NOTES ON THE GEOLOGY OF PENGUIN ISLAND AND CAPE PERON WITH REFERENCE TO ROTTNEST ISLAND

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INTRODUCTION

These notes are to accompany the Geological Sketch Maps of Penguin Island and Cape Peron, Western Australia (Fig. 2 & 3). The maps represent several days of field investigation carried out during May, 2000. For the information on Rottnest Island this account relies heavily upon the report by Playford (1988). Previous studies describing the geology of Penguin Island were by Playford (1950) and Chape (1984); the latter contains a significant contribution by Dr. J. N. Dunlop. The geology and geomorphology of Cape Peron was described by Fairbridge (1950). Plate I is adapted from Gozzard (1983) and includes geochronological data from Searle *et al* (1988). A brief description of the geology and geomorphology of the Haliotis Bay Headland, Cape Peron, is given by Green (1997). Other information was derived from a number of studies by other workers in the area covering Penguin Island, Cape Peron and the Rockingham-Becher Plain; these are referred to in the following text. Tingay (1995) provides a review of coastal studies in the Rockingham area.

REGIONAL SETTING

Penguin Island is part of the largely submerged Garden Island Ridge (Searle, *et al*, 1988). The ridge is built of the late Pleistocene to Holocene Tamala Limestone (Playford, 1988). The ridge extends from Rottnest Island southwards through Carnac Island, Garden Island, Cape Peron and Penguin Island to the Murray Reefs (see Fig. 1 and Plate I). The ridge represents a fossil coastline built of sand dune material. The oldest portions of the Tamala Limestone are probably not more than 140,000 years old (Playford, 1988). A thin marine limestone intercalation in the Tamala Limestone at Fairbridge Bluff on Rottnest Island was dated by uranium/thorium methods as 132,000 plus or minus 5000 years (Szabo, 1979).

The geological units defined by the accompanying maps (Fig. 2 & 3) are, in descending order of age:-

Qhb: Modern beach sand and rock rubble.
Qhd(y): Younger dune sand.
Qhd: Dune sand.
Qhp: Penguin Island Limestone (informal name).
Qtc: Calcrete surface of Tamala Limestone.
Qt: Tamala Limestone.

The modern beach sand, younger dune sand and dune sand are included in the Safety Bay Sand (Playford *et al*, 1976, and Searle, *et al*, 1988).

PLEISTOCENE

Tamala Limestone

The Tamala Limestone is an aeolian calcarenite; it is composed of wind-blown, sand-sized grains of shell fragments, foraminifera and calcareous algae, with some quartz sand grains. The limestone is characterized by large scale aeolian cross-bedding which mark successive sand dune slopes. At both Penguin Island and Cape Peron, the aeolian bedding planes are inclined parallel to the original sand dune surfaces towards the northeast, away from the prevailing southwesterly winds (Fairbridge, 1950; Playford, 1950; Chape, 1984).

On Garden Island the Tamala Limestone core was probably formed in the late Pleistocene at the same time as the surface material on Rottnest Island (McArthur & Bartle, 1981. The lower layers of the island may be older – near point Atwick and at Collie Head at 1-2 m above sea level, there is a well-defined soil horizon formed on an earlier surface.

In a number of places around the coasts of Penguin Island and Cape Peron, evidence of the former vegetation of the old sand dunes can be seen. The limestone contains fossilized shrub and tree roots. The former wood of the roots is now replaced by calcium carbonate; in some places the wood-like preservation of the fossils is remarkably good. However, in many places the detailed appearance of the roots has been obscured by the precipitation of lime from solution in groundwater to form envelops of fine crystalline calcite around the roots. The resultant structures are called *rhizoliths*. Excellent examples of tree and shrub root systems – as rhizoliths and as fossils – can be seen near the northern walkway exit on the west beach of Penguin Island.

Within the rhizolith zones are conspicuous solution pipes. The outer cylindrical casing of the pipes can be up to 0.5 metre in diameter and several metres long. They are thought to have formed around the tap roots of large trees by ground water circulating along the zone of the root, dissolving and precipitating calcium carbonate. The outer casing of the pipes consists of strongly cemented limestone. The inside of the pipes is composed of softer calcified roots, or sand that has entered from above if the original root rotted away (Playford, 1988).

Tamala Limestone Calcrete

Penguin Island

At the northern and southern ends of Penguin Island, the surface of the Tamala Limestone consists of a hard calcrete ranging from 0.2 to 3 metres thick. The calcrete is an expression of an old landscape, and was formed in the zone of capillary rise between the water table and ground surface. It forms as a sheet just above the water table in the zone of capillary rise, particularly in humid climates. Unlike Cape Peron (see below), relics of fossil soil overlying the calcrete are present in only one or two places at the southern tip of Penguin Island. Chape (1984) states that the northern and southern plateaux of the island were scraped clear of their nitrogenous soils early in the last century (See Appendix I).

The calcrete surface is not flat. The contours on the map (Fig. 2) indicate directions of slope of the calcrete surface, and suggest the form of the old landscape. In the south, the calcrete slopes to the east. In the north, the Lookout is located on a "hill" of the calcrete surface, sloping north to a "valley"; the pelican colony is located at the top of another low calcrete "hill". These landscape relics must be tens of thousands years old, and are now being destroyed by modern coastal erosion around the cliffs.

Unlike the calcrete at Cape Peron (see below), the calcrete surface slopes appear to conformably overlie the aeolian dune foreset bedding; hence it probably represents a Tamala Limestone dune surface.

Within the cliffs on the northwest coast one or two thin calcrete layers occur within the Tamala Limestone. These are overlain by thin layers of fossil soil. These horizons mark interruptions in the deposition of the aeolianite dune sand, when plant growth allowed soil to form, with the development of the associated calcrete beneath it.

Cape Peron

As at Penguin Island, the calcrete surface is not flat. Arrows shown on the Cape Peron map (Fig. 3) in the area between Emplacement No. 1 and John Point indicate a gently undulating topography, with remnant "hills" west of Emplacement No.1 and at John Point, separated by a gentle "valley". At the small bay southeast of John Point and at the north end of Long Reach, the calcrete descends to the current sea level.

At John Point and at the north end of Long Reach along the northwest coast, the surface of the calcrete layer consists of a fossil soil composed of rounded cobble-sized Tamala Limestone clasts enclosed in a reddish-brown sandy matrix. This suggests that the Tamala Limestone was already lithified and therefore solid at the time of formation of the calcrete and soil. If this is the case, the calcrete surface does not represent a Tamala Limestone dune surface, as Playford (1988) interpreted at Rottnest Island. It appears to be an eroded surface.

This view is supported by observations of the relationship between the calcrete and the underlying Tamala Limestone. At a number of locations at Cape Peron the near horizontal calcrete unconformably overlies sloping aeolian bedding planes of the limestone. The calcrete lies on an erosion surface of the limestone, formed after the limestone had completely lithified.

The Small Islands

Bird Island and Seal Island, between Cape Peron and Penguin Island (Plate I) also show a solid layer of calcrete overlying the Tamala Limestone. On both islands, the limestone beneath the calcrete contains strong rhizolithic structures, indicating the former existence of plant growth on the former sand dunes. Passage Rock, 2.5 km south of Penguin Island, is capped by an eroded, residual layer of calcrete; it has the appearance of a snow cap.

Rottnest Limestone

The Rottnest Limestone is a unit of coral-reef limestone, and can be found at Fairbridge Bluff in Salmon Bay, Rottnest. To the writer's knowledge, it does not crop out above sea level at Penguin Island. However, samples of brain coral and staghorn coral have been washed ashore on the island's west beach, hence, it is possible that it crops out below sea level at that beach. The Rottnest Limestone has not been recognized on Garden Island (McArthur & Bartle, 1981).

At Rottnest Island it is both underlain and overlain by Tamala Limestone, and so probably represents an interval when the sea level had risen somewhat for a time. Its thickness at Rottnest is 3 m. It contains staghorn and platy corals (*Acropora sp.*), together with brain coral (*Goniastra sp.*); in addition, coralline algae and mollusc shells are found.

The Rottnest Limestone's age was determined by uranium/thorium methods, and given as 132,000^{+}. 5,000 years (Szabo, 1979). The sea level at this time must have been at least 3 m higher than at present, and occurred during the last interglacial period, which is widely dated along the Western Australian coast, e. g., the Abrolhos Islands (Zhu, *et al*, 1993).

HOLOCENE

Penguin Island Limestone (informal name)

Introduction

The Penguin Island Limestone was first noted by the writer at Penguin Island, and later at Long Reach on Cape Peron. Playford does not describe an equivalent unit at Rottnest Island. Fairbridge (1950) refers to the Cape Peron occurrences as "beach rock". Beach rock is the result of induration of beach sand in the phreatic zone where the mixing of marine water and outflowing freshwater takes place (Semeniuk & Searle, 1987b). The origin of the limestone in terms of beach rock will be discussed below.

Penguin Island

The limestone crops out at the southern end of the west beach, at current sea level, extending to approximately 1 metre above sea level. It probably forms the wave cut platform that can be seen below the low water mark. The limestone is a slightly friable brown rock consisting of calcium carbonate shell fragments and sparse quartz grains, all about 1-2 mm in size. As Semeniuk & Searle (1987b) found, only two facies (varieties) of the beach sequence described by Semeniuk & Johnson (1982) are present. At sea level, near the southern walkway exit, a lower inshore trough-bedded sand is present. An overlying laminated seaward-dipping swash zone sand is exposed to the north of the walkway exit, extending up to 1 metre above current sea level.

The limestone overlies and overlaps on to a strongly eroded surface of Tamala Limestone aeolianite. In places where it is only tens of centimetres thick, inliers of the underlying aeolianite occur. The full thickness of the limestone is not accurately known, but is estimated to be about 2 m.

