Barry Hussey

# Penguin Island
# Draft Management Plan

Stuart Chape

**Acknowledgements**

Most of the resource information contained in Chapter 2 was prepared by Nick Dunlop following a terrestrial resource survey of Penguin Island. Special mention should be made regarding his detailed ecological work on the seabirds of the Fremantle area which has provided valuable information for this management plan.

I also wish to thank Dr. Michael Borowitzka, Dr. Roger Lethbridge and Professor Ian Potter of Murdoch University who provided the valuable text and diagrams describing the marine environment in Chapter 2. Thanks also to Steven Davies who worked on the penguin observatory proposal and prepared numerous drawings.

## Preface

Penguin Island, lying at the southern end of Shoalwater Bay in the Shire of Rockingham, is one of the most valuable conservation and recreation resources in the metropolitan region. In 1982, the National Parks Authority resolved to prepare a comprehensive management plan to address the major management issues on the island, especially those concerning erosion and access control. Following consultation with the Department of Conservation and Environment it was agreed that the Department would provide the services of its coastal management staff to undertake preparation of a management plan on behalf of the Authority.

This draft plan has now been adopted in principle by the National Parks Authority subject to the receipt of public comments over the next three months. All comments will be considered and a final document prepared. Closing date for comments is 24th August, 1984 and correspondence should be sent to:

Director,
Department of Conservation & Environment,
1 Mount Street,
Perth, W.A. 6000.

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# 1. INTRODUCTION

## 1.1 The Island

Penguin Island is an A-class reserve (A17070) vested in the National Parks Authority of Western Australia. The island is 42 kilometres south-west of Perth, situated at the southern end of Shoalwater Bay approximately 600 metres west of Mersey Point in the Shire of Rockingham (see Map 1). The reserve has a total area of 12.54 hectares, of which approximately eight hectares are leased to Penguin Island Pty. Ltd. The gazetted purpose of the island's reservation is 'Recreation camping and enjoyment by the public for holidays and for purposes ancillary thereto'.

