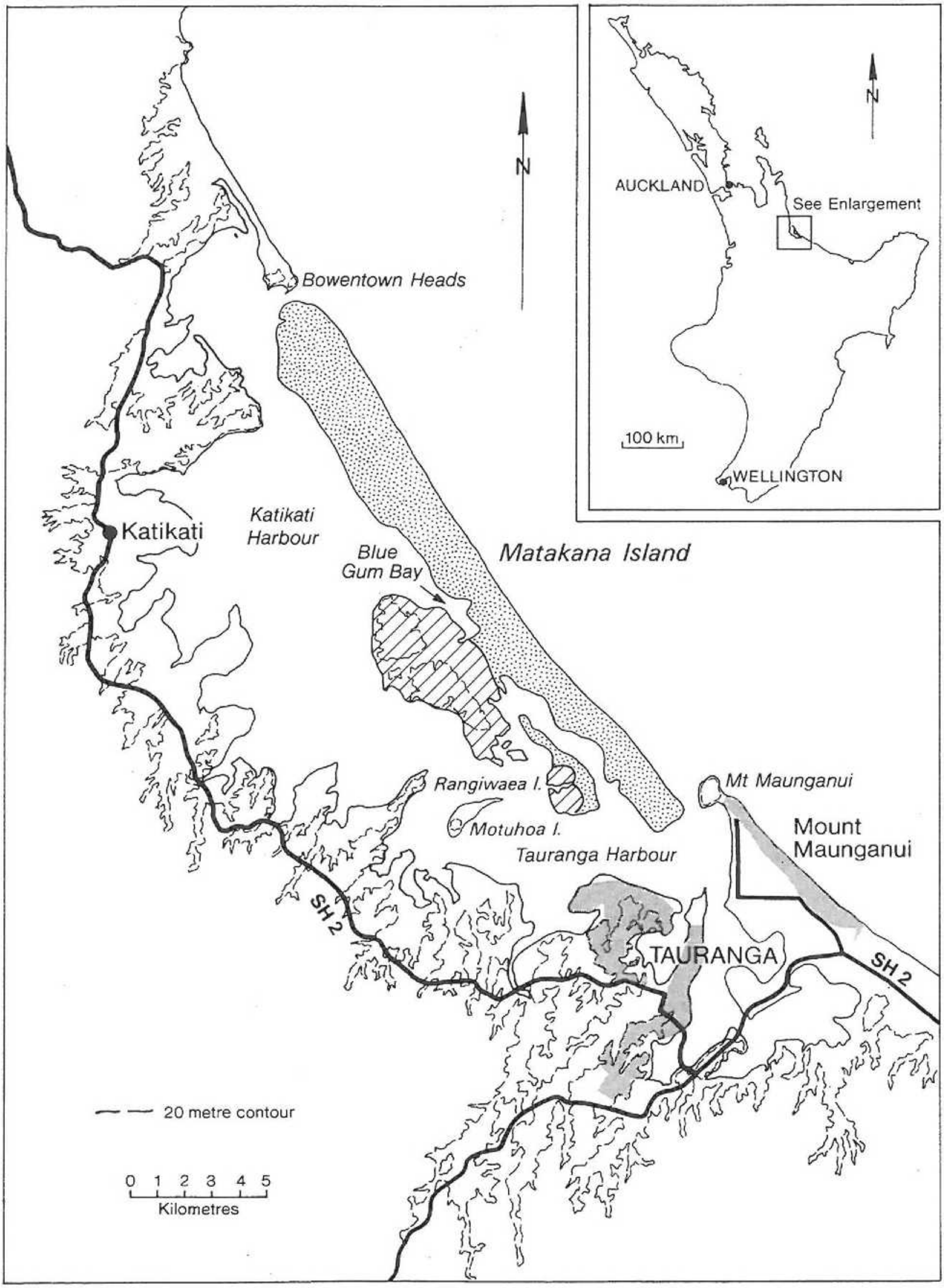

FIGURE 1. LOCALITY MAP FOR MATAKANA ISLAND. HOLOCENE BARRIER INDICATED WITH STIPPLING, PLEISTOCENE CORE OF ISLAND WITH DIAGONAL SHADING. NOTE ALSO THE HOLOCENE BARRIER AND PLEISTOCENE CORE OF RANGIWAEA ISLAND SH 2 = STATE HIGHWAY 2.