Cape Peron

Here, the limestone (the "beach rock" of Fairbridge, 1950) occurs along the Long Reach beach, and in small coves on the coast to the southeast of this bay. In the small cove immediately south of Car Park 4 (see Fig. 3) a basal conglomerate of aeolianite cobbles and pebbles, water-smoothed rhizoliths and large gastropods in a calcareous grit matrix is at the base of a 0.5 m to 1 metre thick coarse bedded calcarenite. Both are at or slightly above current beach level. Similar limestone is present in the cove to the west, and in Haliotis Bay. At the eastern side of Haliotis Bay, the limestone can be seen to overlie a strongly eroded surface of Tamala Limestone aeolianite, similar to the unconformity observed on Penguin Island.

At Long Reach the limestone is medium grained with gentle laminated bedding inclined at 5° to 10° to the west, i.e., seawards. The upper surface of the calcarenite bedding extends to about 1.5 metres above current beach level at the northern end of the bay. Fairbridge (1950) included this as part of his 5 foot (1.5 m.) bench in Plate I of his paper. At the southern end of the bay, the limestone overlies an eroded surface of Tamala Limestone aeolianite.

Significance Of The Penguin Island Limestone

1. Very young beach rock can be seen on Penguin Island on the southeast beach between the "Penguin Experience" and the southern walkway steps. It is an ochre-coloured very weakly cemented carbonate sand exposed after stormy weather has washed the beach out. The writer has observed it after storms on the Warnbro

beach. Semeniuk & Searle (1987b) state that this sort of material has been observed in the phreatic zone under the backshore of beaches that have formed only in the last forty years.

2. The mud-brown coloured Penguin Island Limestone is much more strongly cemented than the young beach rock.
3. At the northern end of Long Reach at Cape Peron, the upper surface of the limestone is 1 to 1.5 metres above current sea level, where it forms part of the 3 foot (1.5 metre) bench of Fairbridge (1950).
4. The Tamala Limestone was consolidated and strongly cemented before being eroded prior to the deposition of the Penguin Island Limestone.
5. Nowhere has it been seen to be overlain by Tamala Limestone.
6. It therefore seems to have resulted from deposition at a time when the sea level was 1 to 1.5 metres above the current level about 4,800 – 4,000 years BP (see "SUMMARY OF GEOLOGICAL HISTORY" below.

Herschell Limestone

The Herschell Limestone (Playford, 1977) of Rottnest Island has not been identified at either Penguin Island or Cape Peron. It is a unit of Holocene marine shell beds with interbedded lime sand, exposed around margins of salt lakes on Rottnest Island. Playford (1988) states that the unit is at least 2.5 m thick, and is thought to have been laid down in tidal environments when the lakes formed lagoonal arms of the sea, with the sea level being up to 2.4 m higher than at present.

Playford (1988) divides the limestone into two parts: the older Vincent Member and the younger Baghdad Member. The Vincent Member has been radiocarbon dated at 4,800 – 5,900 years old, and is believed to have deposited when the sea level was about 2.4 m above current sea level. The Baghdad Member has been radiocarbon dated at 2,200 – 3.100 years old, when the sea level was about 1 m higher than today.

According to McArthur & Bartle (1981) there are outcrops of limestone, on the west coast of Garden Island, younger than the Tamala limestone, 2-3 m above sea level: it may represent a calm – water facies of the Herschel Limestone.

Safety Bay Sand: Penguin Island And Cape Peron

Introduction

Two facies (varieties) of the Safety Bay Sand are present. One is represented by the Dune Sand and the "Young Dune Sand"; the second is the current beach deposits – mainly sand, but including rock rubble from erosion of cliffs.

Dune Sand

In the central portion of Penguin Island, the Tamala Limestone and its calcrete are overlain by a system of high sand dunes forming a somewhat rugged landscape, with a very steep slope down to the Young Dune Sand on the eastern side. At Cape Peron, dune sand covers much of the southern and eastern portions of the cape. There is a steep slope to the flat country behind Mangles Bay.

At the northern margin of Long Reach, Cape Peron, a 10 cm thick friable calcrete layer has developed within the dune sand. The layer was seen to be about 1 metre above the then beach level after a storm in late April, 2000. It overlies older unconsolidated dune sand. About 20 metres north the calcrete layer rises to eventually overlie Tamala Limestone calcrete at the point where the walking track reaches the beach. At this location, a thin (0-10 cm) horizon of moderately lithified dune sand containing incipient rhizoliths underlies the dune calcrete. The surface of the latter shows petrified twigs of plant root material.

The moderately lithified, rhizolith-bearing dune sand is banked against, and overlies a 10 – 15 cm thick brown conglomeratic carbonate sand that contains aeolianite pebbles. This overlies Tamala Limestone aeolianite calcrete, and probably represents the soil layer that formed over the calcrete.

Young Dune Sand

At Penguin Island, these sands occupy the low flat area extending from the jetty to the Penguin Experience, the toilet block and the generator building. They are probably built on the former beach sand that formed an early phase of the current tombolo (sand bar) that now extends to the mainland at Mersey Point.

Very low dunes at Cape Peron occur behind Mangles Bay, beneath the steep slope below Emplacement No. 1 and the site of the Peron Battery Barracks. These probably represent a former beach zone, now built up and vegetated.

Beach Sand and Rock Rubble

This material represents the modern beach deposits – sand on most of the beaches, but rock rubble at the feet of the cliffs at the northern and southern ends of Penguin Island. On the western beach, the sand movements between summer and winter are dynamic. Waves from winter gales strip sand off the beach; the calm summer breezes generate constructional waves that rebuild the beaches.

In a few places – for example, on the southeast beach near the Penguin Experience, a reddish-brown partly cemented beach rock is present. This is modern material partly lithified at deeper levels in the beach, and is only exposed during rough weather, when the upper levels of the beach are washed away.

Other Holocene Units

Safety Bay Sand: Rockingham – Becher Plain

The Rockingham-Becher Plain, inshore from the Garden Island Ridge (see Plate I and Fig. 1), is a large cuspate beach ridge system that consists of Pleistocene Tamala Limestone aeolianite ridges, with the intervening basins partly filled by Holocene sediments, ranging from the Cooloongup Sand to the Safety Bay Sand. The Safety Bay Sand accumulated in beach, beach ridge and dune sand deposits (Semeniuk *et al*, 1988).

Sediments have been accumulating in the Rockingham area for about 8,000 years (Searle, *et al*, 1988; also see Fig. 5 and Plate I of this report). Some of the sedimentation has resulted from the erosion of breaks in the Garden Island Ridge, and built up as prograding banks similar to the sand bar at Penguin Island, the isthmus joining Cape Peron to the mainland (Green, 1997), and the growth of "Tern Island" at the Safety Bay coast. Other sediment has been derived from northerly directed longshore drift from the Mandurah coast: the Marine & Harbours Department (1992, p. 41) estimated that some 80,000 m^3 of sand is moving north past Mandurah annually, with some 70,000 m^3 being deposited along the coast south of Becher Point.

Drill core and other observations made by Searle *et al* (1988) revealed that the Safety Bay Sand has a consistent stratigraphic sequence of dune sand grading downwards through a backshore unit overlying a swash unit to a basal trough-layered inshore beach unit. This lowest unit overlies the bioturbated Becher sand (see below).

Radiocarbon age determinations were made on selected sea shells and peat from the lowest unit and the underlying Becher Sand. These determinations form the basis of geochronological information summarised in Fig. 5 and Plate I.

Cooloongup Sand

This unit consists of sub-aerial to shallow marine feldspathic quartz sand with up to 25% shelly material (Passmore, 1970) that forms thin ribbon-like bodies that drape over the undulating surface of Tamala Limestone (see Fig. 5, Transects 1 and 2). It ranges up to 15 metres in thickness.

Leschenault Formation

This is an estuarine/lagoonal deposit, a grey, sometimes muddy, sand that is shelly in some layers (Semeniuk, 1983). Searle, *et al* (1988) reported a drill hole intersection below Lake Cooloongup (Fig. 5, Transect 1), where it overlies Cooloongup Sand.

Bridport Calcilutite (Plate I)

A grey homogenous sequence of carbonate mud that occurs as a buried deposit towards the middle and western portion of the Rockingham-Becher Plain (Fig. 5, Transects 1 – 4), and forms the contemporary surface in Warnbro Sound (Semeniuk & Searle, 1987a). It has a gradational contact with the underlying Cooloongup Sand.

Becher Sand (Plate I)

This unit consists of grey bioturbated sand and shelly sand that mainly forms as seagrass bank sequences (Semeniuk & Searle, 1985). In the Rockingham – Penguin Island area it forms depositional banks in Warnbro Sound and Shoalwater Bay. It overlies the Bridport Calcilutite and underlies the Safety Bay Sand beneath the Rockingham – Becher Plain with sharp contacts (Fig. 5, Transects 1 – 4).

Sheet Unit (Plate I)

The Sheet Unit (Gozzard, 1983; Plate I) consists of well-sorted medium-grained sand composed of carbonate lithoskels and lithoclasts with minor skeletal fragments of molluscs and algae. It occurs in deeper water within and to the west of the Garden Island Ridge.

GEOMORPHOLOGICAL FEATURES

Emergent Platforms (Wave Cut Benches)

Penguin Island

The three metre (ten foot) bench noted by Fairbridge (1950) at Cape Peron – see below – is present along the northwestern coast of Penguin Island. It is raised along its seaward edge, and slopes gently eastward. On the immediate south side of "The Bluff" on the island's west beach is an emergent platform about 1.5 metres above sea level. Remnants of a similar bench about 0.5 metre high can be seen in a small bay at the southwest coast of the island (see Fig. 6, and the discussion on past sea level changes below).