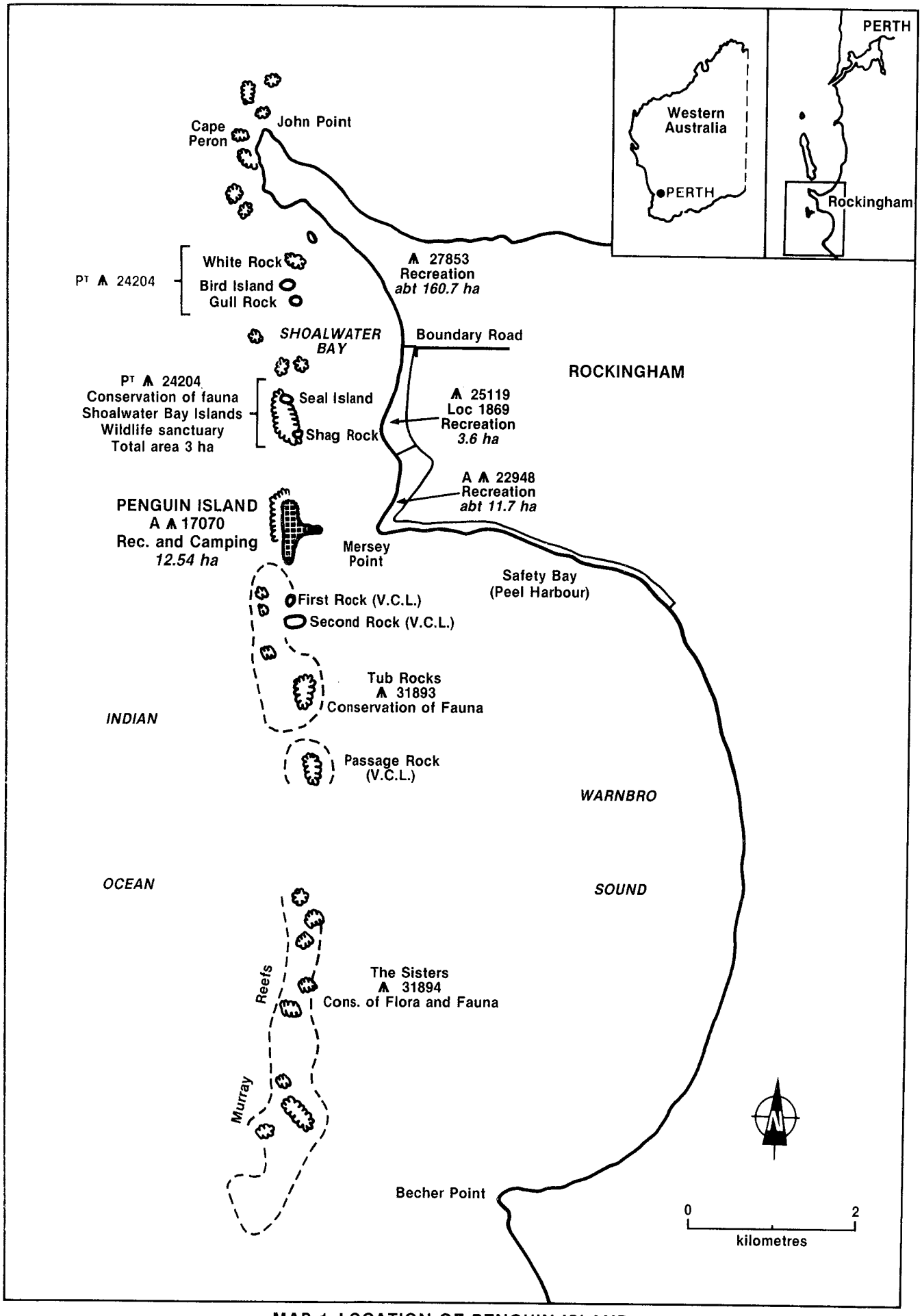
## 1.2 Purpose of the Plan

In recent years the loss of vegetation and destabilisation of sand dunes on Penguin Island has become increasingly evident. This has resulted primarily from the unmanaged activities of visitors, especially the large numbers of day visitors in the warmer months who walk across the shallow sand bar which connects the island to the mainland. The impact on fauna populations is not as obvious but it appears that changes have occurred as a result of gross modification to habitats as well as direct disturbance of nest sites and individual fauna.

However, although widespread destabilisation has increased in recent years due to intensifying use pressures, the island has been subject to man-induced environmental change for most of this century. Public awareness of human disturbance to Penguin Island is not a recent phenomenon either, as shown by the following press article written in 1949:

> WANT AN ISLAND?
>
> Does anybody want a beautifully situated island within 20 miles of Fremantle? Penguin Island, in the western end of Safety Bay, has become a problem child of the State Gardens Board.
> "We wish somebody would come forward with a plan for converting it into a resort", Gardens Board secretary Wm C. Hobson said yesterday.
> Thirty years or so ago, picturesque "Seaforth" MacKenzie lived a Robinson Crusoe existence here, alone with the penguins and a host of other feathered friends.
> Later it was administered by a trust. Tired of the trust, the members handed the island over to the Rockingham Road Board. The Road Board has so much trouble with weekend trippers, some of whom fouled the island disgracefully, that they recently handed it on to the State Gardens Board.
> (Sunday Times, 16 October 1949)

The last 30 years has seen a great expansion of the Perth metropolitan region with respect to development and population growth, especially in the Rockingham-Kwinana area since the early 1960s. During this time Penguin Island has come under increasing pressure as road systems have been improved and




MAP 1 LOCATION OF PENGUIN ISLAND.

nearby residential development has expanded. Forty years ago Penguin Island was perceived as being an 'out of town' holiday venue, now the suburbs of Rockingham lie a few hundred metres away.

Unfortunately, management of the island has not kept pace with increasing use pressures, despite the efforts of previous and current administrative authorities and their lessees. Although various attempts at management have been made they have tended to be piecemeal in approach and generally aimed at facilitating development and public use of the island without conserving the natural resources which are its perceived attractions. In 1982 the National Parks Authority recognised the need to address the major management issues regarding erosion and access control and, in consultation with the Department of Conservation and Environment, resolved to prepare a management plan for Penguin Island. Accordingly, the purpose of this report is to present a comprehensive management plan which examines all aspects of the island and makes recommendations on interim and long term management and development.