1.1 GEOLOGICAL SETTING

Matakana Island and Tauranga Harbour are located within the Tauranga Basin, which was formed during the last 2 to 4 million years by subsidence (Shaw and Healy 1962; Whitbread-Edwards 1994). At the present time the Tauranga Basin is thought to be either stable (Selby *et al*. 1971; Wigley 1990) or subsiding (Schofield 1968; Cole 1978). At times of high sea level the basin forms an embayment into which both fluvial sediment from the hinterland (Healy *et al.* 1964, Davies-Colley 1976) and marine sediment accumulates. During times of low sea level, the Pleistocene deposits, including thick tephra deposits (Selby *et al*. 1971; Pullar and Birrell 1973; Hogg 1979; Dahm 1983), have been dissected by streams and rivers. The Matakana and Rangiwaea cores are old interfluves isolated from the mainland by the rise in sea level following the Last Glacial.

It has been suggested that the valley systems, drowned during the Postglacial Marine Transgression (Healy *et al*. 1964; Davies-Colley 1976), control the present configuration of tidal channels in the harbour (Dahm 1983; Healy and de Lange 1988) and possibly the position of the Tauranga Entrance (Dahm 1983). The locations of the present entrances are also influenced by the isolated outcrops of volcanic rock at Bowentown Heads and Mount Maunganui. A small volcanic outcrop, Ratahi Rock (NZMS 260 788953), also occurs near Flax Point on the harbour side of Matakana Core.

1.2 FACTORS CONTROLLING THE GROWTH OF MATAKANA BARRIER

Factors controlling the growth of Matakana Barrier following the Postglacial Marine Transgression include sea level, offshore bathymetry, wave and tidal environments, sediment supply, wind climate and vegetation.

1.2.1 Sea level

Barrier development is closely associated with sea level change (Zenkovich 1967; Roy et al. 1994). In New South Wales, most Holocene barriers began prograding soon after c. 6500 yr (radiocarbon years) BP when the sea reached its present level at the end of the Postglacial Marine Transgression. A Holocene eustatic sea level curve for New Zealand (Gibb 1986) indicates that in New Zealand modern sea level was also reached c. 6500 yr BP. As the Tauranga region is fairly stable tectonically (Pillans 1986), the relative sea level curve for Matakana Island is unlikely to differ significantly from Gibb's curve and our fieldwork on the island has provided no evidence to the contrary.

1.2.2 Offshore bathymetry

The continental shelf off Matakana Island is generally uniform and smooth, except near Karewa Island and Steels Reef, and has a gradient of about 1:300 (Pantin *et al.* 1973; Hume and Hicks 1993).

The uniformity of the inner shelf has been modified near the entrances to Tauranga Harbour by strong tidal currents. Longshore sediment transport paths have been disrupted and large ebb-tidal deltas have formed (Davies-Colley and Healy 1978a). The deltas are major sub-tidal stores of sediment (Boothroyd 1985; Hicks and Hume 1993; Hume and Hicks 1993) and have played an important role in the development of Matakana Island.

1.2.3 Wave and tidal environment

The western Bay of Plenty coast, with its northeasterly aspect and prevailing offshore winds, has a lower-energy wave climate than most other New Zealand coasts. Swell waves dominate over locally-generated waves and the Bay of Plenty wave climate has thus been classified as a "mild-meso energy swell wave environment" (Healy *et al.* 1977). The offshore and nearshore significant wave heights are 1.5 m and 0.6 m respectively (Healy *et al.* 1977). The predominant wave approach direction, from the north to northeast, is approximately normal to the coast (Fig. 2), with low northerly swell (usually less than 1 m high) particularly frequent. Higher waves, which generally approach from the east or northeast (Davies-Colley and Healy 1978a), are associated with extra-tropical storms and winter depressions (de Lisle 1962; Heath 1985).