Cape Peron

Fairbridge (1950) identified emergent platforms at ten feet (3 metres), five feet (1.5 metres) and two feet (0.6 metre) above sea level. The ten feet and five feet levels are shown in Plate I of his paper, and are reproduced in Fig. 3. It will be seen that these platforms occur on the western and southwestern coasts of Cape Peron. At Long Reach, the five feet platform is "…. bevelling outcrops of old beach rock" (quote from Fairbridge, 1950), i. e., the Penguin Island Limestone.

Reef Platforms

Reef platforms are present along the southern and western coasts of Penguin Island and Cape Peron, and off the north coast of Penguin Island. They are the result of marine erosion within the intertidal zone. Fairbridge (1950) suggested that the planation of the limestone is brought about by chemical dissolution by sea water. The water is enriched in carbon dioxide because of changes in temperature and production of carbon dioxide by plant and animal respiration. This chemical erosion would be reinforced by the mechanical action of waves and the attack of grazing and burrowing marine organisms (Chape, 1984).

Tombolos And Banks

Shallow tombolos and banks connect Penguin, Seal and Bird Islands to the adjacent mainland in Shoalwater Bay. These form where wave patterns are refracted and diffracted by the islands and reefs, and intersect; this leads to the deposition of the sands transported by breaking waves. The sand is derived from the reefs and islands of the Garden Island Ridge. Cape Peron, formerly an island, is now connected to the mainland by a tombolo that has subsequently been built up to form the current sand dunes that form the peninsular.

SEA LEVEL CHANGES

Introduction

There is evidence to suggest that either world-wide climate change or the warping of the Earth's crust could account for the fluctuations of sea level. Or, possibly, both factors worked together. The following paragraphs discuss both ideas.

Climate Change

Sea level fluctuations can be related to global freezing and warming events in the Earth's recent geological history. When global freezing occurs, the polar ice sheets extend over larger areas of the Earth's surface than at present. Thus, water is locked up in the ice sheets and the sea level drops considerably. At the outset of global warming, the ice sheets melt, thus releasing water to the sea, and so the sea level rises. From the point of view of the Garden Island Ridge, the Wurm Glaciation (17,000-10,000 years B.P.), and the Riss Glaciation (170,000-130,000 years B.P.) are the key factors. Fig. 4 shows a eustatic sea level curve for the past 140,000 years, related to these two glaciations and their intervening interglacial periods. At about 130,000 years BP the sea level rose at the close of the Riss Glaciation; at around 10,000 years BP, the Wurm Glaciation finished, and the sea level began rising again. Direct evidence for a lower sea level at about this time was the dating of a fresh water peat 20 metres below present sea level in the Swan River District at 9850 years B.P. (Churchill, 1959).

Crustal Movement

There is, however, strong evidence that sea level changes were also due to warping of the Earth's crust in the Perth coastal region. Seismic surveys during petroleum exploration have shown the presence of a number of faults cutting older rocks (Lower Cretaceous and older), some of which could have moved during the last 150,000 years. These faults are shown in Figure 1. That movement along faults in southwestern Australia has taken place in historic times is shown by, for example, the Meckering (1968) and Cadoux (1979) earthquakes (Gordon & Lewis, 1980; Lewis *et al*, 1981).

Detailed studies at several locations in the southwestern Australian coastal zone show that during the last 8,000 years sea level changes have not been uniform along the coast. Semeniuk & Searle (1986) investigated three transects along 170 km of the southwestern coast at Whitfords, the Rockingham Plain and the Leschenault Peninsula (Fig. 6B, transects 1, 3 and 4). At each transect the Holocene stratigraphy was examined down to the Holocene/Pleistocene boundary. Material was collected for radiocarbon age determination.

At Whitfords (Fig. 6B, transect 1), the sea level was found to be about 1 metre below the present level at 7,415 years BP, and gradually rose to current levels at around 5,100 years BP. At the Rockingham - Becher Plain, in the vicinity of Penguin Island, the earliest sedimentation began at 6,400 years BP, with a sea level of +2.5 metres. It then fell to +1.5 metres at about 4,800 years BP, halted, then fell to +0.5 metre at 3,600 years BP. Sea level began to fall to current levels at around 2,600 years BP (data from Fig. 3 of Semeniuk & Searle, 1986).

In the Leschenault Peninsula area (Fig. 6, transect 4), the sea level was 2 to 3 metres below current levels from 7,000 to 5,500 years BP. It then rose to 3 – 4 metres above the current level between 4,800 – 3,500 years BP. By 2,800 years BP, the sea level was lowered to current levels.

Information from Playford's (1988) studies of Rottnest Island has been included in Fig. 6 (transect 2). There the sea level rose to +2.5 metres between 5,900 – 4,800 years BP (the deposition of the Vincent Member), and to +1 metre between 3,100 – 2,200 years BP (deposition of the Baghdad Member).

Searle & Woods (1986) found that in the Swan coastal plain near Rockingham about 6,500 - 6,400 years ago, the sea level was 2.5 to 3 metres higher than today, and that it fell to its present level about 1,000 years ago. However, Kendrick (1977) found that the sea level in the Swan River Valley rose no higher than 0.5 m above today's level about 6,700-4,500 years ago.

Thus, from the foregoing paragraphs we can see that the fluctuation of sea level over the last 8,000 years is most obviously explained by crustal movement along faults such as those illustrated in Fig. 1. It seems that some of these happenings over the last 10,000 years are recorded in Aboriginal legend (Glover, 2003; see also Appendix II).

Comment

From the two previous sections, we can see that both glacial events and local crustal movement will probably account for sea level changes. Glacial events will provide world-wide sea level changes; The crustal warping here and there will account for local sea level changes.

SUMMARY OF GEOLOGICAL HISTORY

1. The end of the Riss Glaciation occurred about 140,000 years ago. The sea level rose to its highest level during the succeeding interglacial period at 117,000 – 130,000 years B.P.
2. The fossil coral reef represented by the Rottnest Limestone extends to 3.02 m above the adjoining shoreline platform at Rottnest (the current sea level). The reef was built mainly by the coral *Acropora*, which at present time, does not build reefs further south than the Houtman Abrolhos, 350 km to the north. This indicates warmer water conditions than today. The height of the reef, 3 m above current sea level, is evidence of a higher sea level than currently at that time (c. 132,000 BP – Fig. 6).
3. The sea level proceeded to fall during the following glacial period, reaching its lowest level about 18,000 years ago (Fig. 4), with the coastline being some 10 km west of Penguin Island.
4. About 10,000 years ago the sea level rose rapidly to near current levels at around 6,500 – 7,000 B.P. (Fig. 6).At Rottnest Island there were two brief periods when the transgression halted, when wave-cut benches and notches were eroded at about 0.5 m and 1.1 m above present sea level. The peak transgression was reached at 2.4 m.
5. In the Rockingham Plain, Penguin Island and Cape Peron area, the peak submergence at +2.5 to +3 metres occurred at around 6,500 - 6,200 years BP (Semeniuk, 1995). At this time, the 3 metre emergent platform may have been formed by erosion (Fig. 6).
6. Between 4,800 –4,000 years BP the sea level was at about +1.5 metres (Fig. 6); at this stage, the 1.5 metre (5 foot) emergent platform may have been formed. Also, the beach rock of the Penguin Island Limestone was possibly formed; at Long Reach, Point Peron, the calcarenite forms Fairbridge's (1950) 5 foot platform.
7. Between 4,000 – 2,600 years BP the sea level was at about +0.5 metre, when the 0.5 metre platform was probably developed (Fig. 6).
8. After 2,600 years, sea levels descended to current levels, and current beach deposits and beach rock were formed.

CONCLUDING REMARKS

This report has been compiled in order to provide CALM and other interested bodies with geological information on Penguin Island in context with the wealth of information the Garden Island Ridge and the adjoining mainland.

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REFERENCES

Chape, S. (1984): Penguin Island Draft Management Plan. *National Parks Authority, Department of Conservation & Environment, Western Australia.*

Churchill, D. M. (1959): Late Quaternary eustatic changes in the Swan River District. *J. Roy. Soc. W. A., v. 42, 29-41.*

Dodds, Frances S., Kendrick, George W., Lefevre, Margaret C. & Roe, Robin (1991): Fossils from Orange Grove: a local puzzle solved. *The Western Australian Naturalist, v. 18, no. 6, 148-157.*

Fairbridge, R. W. (1950): The geology and geomorphology of Point Peron, Western Australia. *J. Roy. Soc. W. A., v. 37, 35-72.*

Glover, J. (2000): Geology in Myth and Legend. GEOLOGICAL JOURNEYS: FROM ARTIFACTS TO ZIRCON. *Geol. Soc. Of Australia (WA Division), p. 39.*

Gordon, F. R. & Lewis, J. D. (1980): The Meckering and Calingiri earthquakes, October 1968 and March 1970. *West. Australia Geol. Surv. Bull. 126, 229 p.*

Gozzard, J. R. (1983): Rockingham part Sheets 2033 III and 2033 II. *Perth Metropolitan Region, Environmental Series; Geol. Surv. W. A.*

Green, B. (1997): Rehabilitation and management plan for the Haliotis Bay Headland, Point Peron. *Ministry For Sport & Recreation: Science Rept. 97/6.*

Kendrick, G. W. (1977): Middle Holocene marine molluscs from near Guildford, Western Australia, and evidence for climatic change. *Roy. Soc. W. A. Jour., v. 59, pp 97-104.*

Lewis, J. D., Daetwyler, N. A., Bunting, J. A.& Moncrieff, J. S. (1981): The Cadoux earthquake, 2nd June 1979. *West. Australia Geol. Surv. Rept. 11, 133 p.*

McArthur, W. M. & Bartle, G. A. (1981): The landforms, soils and vegetation as a basis for management studies on Garden Island, Western Australia. *CSIRO Land Resources Management Series No. 7.*