## 1.3 Nearby Lands and Waters

Penguin Island is the largest in a chain of islands and rocks stretching south from Cape Peron to Becher Point. As can be seen from Map 1 these emergent features are either conservation reserves vested in the Western Australian Wildlife Authority, or vacant Crown land administered under the Land Act by the Department of Lands and Surveys. The Western Australian Wildlife Authority has a statutory responsibility under the Wildlife Conservation Act to prepare management plans for reserves vested in it. Reserve 24204 (Shoalwater Bay Islands Wildlife Sanctuary) includes the two important insular features of Seal and Bird Islands, the former under increasing pressure from people arriving in boats or walking the shallow sand bar to the island.

Statutory controls also apply to the waters surrounding Penguin Island. The Department of Marine and Harbours is responsible for navigation, including the safety aspects of aquatic recreation, and also administers the Jetties Act. The Department of Fisheries and Wildlife administers the Fisheries Act, with regulations to control all aspects of professional and amateur fishing.

On the adjacent mainland the large Reserve 27853 (Recreation, about 161 hectares) covers most of Cape Peron south to Boundary Road (see Map 1). The reserve is vested in the Department for Youth, Sport and Recreation and contains numerous leases and sub-leases for recreation and holiday camps which attract thousands of visitors annually, especially in the summer months. Cape Peron also attracts day visitors and its south-western beaches and nearshore waters are heavily used in the warmer period of the year. Two foreshore reserves extend south from Boundary Road to Mersey Point. An unvested recreation reserve (25119, 3.7 hectares) extends as far as Coventry Road; while Reserve A22948 (Recreation, about 11.7 hectares) which is vested in the Rockingham Shire Council with power to lease, continues south into Safety Bay. The foreshore is well managed by the Council, although the area adjacent to the jetty at Mersey Point needs access control and dune restoration work.

## 2. NATURAL RESOURCES

### 2.1 Topography and Landscape

Penguin Island is part of a partially inundated late Pleistocene ridge of aeolianite limestone which extends northwards from the Murray Reefs west of Becher Point. The most prominent features of the ridge above sea level are Penguin, Seal and Bird Islands, Shag Rock and Gull Rock in Shoalwater Bay, the Cape Peron peninsula and Garden Island. The larger islands are covered in central areas by recent dunes derived primarily from wind blown calcareous sands of recent marine origin and, to a lesser degree, from the weathering of soft limestone bedrock.

The topography of Penguin Island (Map 2 and Figure 1) evidences the north-south alignment of the Pleistocene ridge, which can be clearly seen in the island's narrow northern and southern promotories. A large dune area rises to 20 metres above sea level in the central portion of the island, while the highest points on the narrow northern and southern plateaux are 10 metres and 12 metres respectively. The steep eastern face of the central dune area drops to the low triangular shaped tombolo feature on which the settlement has been constructed. Penguin Island is fringed on its northern, western and southern shores by limestone platform reefs and, due to its predominantly north-south orientation, beaches have formed along its eastern and central western shores.