Tidal range is important for barrier development. The relatively low tidal range of 1.8 m-2.0 m (Healy *et al.* 1977) for the Tauranga Entrance is classified as "microtidal", which is conducive to barrier development (Davies 1980). The Tauranga and Katikati entrances would be classed as "tidally-dominated" (Hubbard et al. 1979) by reason of their morphology and extensive ebb-tidal deltas, which reflect the dominant influence of their large tidal prisms (130.8 x 10^6 m^3 and 95.8 x 106 m^3 respectively (Hume and Herdendorf 1992)) relative to the moderate wave energy of the ocean coast. The deltas store large amounts of sediment (the ebb-tidal delta at Tauranga has a volume of c. 47 x 10^6 m^3 and at Katikati c. 30 x 106 m^3 (Hicks and Hume 1991)), which may otherwise have been added to the shore. The ebb-tidal deltas also appear to have provided sediment to the barrier at certain times in its development, and their presence modifies the incoming waves by refraction and energy dissipation.

1.2.4 Sediment supply

Healy *et al.* (1977) used wave data from Davies-Colley (1976) to calculate a wave approach resultant of 4° north of normal to the coast, suggesting nett littoral drift from northwest to southeast. They estimated littoral drift along the Matakana Island barrier to be at least 40 000 m^3 per year based on observations of long-term progradation at Panepane Point.

Tidal inlets are the most dynamic parts of a barrier system (Hayes 1991). The convergence of tidal currents at the harbour entrances has scoured deep inlet gorges with depths that exceed 24 m at the Katikati Entrance and 30 m at the larger Tauranga Entrance (Hydrographic Office 1993). Interaction between the ebb-tide deltas and the beach on Matakana Barrier is demonstrated by bulges at the northwestern and southeastern ends of the barrier (Fig. 1), which are related to the ebb-tidal deltas of the Bowentown Bar and Matakana Bank respectively (Healy et al. 1977). Marine sediment carried into the harbour is deposited in flood-tide deltas which contribute to the inflling of the harbour.