Marine & Harbours Technical Services Division (1992): MANGLES BAY MARINA: Public Environment Review. *Report No. DMH P15/92, October, 1992.*

Passmore, J. R. (1970): Shallow coastal aquifers in the Rockingham district, Western Australia. *Water Research Foundation, Bull. 18.*

Playford, P. E. (1950): Penguin Island. *Res. Rept. No. 19, Geographical Laboratory, Univ. W. A. Nedlands, W. A. Australia.*

Playford, P. E. (1977): Geology and groundwater potential, in Geology and hydrology of Rottnest Island. *West. Australia Geol. Surv. Rept 6, Part 1,1-53.*

Playford, P. E. (1988): Guidebook to the geology of Rottnest Island. *Geol. Soc. Aus. (W. A. Div) Excursion Handbook No. 2.*

Playford, P. E., Cockbain, A. E. & Low, G. H. (1976): Geology of the Perth Basin, Western Australia. *West. Australia Geol. Surv. Bull. 124.*

Searle, D. J., Semeniuk, V. & Woods, P. J. (1988): Geomorphology, stratigraphy and Holocene history of the Rockingham-Becher Plain, southwestern Australia. *J. Roy. Soc. W. A., v. 70, 89-109.*

Searle, D. J. & Woods, P. J. (1986): Detailed documentation of a Holocene sea-level record in the Perth region, southern Western Australia. *Quaternary Research, v. 26, 299-308.*

Semeniuk, V. (1983): The Quaternary history and geological history of the Australind - Leschenault Inlet area. *J. Roy. Soc. W. A., v. 66, 71-83.*

Semeniuk, V. (1986): Holocene climate history of coastal Southwestern Australia using calcrete as an indicator. *Palaeogeography, Palaeoclimatology, Palaeoecology, v.53, 289-308.*

Semeniuk, V & Johnson, D. P. (1982): Recent and Pleistocene beach/dune sequences, Western Australia. *Sed. Geol., v. 32, 301-328.*

Semeniuk, V. & Searle, D. J. (1985): The Becher Sand, a new stratigraphic unit for the Holocene of the Perth Basin. *J. Roy. Soc. W. A., v. 67, 109-115.*

Semeniuk, V. & Searle, D. J. (1986): Variability of Holocene sealevel history along the southwestern coast of Australia – evidence for the effect of significant local tectonism. *Marine Geol. v. 72, 47-58.*

Semeniuk, V. & Searle, D. J. (1987a): The Bridport Calcilutite. *J. Roy. Soc. W. A., v. 70, 25-27.*

Semeniuk, V. & Searle, D. J. (1987b): Beach rock ridges/bands along a high-energy coast in southwestern Australia – their significance and use in coastal history. *J. Coast. Res., v. 3, 331-342.*

Szabo, B. J. (1979):Uranium-series age of coral reef growth on Rottnest Island, Western Australia. *Marine Geology, v. 29, M11-M15.*

Tingay, A. (1995): City of Rockingham Foreshore Appraisal. *Alan Tingay & Ass., June 1995; Rept. No. 95/12.*

Zhu, Z. R., Wyrwoll, K. H., Collins, L. B., Chen, J., Wasserburg, G. J., & Eisenhauer, A. (1993): High-precision U-series dating of Last Interglacial events by mass spectrometry: Houtman Abrolhos Islands, Western Australia. *Earth & Plan. Sci. Letters, v. 118, 281-293.*

APPENDIX I: MINING ACTIVITY – PENGUIN ISLAND

The White family settled in the Canning District in 1842 and subsequently acquired land near Bickley Brook, Orange Grove (Dodds, *et. al.*, 1991). They established a vineyard in 1874 and, about 1880, began to crop wheat and oats on soil deficient in nutrients. During an investigation into a mysterious occurrence of apparent fossil sea shells in the area in 1987, Dodds *et. al.* (1991) held discussions with Mr. George White, a descendant of the White family. Mr. White recalled being told (in the 1920's) by his uncles Jabez and Harry (grandchildren of the original Whites) of trips by horse and cart to Rockingham during the previous century. They picked up loads of guano which were brought back to the farm, spread out and ploughed in. Obviously, the sea shells came with the guano.

Mrs. Robin Roe, a co-author of the Dodds, *et. al.*(1991) paper, in a personal communication, quoted some oral history from a White family descendant – a Mrs. E. A. Morrow – recorded in 1987: "That it took three weeks for the Whites to go to Rockingham by wagon/dray to get guano from an island; there was a spit you could go over at low tide" (*? Penguin Island?*). She suggested that they floated the guano back on a raft.

The Government Gazette Index 1836-1890 lists licences to collect guano from Crown Lands. It seems that J. & W. Bateman were licensed to collect 9 tons of guano from "Rocks south of Fremantle" between 4 March and 4 April, 1885.

The writer is greatly indebted to Mrs. Robin Roe of the Royal Western Australian Historical Society for all the above information, and wishes to thank her.

As mentioned on page 2 of this report, Chape (1984) states that the plateaux were scraped clear of their nitrogenous soils early this century. Penguin Island's Lease was taken over in 1969 by **Penguin Island Ltd**. The following is quoted from this company's brochure: "Mr. Gus Smith of Claremont, now nearly 90, first visited the island in 1901 and planted several fig trees in the present picnic area. He remembers the black soil on the island being collected as guano by **Bunny & Son**, Welshpool, and taken by boat to Fremantle where it was sold as fertilizer". The writer has searched the Battye Library and the Public Records Office for supporting evidence, but in vain.

On 9th August, 1922, Temporary Reserve 307^{H}, for exploration for phosphate rock, was applied for by Mr. A. P. Lennon. It covered the reef south of Cape Peron to The Sisters, and included Penguin Island (Fig. 7). The Application was refused on 5 February, 1923, and no phosphate rock (i. e., guano) was mined. Jan Lord noted that Mr. Lennon's name was signed in Seaforth McKenzie's Visitors Book during 1922.

Some inspiration for my search for information could come from the reading of the following legal idiosyncrasy still contained in Western Australia's Criminal Code:

Criminal Code s 387: "Removing guano without a licence": any person who collects or removes guano (in WA) without lawful authority.....is liable to imprisonment for one year.

Maybe the writer should look through Fremantle Prison Records for other information.

APPENDIX II: ABORIGINAL MYTHS AND LEGENDS.

From knowledge of my native Welsh folk lore, I have found that certain geological happenings from 10,000 years ago have been recorded in folk stories: for example, a story of the world-wide sea level rise after the last glaciation is told. Briefly, it goes: "If you go to Fishguard in Pembrokeshire, West Wales, and stand on top of the cliffs looking northward over Cardigan Bay, you will see the Irish Sea. But, if you are lucky, you may stand in a fairy circle: then you will not see the bay. You will sea all the forests that used to be there, along with the little clearings where the people used to live". Now, apart from the geological knowledge of the sea level rise at the end of the glaciation, there is other confirmation of this story: if one goes around the coast northwards to Borth, just north of Aberystwyth, at a "king" low tide one will see the remains of the old stumps of the trees that once formed a forest that has now been drowned by sea level rise. Because of stories such as this example, I had often wondered if such memories are recorded in local (i. e., southwestern Australian) aboriginal legend. Then I saw the article in the *West Australian Geologist*, December, 2000, by John Glover of the University of W. A. (now published in Glover, 2003). I quote the relevant section from his article, referring to southwestern Australia:-

An Australian Euhemeristic Legend

"The legend is summarised by Moore, in his 1884 book *Diary of Ten Years Eventful life of an Early Settler in Western Australia; and also a Descriptive Vocabulary of the Language of the Aborigines*, Walbrook, London. Moore wrote: 'The natives have a tradition that Rottnest, Carnac, and Garden Island once formed part of the mainland, and that the intervening ground was thickly covered with trees; which took fire in some unaccountable way, and burned with such intensity that the ground split asunder with a great noise, and the sea rushed in between, cutting off those islands from the mainland'.

We know that eustatic oscillations of the sea were followed by a general rise of sealevel during the late Pleistocene and early Recent. There were probably sudden surges of the sea when barriers gave way during its otherwise slow advance. We know also that sporadic faulting and earthquakes currently affect parts of southwestern Australia, causing ground to 'split' noisily, and that lightning currently ignites many bush fires. Each of these events probably occurred many times during the 50,000 years or so of Aboriginal occupation. The legend may have combined separate dramatic events into one story.

Many of the small Aboriginal artifacts scattered on the surface of the Swan Coastal Plain consist of Eocene chert, and these artifacts tend to increase in abundance westward. There is no outcrop of Eocene chert on the plain. The distribution of the chert artifacts suggests that the chert came from outcrops west of the present coast when sealevel was lower. The chert must have been a valuable resource to Aborigines before being inundated. The legend of subsidence recorded by Moore does not mention the chert, but fits in with evidence of its western origin".