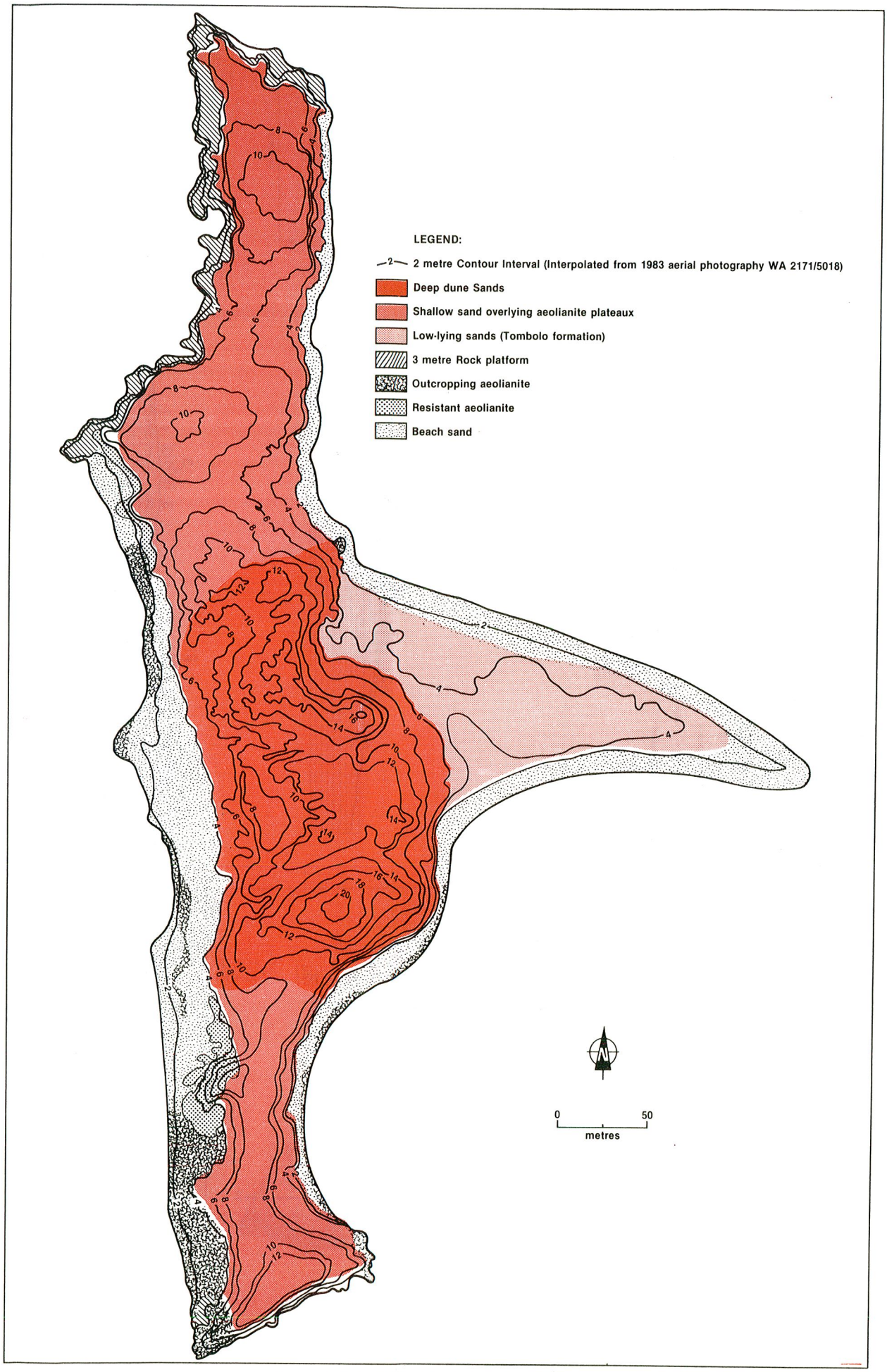
The island landscape has been considerably modified over time, especially with the loss of tall vegetation and construction of buildings on its eastern side. Of particular concern is the visual impact of erosion scars which are becoming increasingly evident from the mainland, as well as the light-coloured buildings which considerably detract from the visual amenity of picturesque Shoalwater Bay with its clear shallow waters, islands, rocks and reefs.

### 2.2 Geology

#### 2.2.1 Aeolianite Limestone

The plateaux of aeolianite limestone which form the northern and southern promontories of Penguin Island are capped with a hard crust of travertine overlying the softer primary aeolianite. Along their edges the plateaux are greatly eroded where wind, spray and ancient sea levels have cut into the exposed limestone beneath the harder crust. The resulting undermining has produced shallow caves and has led to rock falls and the formation of talus slopes. There are also some small outcrops along the western shoreline.