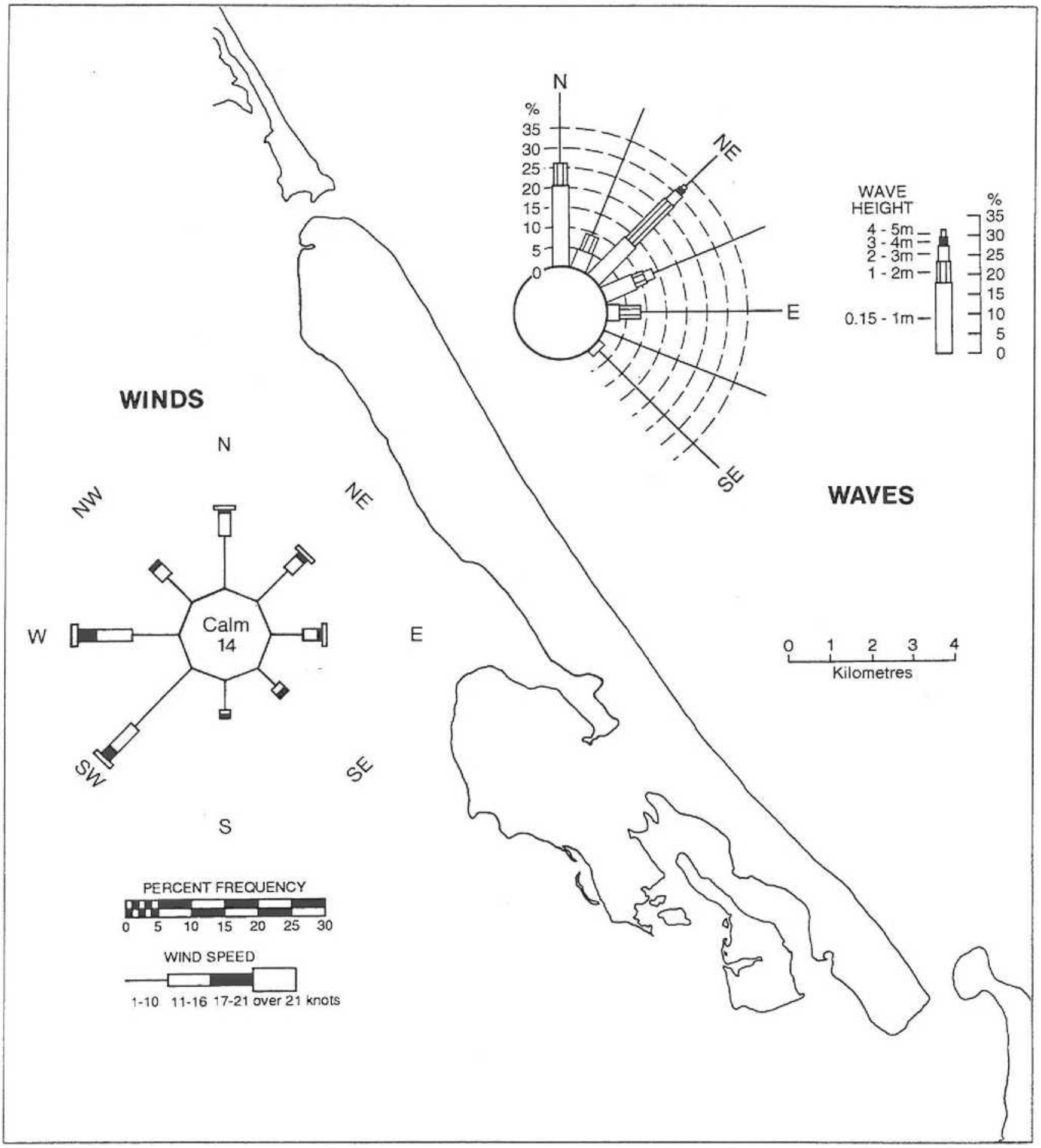

FIGURE 2. WAVE AND WIND CLIMATE FOR MATAKANA ISLAND. (SOURCES: WIND DATA FROM DE LISLE, 1962; WAVE DATA FROM HARRAY AND HEALY, 1978).

1.2.5 Wind climate

Although the Bay of Plenty is sheltered by high country to the west, south and east, westerly and southwesterly winds predominate at Tauranga Airport (de Lisle 1962; Quayle 1984). Gales, generally from the northeast or southwest, occur infrequently; such winds are more common near the coast and about the ranges than in other parts of the region (Quayle 1984). Whilst the coastal region is considerably less windy than other parts of New Zealand (Quayle 1984), the northeasterly and southwesterly winds are sufficiently strong to initiate the development of blowout and parabolic dunes following vegetation disturbance, and determine their orientation. Wind directions for Tauranga Airport are summarised by Fig. 2.

1.2.6 Vegetation

Vegetation today plays a role in the development of the barrier by trapping sand to accrete the foredune, by trapping sand, silt and clay on the estuarine flats, and by infilling lakes and swamps. The vegetation would have played a similar role in the past.

The contemporary vegetation on Matakana Island has been studied by Beadel (1989a,b) and a summary is provided in Appendix 1. Well-developed primary vegetation successions are evident on the island today at prograding shorelines, with pioneering communities on younger surfaces and more advanced communities on older surfaces. The vegetation pattern in the past would have shown similar successions as the island grew in size. The climax vegetation would have been forest, but little of the original forest remains owing to the planting of exotic forests. The largest remaining area of natural vegetation is adjacent to the harbour shoreline of the northwest part of the barrier, where well-developed swamp forest is present on relict estuarine flats.