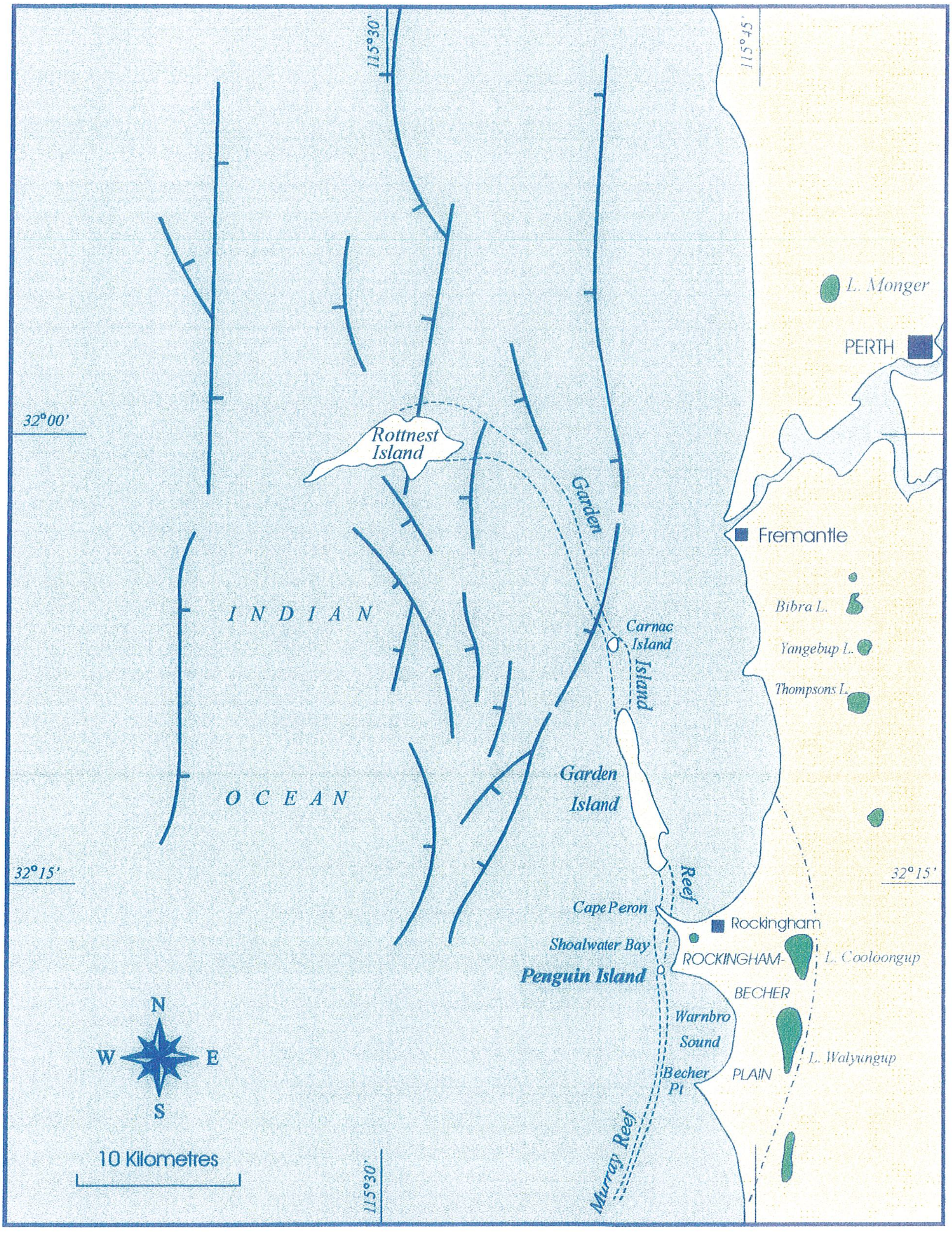


FIGURE 1 Perth-Rottnest-Penguin Island area showing faults that cut Lower Cretaceous and older rocks (deduced from seismic surveys). Also showing the Rottnest to Penguin Island Reef as seen on Landsat image "Perth From Space" (DOLA 1996) (After Playford, 1988, with modification)

Cartography by D. Maxwell

Geology by W.R. Morgan, June 2000

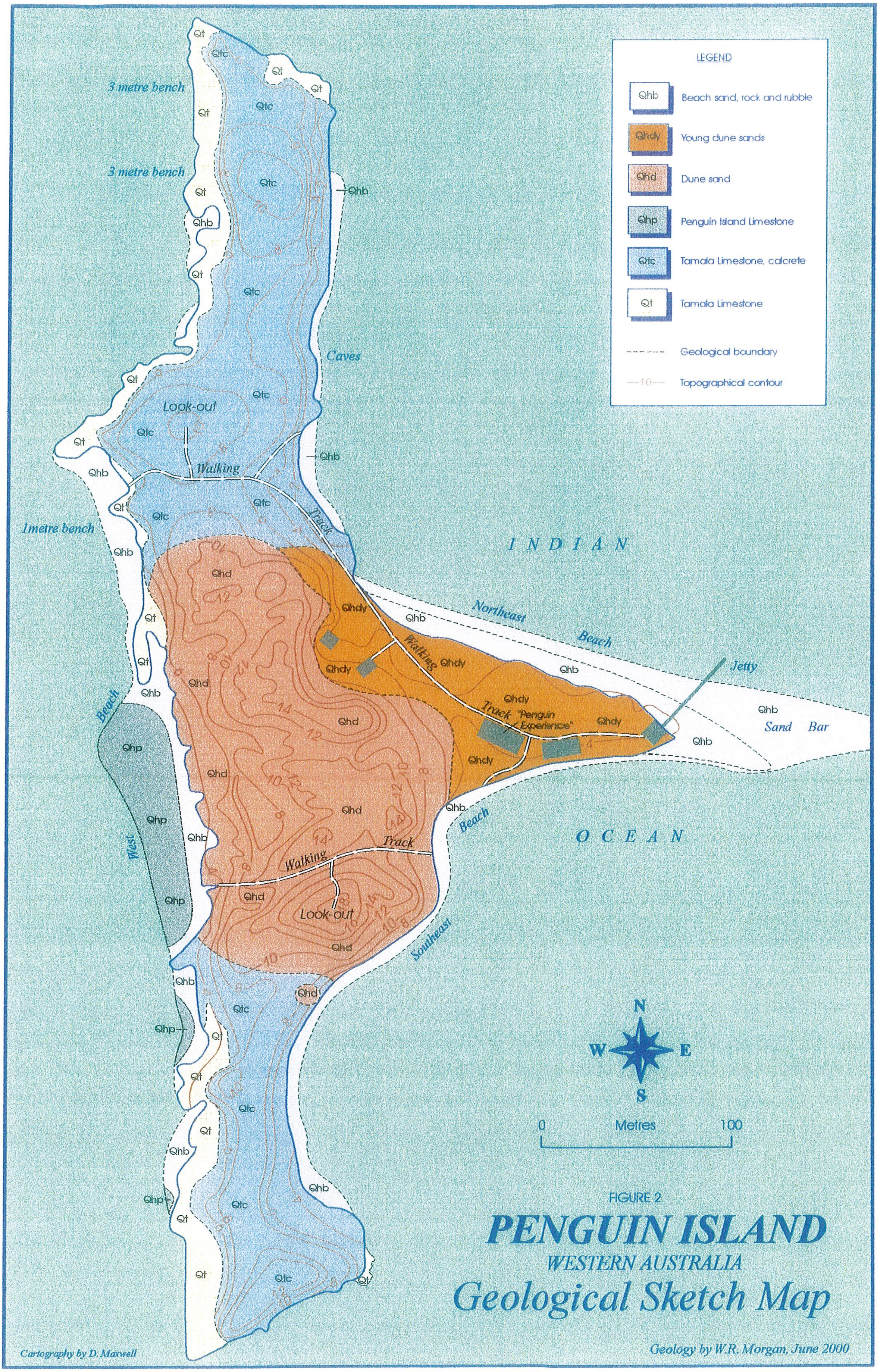
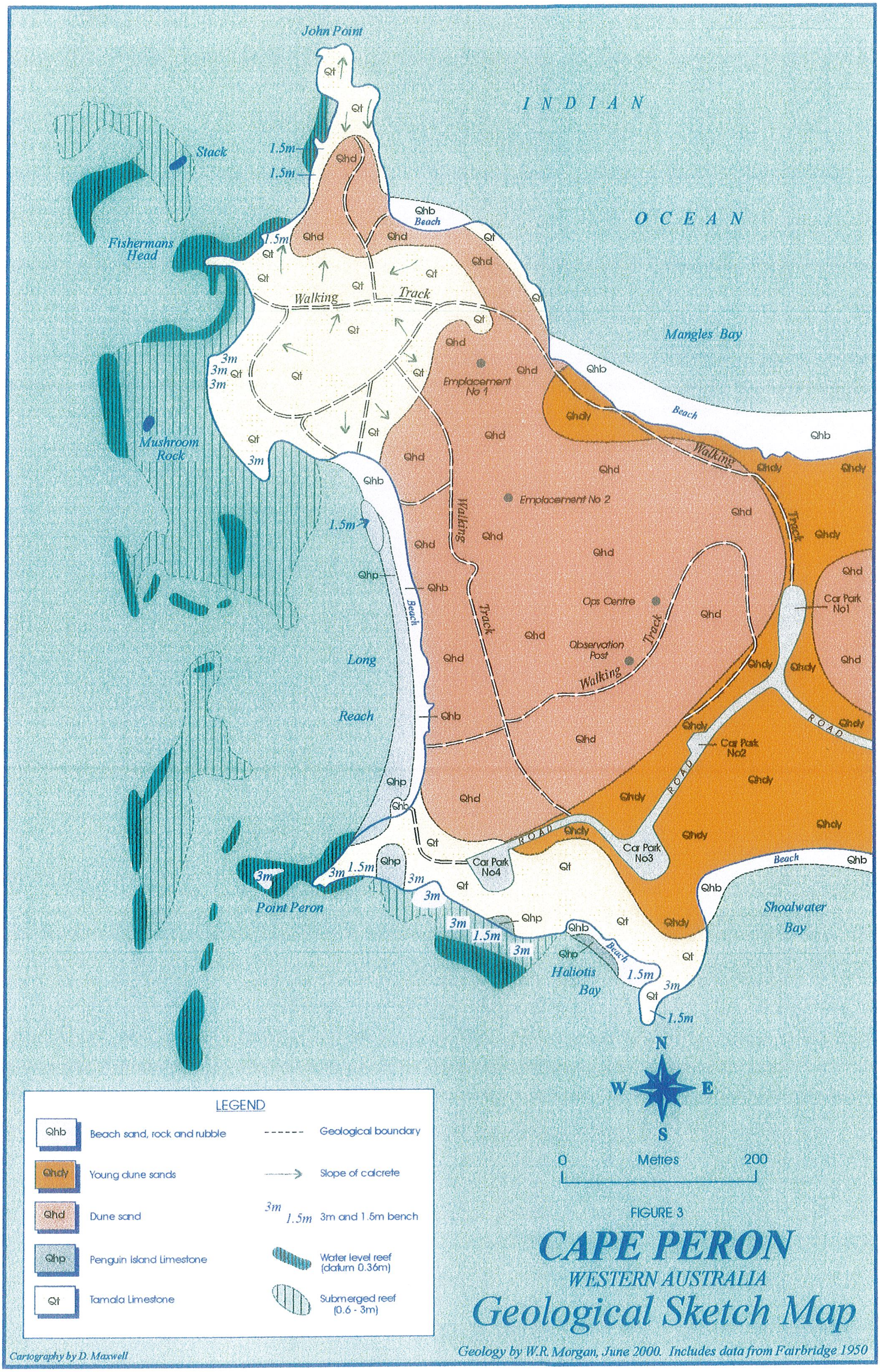