The aeolianite was formed by the leaching of calcium carbonate from the surface of late Pleistocene coastal dunes and its re-deposition as limestone at lower levels. Cross bedding is clearly evident in much of the aeolianite of Penguin Island but the best examples occur along the north-western coastline and on an isolated rock at the northern tip of the island. As observed at Cape Peron (Fairbridge, 1950) the bedding planes dip steeply parallel to the original dune surfaces towards the north-east away from the prevailing wind. Thus the bedding indicates the shape and orientation of the original late Pleistocene dunes. It has been suggested that banding effects in the




**MAP 2 TOPOGRAPHY AND GEOLOGY**

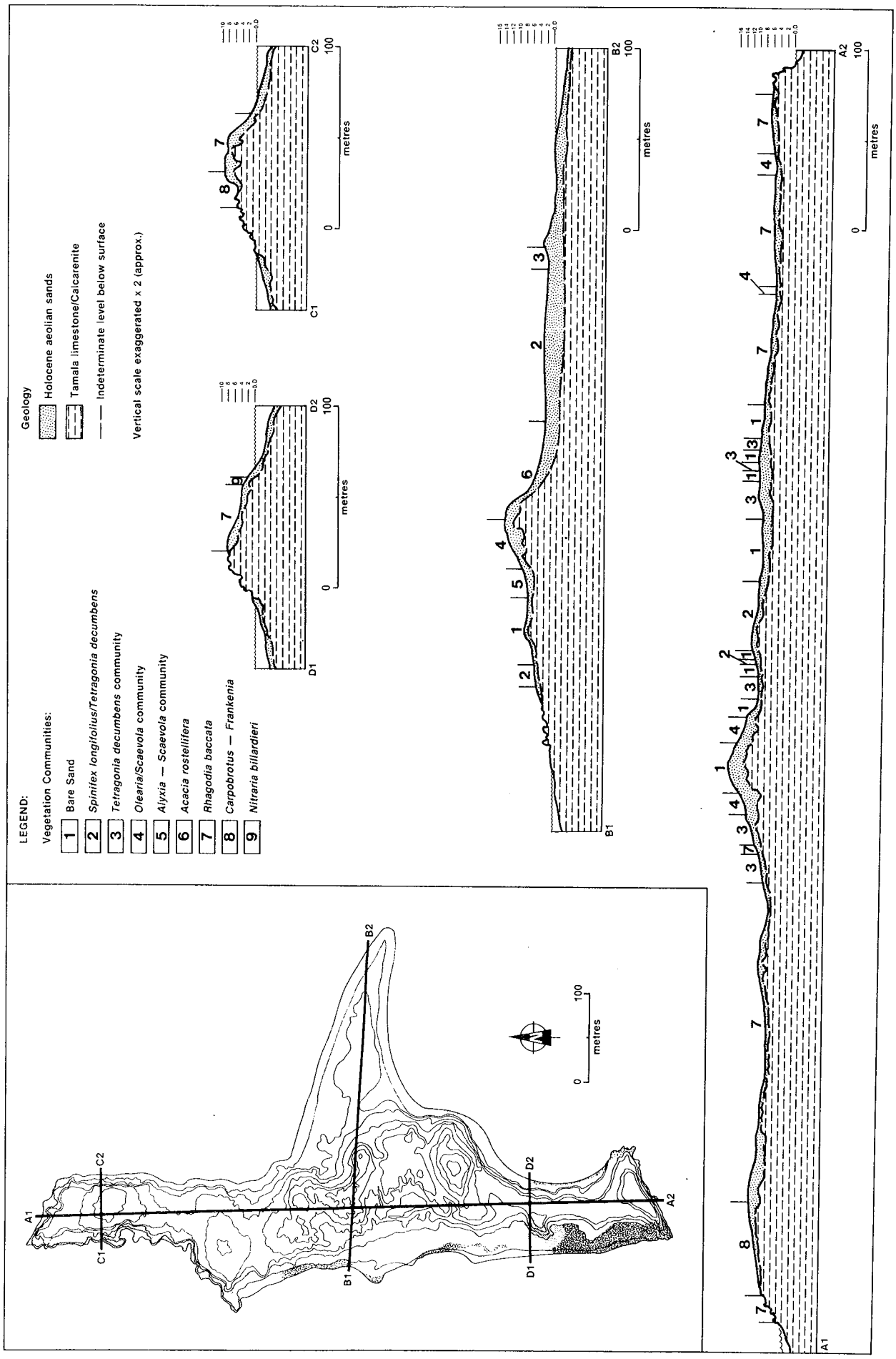



**Figure 1 Topography, Geology and Vegetation**

aeolianite have resulted from leaching calcareous solutions being deflected along older planes of accumulation. The redeposited enriched calcium carbonate formed harder more resistant limestone than the surrounding rock and has therefore been less subject to erosion. The softer rock between the bands has by contrast become honeycombed by the action of wind, water and sea-spray.