1.3 DATING THE GROWTH OF MATAKANA ISLAND

At the end of the Postglacial Marine Transgression, Matakana Barrier began to prograde seawards, forming from sediments derived primarily from offshore. The growth of the barrier is marked by a succession of foredune ridges. The seaward edge of each ridge marks the position of a shoreline and each ridge is considered to be the same age along its entire length. The succession of ridges records the growth of the island through time. The ridges alone, however, record only the sequence of growth, but not the ages of the ridges or rates of barrier growth. To establish the ages of the ridges, and hence growth rates, two methods are used: radiocarbon dating and tephrochronology.

1.3.1 Radiocarbon dating

The interpretation of radiocarbon ages depends upon their stratigraphic relationship to the event to be dated and upon the inbuilt age of the samples. Samples may be within strata older than the event, contemporaneous with the event, or younger than the event. Inbuilt age is the length of time between the death of the organism dated and its arrival in the place from which it was collected (McFadgen 1982).

Inbuilt age is comprised of two parts: growth age and storage age (McFadgen 1982). For shells, the important component is storage age, i.e., the period between the death of the shellfish and their deposition within the deposits in which they were found. This could be many hundreds or even thousands of years for shells which were stored in ebb-tidal deltas before being transported onshore. Bivalves found in position of articulation are assumed to have negligible inbuilt age. Single bivalve shells and gastropods have unknown, and

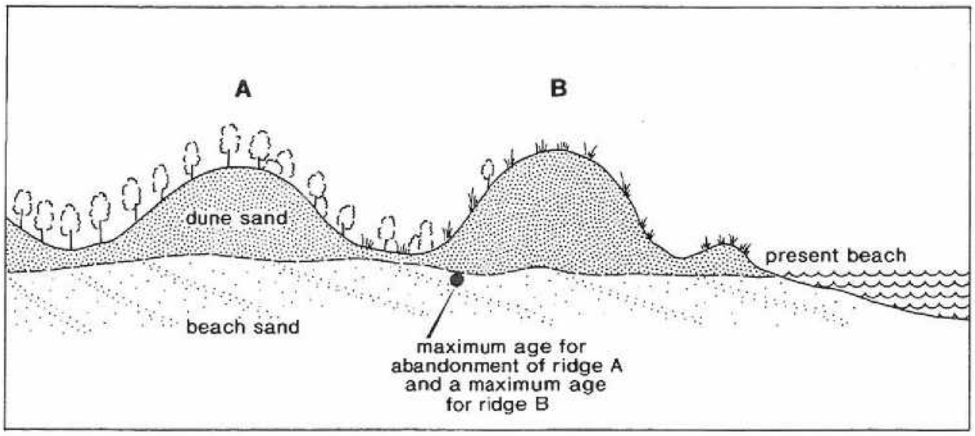

FIGURE 3. DIAGRAM ILLUSTRATING THE AGE RELATIONSHIP BETWEEN SHELL SAMPLES AND BARRIER STRATIGRAPHY. FOR EXPLANATION SEE TEXT.

possibly large, inbuilt age because there is no way of knowing their past transportational history. For midden shells, storage age is assumed to be negligible where the species dated are food species.

The relationship of shell samples to barrier sediments and the interpretation of their radiocarbon ages is illustrated by Fig. 3 which shows two foredune ridges A and B and their associated beach sand deposits. Shells from all barrier samples were either gastropods, or bivalves which were not in position of articulation when found. The shells therefore have an unknown and possibly large inbuilt age. Foredune ridge B forms above beach sand deposited while foredune ridge A was growing. Shells in beach sand immediately seaward of dune ridge A provide a maximum age for foredune ridge B because they are harbourward of ridge B. The shells are in sand which formed the beach while ridge A was forming and therefore provide a maximum age for the retreat of the sea from the beach in front of ridge A.

The shells are considered to be unsuitable for determination of the age of ridge A. This is because they have an unknown and possibly large inbuilt age. The shellfish may have died some considerable time before the formation of ridge A and only later transported into the position in which they were found.