FIGURE 2

PENGUIN ISLAND

WESTERN AUSTRALIA

Geological Sketch Map


John Point
INDIAN
OCEAN
Stack
Fishermans Head
Mushroom Rock
Mangles Bay
Walking Track
Emplacement No 1
Emplacement No 2
Ops Centre
Observation Post
Car Park No1
Car Park No2
Car Park No3
Car Park No4
ROAD
Beach
Long Reach
Point Peron
Haliotis Bay
Shoalwater Bay
Qhb
Qhdy
Qhd
Qhp
Qt
3m
1.5m
LEGEND
Qhb Beach sand, rock and rubble
Qhdy Young dune sands
Qhd Dune sand
Qhp Penguin Island Limestone
Qt Tamala Limestone
Geological boundary
Slope of calcrete
3m 1.5m 3m and 1.5m bench
Water level reef (datum 0.36m)
Submerged reef (0.6 - 3m)
N
W
E
S
0
Metres
200
FIGURE 3
CAPE PERON
WESTERN AUSTRALIA
Geological Sketch Map
Cartography by D. Maxwell
Geology by W.R. Morgan, June 2000. Includes data from Fairbridge 1950

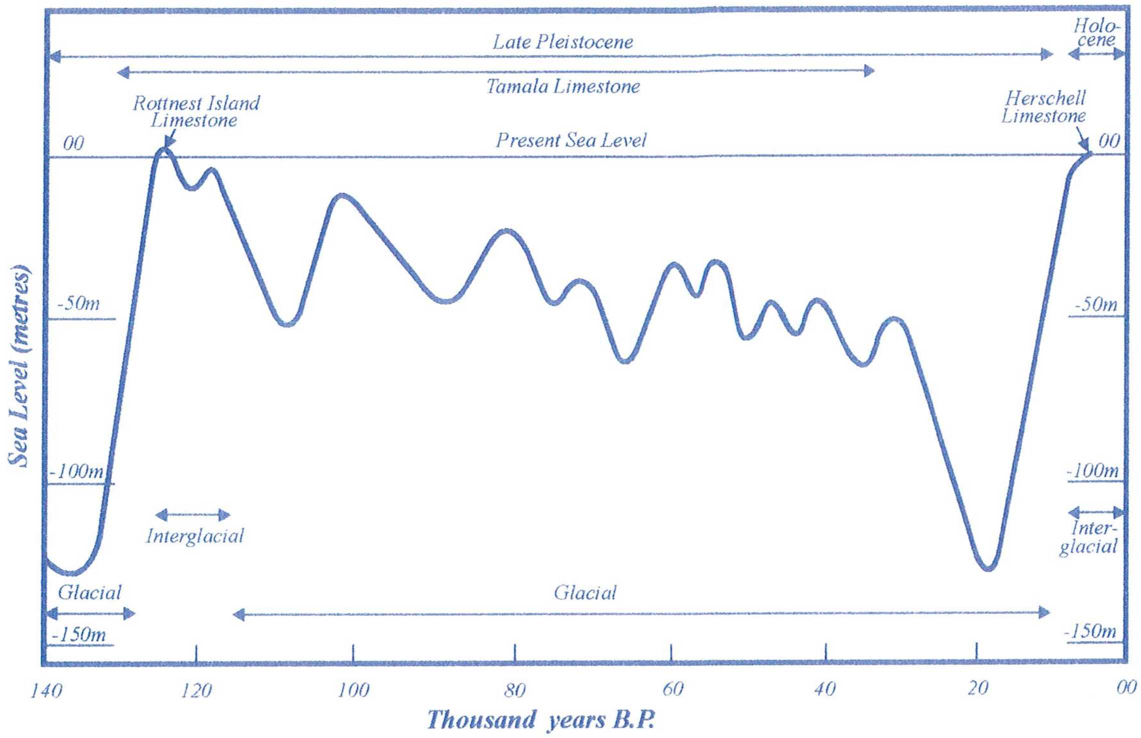


FIGURE 4 : Eustatic sea level curve for the past 140 000 years (after Playford 1988)

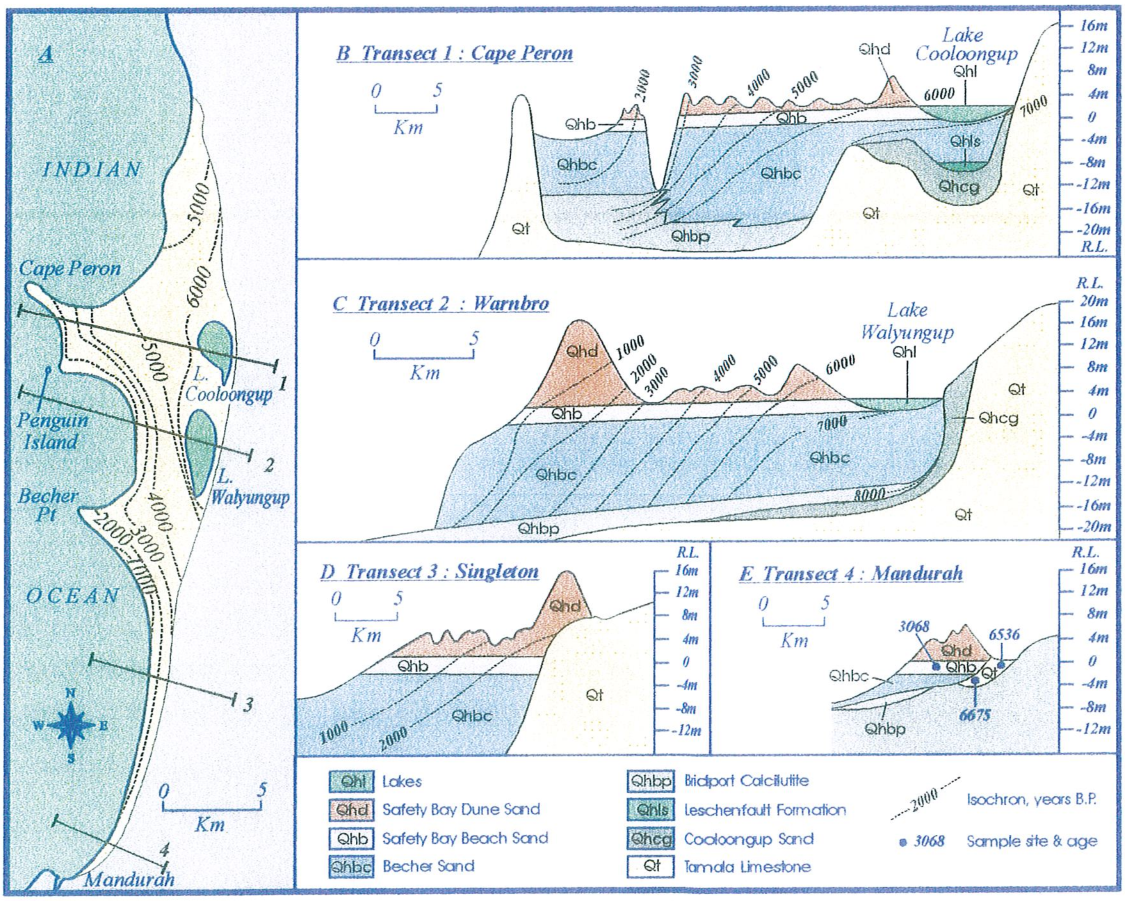


FIGURE 5 : Age structure of the Rockingham - Becher Plain
A: Plan view showing isochrons in 1000's of years B.P.
B - E: Cross sections showing the Holocene stratigraphy and interpreted isochrons based on radiocarbon dating (After Searle, Semeniuk & Woods 1988)