### 2.2.2 Karst Features

The vertical movement of rainwater and the dissolution and redeposition of calcium carbonate at lower levels in the ancient coastal dunes has created a number of karst features in the aeolianite. The resistant travertine crust which caps the plateaux on Penguin Island was formed as a sub-aerial hardpan of leached, enriched calcium carbonate. Through much of the aeolianite are many fine vertical pencil-structures which have resulted from the precipitation of calcium carbonate along vertical channels or pores in the ancient dunes. Similar processes have given rise to much larger hollowed out vertical channels, the solution pipes. It has been suggested that these structures have formed at locations where there was a greater water flow through the dunes such as beneath interdunal swamps. Many good examples of solution pipes occur on the talus slopes at the northern end of the island including specimens *in situ* or as talus showing the pipe in transverse section. Because they are composed of resistant, travertinised limestone the solution pipes have withstood erosion whereas the softer primary aeolianite has weathered away. This has led to the formation of a number of interesting erosional features including natural archways and bridges. In some solution pipes there are deposits of pinkish fossil soils. The solution pipes are not confined to the limestone plateaux and cliffs but also penetrate deeply into the reef platforms.

In many places, particularly on the northern cliffs of Penguin Island, fossil karst root structures (possibly from an ancient tuart forest) are evident in the aeolianite and on the inner and outer walls of the solution pipes.

### 2.2.3 Reef Platforms

Reef platforms or water level benches found along or adjacent to the southern, western and northern coasts are the result of recent marine erosion within the intertidal zone. The general level of the platforms is about datum (that is, sea level at low water spring tides) but the surfaces are often irregular, dipping to below datum with some stacks of resistant rock emerging above sea level. The seaward edges of the platforms are usually raised slightly and form a rim. It has been suggested (Fairbridge, 1950) that the planation of the limestone to form a horizontal bench is brought about primarily by chemical dissolution.

Normally seawater is saturated in calcium carbonate; however, in the intertidal shallows seawater appparently acts as a powerful solvent which attacks and undercuts the limestone coastline. Increases in carbon dioxide concentration in the intertidal shallows due to changes in temperature and production of carbon dioxide by plant and animal respiration could change the pH of nearshore seawater. Therefore, instead of deposition of calcium carbonate the limestone dissolved, forming a planar bench in the intertidal zone with an

undercut or notch near the high water mark. The effects of chemical erosion are no doubt re-enforced by the mechanical action of waves and the attack of burrowing marine organisms. The reef rim is in contact with deeper, mixing seawater and tends to be less subject to chemical erosion and is usually protected by a growth of the encrusting algae Lithothamnion.

Seaward of the reef rim west of Penguin Island the seabed drops abruptly to 3-5 metres. The limestone face normally forms a cliff which is sometimes undercut. There are numerous caves and tunnels in the submarine limestone.

### 2.2.4 Emergent Platforms

Stable periods with sea-levels above the present marine erosional cycle have produced emergent platforms on the limestone coast of Cape Peron and the three metre (10ft) bench of Fairbridge (1950) is also clearly evident along the north-western shoreline of Penguin Island. The bench is raised along its seaward edge and slopes gently eastward to the base of the limestone cliffs of the northern plateau. It is undercut by the notch of the contemporary marine platform. On the surface of the bench there are resistant pinnacles of aeolianite, talus rocks from the cliffs, and, in the spray zone there are cavities formed by recent pool-level weathering. Planar levels conforming to the three metre bench can also be seen in the limestone on the southwestern shoreline of the island, and on nearby satellite rocks and islets.

### 2.2.5 Recent Beach Rock

Small deposits of beach rock are evident on the south-western and western shorelines of Penguin Island. This is a finely grained, evenly indurated limestone which dips gently seaward from a few feet above sea level to below high water. The recent storm which eroded much of the sand on the central western shore (see 2.5) revealed an extensive linear formation of wave-sculpted beach rock usually covered by sand. Above the tide line the beach rock is characteristically jointed and broken up into angular blocks. It is generally accepted that contemporary beach rock is formed by calcium carbonate precipitation in Recent calcareous beaches in sheltered bays in warm temperate and tropical waters.