Radiocarbon ages in this report (Table 1) are calibrated as follows: marine calibrations are based on the carbon cycle model calibration curve of Stuiver and Braziunas (1993), together with geographic offset delta-R set to -30 ± 15 years as recommended by McFadgen and Manning (1990). Terrestrial calibrations are based on a compilation of 20 year tree ring data by Stuiver and Reimer (1993). We do not apply a correction to compensate for the apparent offset of radiocarbon between the northern and southern hemispheres (Vogel *et al.* 1993). Conventional radiocarbon ages are indicated in the text as "yr BP" (years before present, where present = 1950 AD). Calibrated ages are expressed as a 95% confidence interval and indicated in the text as "cal BP".

Adopted ages in cal BP for airfall tephra deposits other than the Kaharoa Tephra are determined by calibrating the mean published radiocarbon ages for each tephra (Froggatt and Lowe 1990; Alloway *et al.* 1994), taking the mid-point of the calibrated 95% confidence interval and rounding the mid-point to the nearest 50 years. The age of the Kaharoa Tephra has recently been determined. (D.J. Lowe, pers. comm.)

LABORATORY NO.	δ ¹³C ‰	CONVENTIONAL RADIOCARBON AGE YEARS BP (1950)	CALIBRATED AGE, YEARS BP[1] (95 % CONFIDENCE INTERVAL)	MATERIAL DATED	NZMS 260 GRID REFERENCE	DEPTH BELOW GROUND SURFACE (m)
NZA-3878	+1.91	5635 ± 69	6205-5905	Marine shells (*Zethalia zelandica*)	U13 775037	5.90-6.40
NZA-3879	+1.74	7697 ± 70	8295-7975	Marine shells (*Zethalia zelandica*)	U13 775037	9.50-10.10
NZA-3880	+1.39	8703 ± 72	9490-9195	Marine shells (*Zethalia zelandica*)	U13 796016	8.00-8.20
NZA-4654	-38.85	10991 ± 94	13110-12700	Estuarine sediment	U14 807973	1.90
NZA-4833	-31.23	8243 ± 88	9425-8985	Plant material	U14 807973	2.93
NZ-7997	+1.60	2114 ± 46	1830-1590	Marine shells (*Paphies ventricosa/ subtriangulata, Maurea tigris, Spisula aequilateralis, Paphies australis, Tawera spissa, Chione stutchburyi, Myadora boltina*)	U14 879917	0.45-1.40
NZ-8021	+1.70	701 ±31	435-295	Marine shells (*Struthiolaria papulosa, Paphies australis*)	U14 884920	0.70-1.20
NZ-8125	+1.50	667 ± 36	415-270	Midden shells (*Paphies subtriangulata*)	U14 855940	1.30
NZ-8187	+0.10	677 ±29	415-280	Marine shells (*Paphies subtriangulata*)	U13 863933	0.30
NZ-8235	+1.30	4914 ± 65	5435-5050	Marine shells (*Zethalia zelandica, Spisula aequilateralis, Paphies subtriangulata*)	U14 800006	0.90-1.10
NZ-8236	+1.50	5462 ± 68	6015-5695	Marine shells (*Zethalia zelandica*)	U14 820988	4.35-4.45
NZ-8294	-25.50	1449 ± 51	1415-1270	Kauri gum (*Agathis australis*)	U13 753071	0.10
NZ-8311	-0.10	751 ± 37	480-315	Midden shells (*Paphies australis*)	U14 882905	2.15

1. New Zealand marine calibrations are based on the carbon cycle model calibration curve of Stuiver and Braziunas (1993), with geographic offset delta-R set to -30 ± 15 as recommended by McFadgen and Manning (1990). Terrestrial calibrations (samples NZA-4654, NZA-4833 and NZ-8294) are based on a compilation of 20-year tree ring data by Stuiver and Reimer (1993).

TABLE 1. RADIOCARBON DATES FOR MATAKANA ISLAND.