Cartography by D. Maxwell

Compiled by W.R. Morgan, June 2001

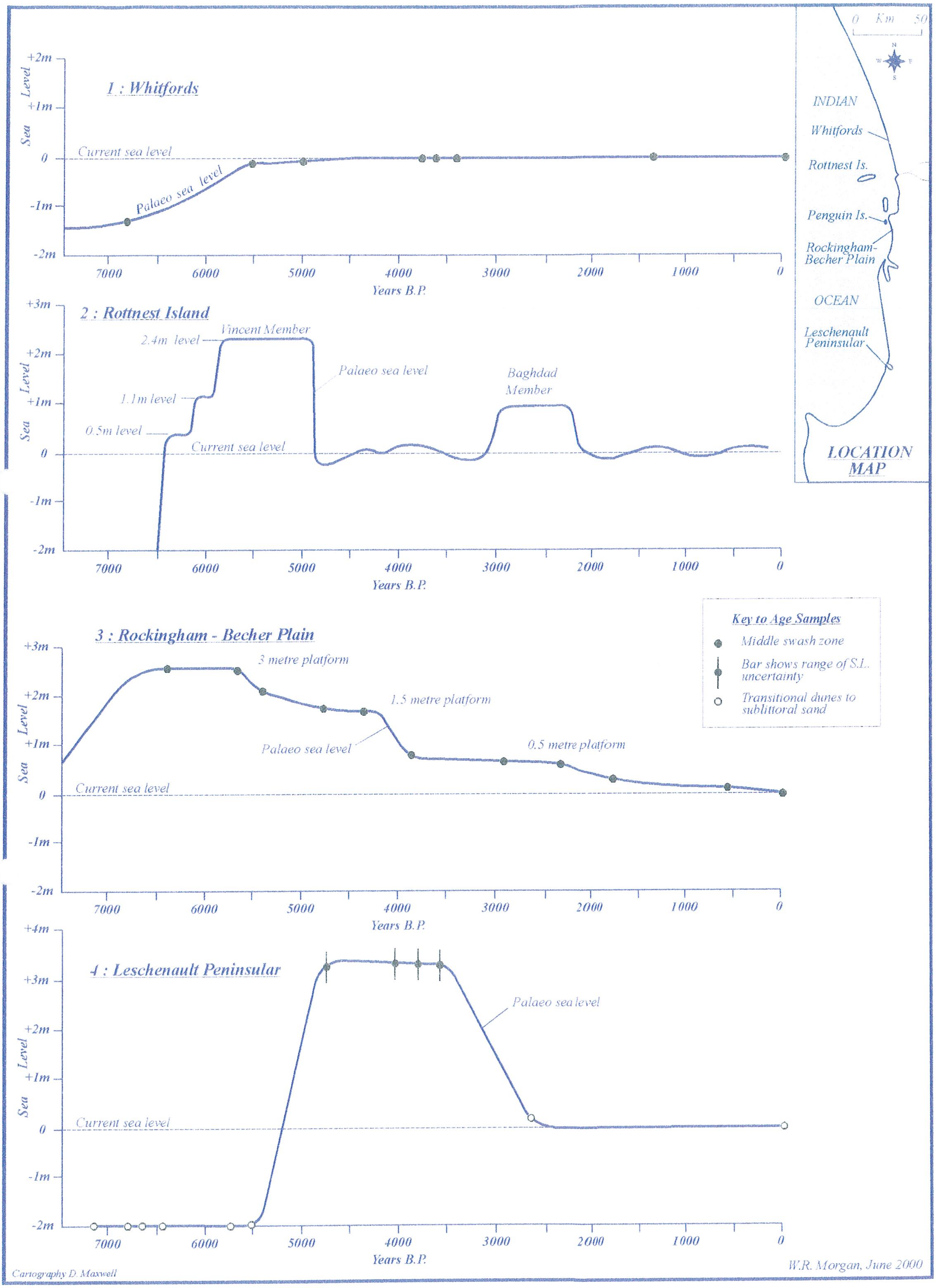
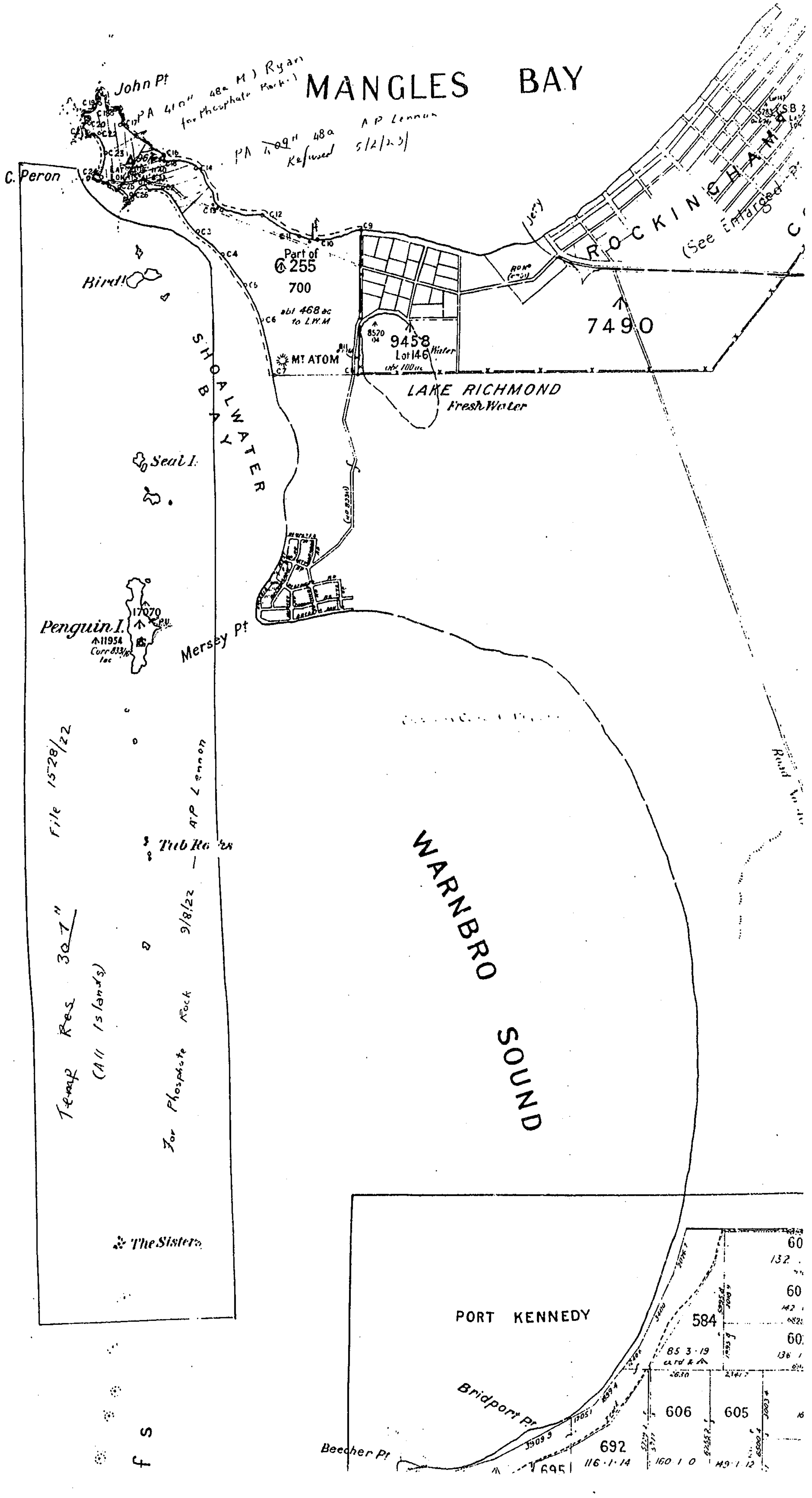


FIGURE 6 : Interpreted curves of sea level history. Whitfords, Rockingham - Becher Plain and Leschenault Peninsular (after Fig. 3 of Semeniuk & Searle 1986). Rottnest Island (after Playford 1988).



Refused
5/2/23

PEEL HARBOUR: ITS LOCATION

The accompanying map shows the location of Peel Harbour as being within Warnbro Sound, south of Waikiki. The map is the result of some research following the publication of a small article in the "*Weekend Courier*" of 15th February, 2002. In this article, Mr. Frank McAullay displayed the results of maps of Warnbro Sound as surveyed by David Adams in 1837 on behalf of Thomas Peel. Mr. McAullay claimed that Peel Harbour underlay a substantial portion of what is now Waikiki.

In my research, I traced the Shoalwater Bay and Warnbro Sound coastline from a print of a map prepared by A. C. Gregory, Colony Assistant Surveyor, during 1843-1844, showing Peel Harbour. The print is contained in the collection of historical maps kept at the Rockingham Museum, Kent Street, Rockingham Beach. By means of an accurate photocopy machine (Sterling Stationery, Kent Street) I reduced the tracing to a scale of 1:25,000. I then traced the coastline of the same area from the DOLA 1:25,000 Rockingham Sheet 2033-III NE of 1978 (the most recent government topographical map of the area).

A third tracing was made by superimposing the DOLA tracing over the 1:25,000 tracing of A. C. Gregory's 1843-4 map. Care was taken to ensure that Cape Peron and Penguin Island of both maps were superimposed on each other. The reason for this is that both the cape and the island are built of solid rock, and, therefore, unlikely to be moved by storm waves. The coastal sands that comprise much of the Rockingham coastline are very unstable, particularly when affected by storm waves, and are moved very easily.

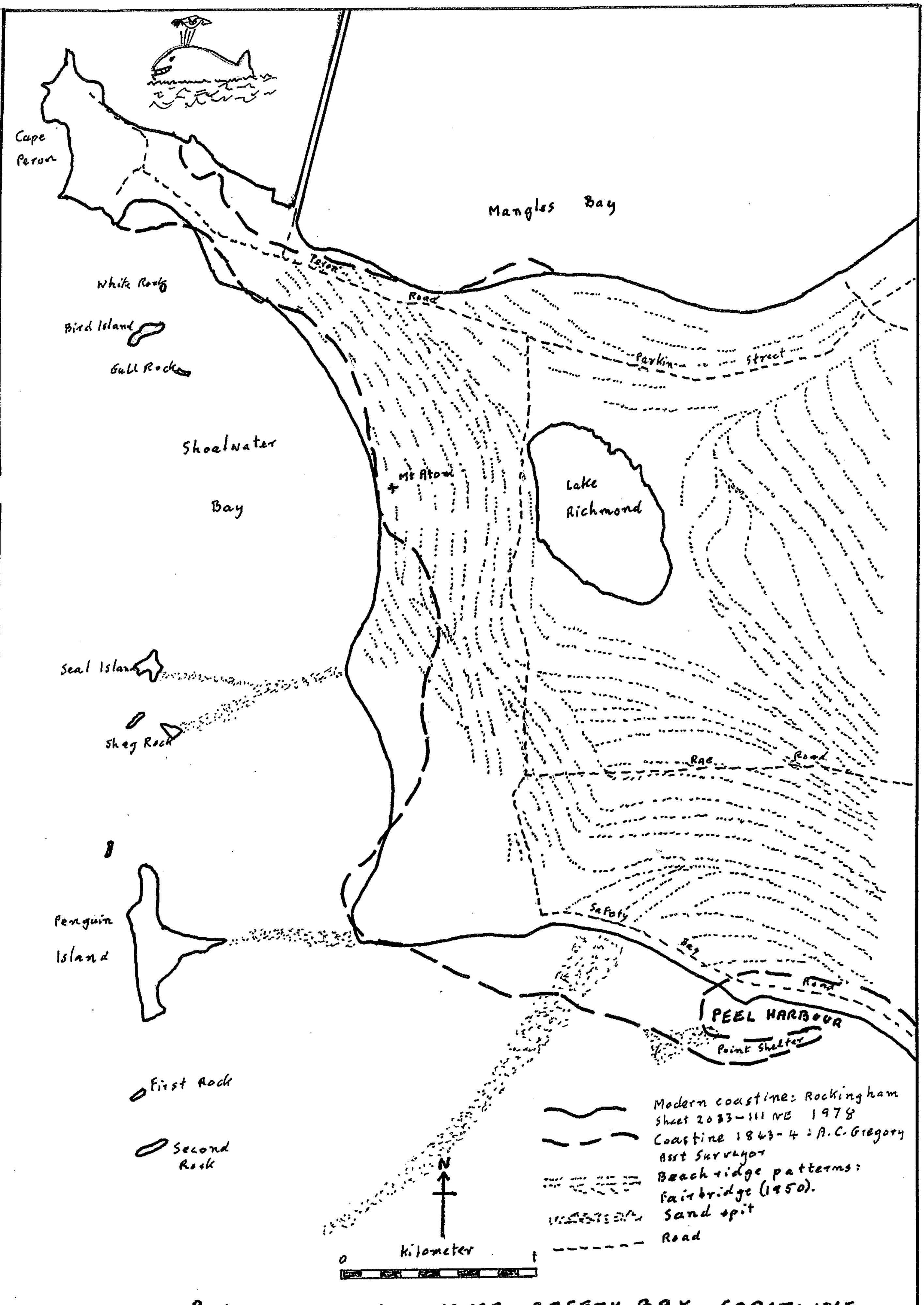
The resulting map shows that Peel Harbour existed south of Waikiki, in what is now Warnbro Sound. The map shows the 1978 coastline (continuous line) and the 1843-4 coastline (heavy dashes). The map also shows the sand spits developed by erosion of the offshore islands and reefs; it is interesting to see how the coastline has been built westward in Shoalwater Bay by the sand spit from Seal Island and Shag Rock.

In addition, I have traced on the beach ridge patterns as shown in a map by Fairbridge (1950). These ridges are the result of the growth of the Rockingham Plain over the last 6,000 years: note that they were – in 1950 – present in the Waikiki area: if, in fact, there was a basin or bay in Waikiki in the early 1800's that was later filled in by storm activity, they would not be present.

REFERENCE

Fairbridge, Rhodes W. (1950): The geology and geomorphology of Point Peron, Western Australia. *Journal of the Royal Society of Western Australia, v. 37, pp 35-72.*

Bill Morgan,
11th March, 2002.



SHOALWATER - SAFETY BAY COASTLINE

1843 - 1978

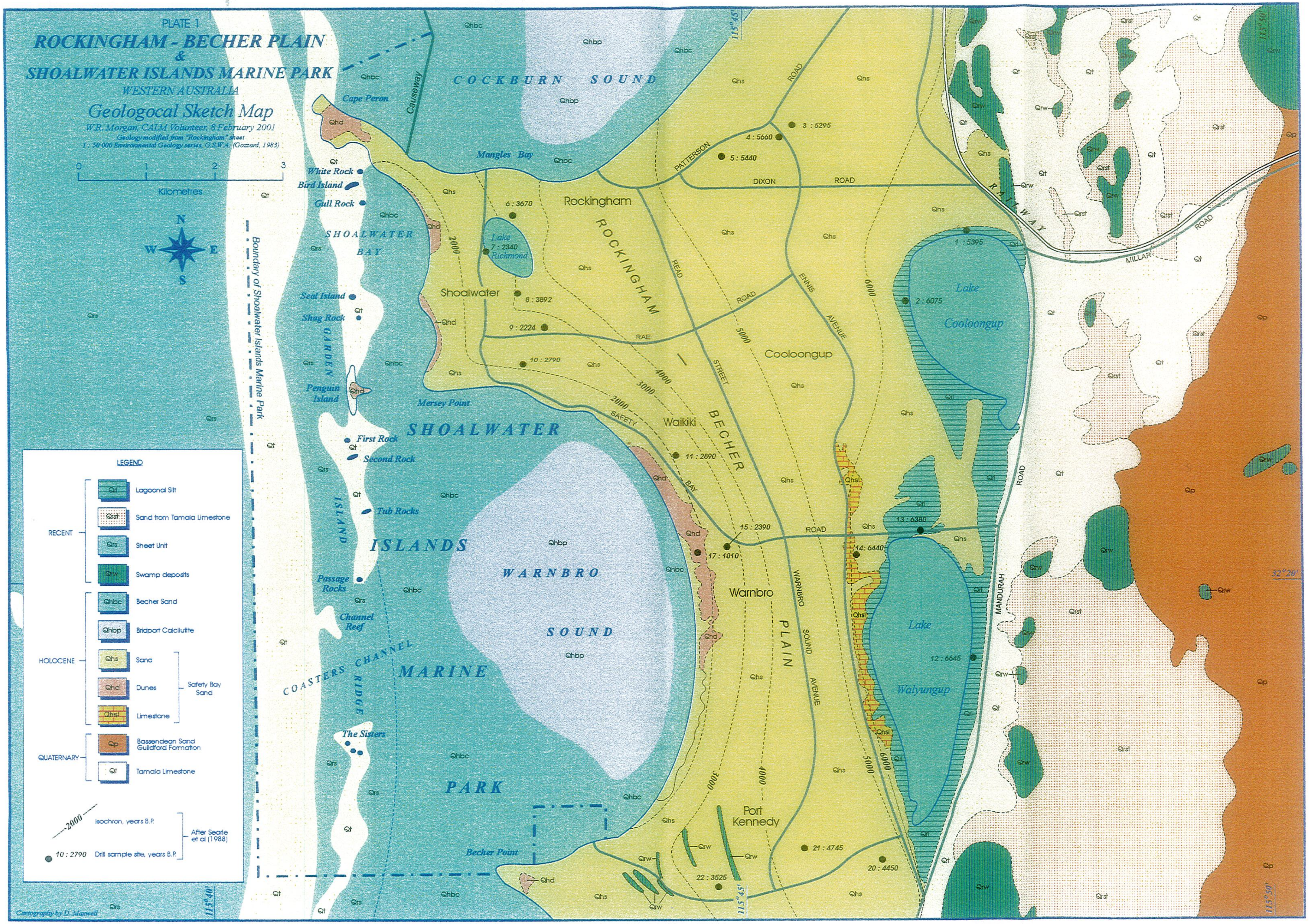


PLATE 1
ROCKINGHAM - BECHER PLAIN
&
SHOALWATER ISLANDS MARINE PARK
WESTERN AUSTRALIA
Geologocal Sketch Map
W.R. Morgan, CALM Volunteer, 8 February 2001
Geology modified from "Rockingham" sheet
1 : 50 000 Environmental Geology series, G.S.W.A. (Gozzard, 1983)
0 1 2 3
Kilometres
N
W
E
S
LEGEND
RECENT
Lagoonal Silt
Sand from Tamala Limestone
Sheet Unit
Swamp deposits
HOLOCENE
Becher Sand
Bridport Calcilutite
Sand
Dunes
Limestone
Safety Bay Sand
QUATERNARY
Bassendean Sand Guildford Formation
Tamala Limestone
2000 Isochron, years B.P.
10 : 2790 Drill sample site, years B.P.
After Searle et al (1988)
Cartography by D. Maxwell
COCKBURN SOUND
Causeway
Cape Peron
Mangles Bay
White Rock
Bird Island
Gull Rock
SHOALWATER BAY
Seal Island
Shag Rock
GARDEN ISLAND
Penguin Island
Mersey Point
First Rock
Second Rock
Tub Rocks
SHOALWATER ISLANDS MARINE PARK
Passage Rocks
Channel Reef
COASTERS CHANNEL RIDGE
The Sisters
Boundary of Shoalwater Islands Marine Park
WARNBRO SOUND
Becher Point
Rockingham
Shoalwater
Lake Richmond
Waikiki
Warnbro
Port Kennedy
Cooloongup
ROCKINGHAM - BECHER PLAIN
Lake Cooloongup
Lake Walyungup
PATTERSON ROAD
DIXON ROAD
RAE ROAD
SAFETY BAY ROAD
ENNIS AVENUE
WARNBRO SOUND AVENUE
MANDURAH ROAD
MILLAR ROAD
RAILWAY
115°45'
115°40'
115°50'
32°20'
1 : 5395
2 : 6075
3 : 5295
4 : 5660
5 : 5440
6 : 3670
7 : 2340
8 : 3892
9 : 2224
10 : 2790
11 : 2890
12 : 6645
13 : 6380
14 : 6440
15 : 2390
17 : 1010
20 : 4450
21 : 4745
22 : 3525