### 2.2.6 Tombolos and Banks

Shallow tombolos connect Penguin, Seal and Bird Islands in Shoalwater Bay to the adjacent mainland and there are also some south-westerly trending banks in Warnbro Sound. The tombolos and banks form where wave patterns defracted by the islands and reefs intersect, leading to the deposition of transported material.

History indicates cycles of sand build up and scouring in the area. When Peel Harbour was originally surveyed in 1837, the bank adjacent to Safety Bay in Warnbro Sound completely enclosed Peel Harbour and, together with the Penguin Island tombolo, were vegetated with foredune plants. Today these features are within the intertidal range and are only completely exposed during spring low tides. However, the Penguin Island tombolo has almost certainly been accreting again during the last decade.

## 2.3 Soils

The soils of Penguin Island consist of undifferentiated calcareous sands of varying depth. The eastern and central western shorelines are beaches, with calcareous sands of a somewhat finer texture on the eastern side due to the higher degree of sorting in material deposited. The dunes in the central part of the island are composed of wind-deposited white marine sand but on the eastern side the dunes have a yellowish tinge indicating that some material is derived from the weathering of the aeolianite bedrock. The organic content of the dune sands is low to non-existent and they evidence high mobility when binding vegetation is removed.

On the limestone plateaux, where there are high densities of surface nesting seabirds, there is a shallow, pinkish brown sand which contains a high proportion of organic material. This soil is probably partially derived from the weathering of the bedrock, from wind deposited sands and faecal material. On the talus slopes there are shallow deposits of sandy scree soil derived from weathered aeolianite.

## 2.4 Climate

The Penguin Island area experiences a Mediterranean climate with cool wet winters and warm dry summers. An average annual rainfall of around 800mm would be expected with almost all falls occurring between late April and early October. The summer drought with attendant high evaporation is an important factor affecting the survival of plants and terrestrial animals on the island.

The island is subject to weather dominated by sea breezes for an average 35% of the year whilst the other major patterns are: winter high pressure systems (19%), low pressure systems (28%), summer high-low pressure systems (5%) and calms (4%). The summer pattern is characterised by morning easterlies and afternoon south-westerly sea breezes. Between August 1977 and November 1978 29 storms were recorded, defined as wind events with mean velocities greater than 15km/hr (Cockburn Sound Environmental Study, 1979).

## 2.5 Coastal Processes

Penguin Island is subject to a small tidal range although wind fetch can greatly raise or lower actual sea levels. Tides vary with the tropic lunar cycle which has a period of 27.3 days and, at Fremantle, have a maximum range of about 0.9m at the solstices and 0.75m at the equinoxes (Hodgkin and Di Lollo, 1958). Changes in sea level caused by variation in barometric pressure, wind strength and direction, and water temperature and salinity have a combined effect on sea level of about 1.2m. This is at least equivalent to the maximum tidal range. During spring (September/October) when peak low tides occur in company with easterly winds the bar connecting Penguin Island to the mainland is often completely exposed. Autumn high tides, accompanied by low pressure systems and westerly winds, have almost lead to the inundation of the southern parts of the settlement area.

Severe winter storms, such as the one experienced in the last week of June 1983, when wind speeds reached 120km/hr, have a major impact on the island's shoreline. The recent storm completely removed sand from the northern and southern ends of the western shoreline, exposing the underlying Pleistocene limestone platforms and Recent

beach rock formations. The central area of the western beach was considerably depleted with beach rock exposed and a steep scarp formed at the base of the remnant foredune. Erosion also occurred on the sheltered eastern shoreline along the north-eastern beach, on the point of the tombolo and at the base of the steeply sloping south-eastern shore.

There are at least three micro and macroscale circulatory patterns in the surrounding ocean which may affect the island's marine life and seabird populations or the processes of sedimentation and erosion. The most important characteristics of the inshore waters of Cockburn Sound, Warnbro Sound and, to a lesser extent, Shoalwater Bay are wind driven currents. Tidal changes are relatively unimportant sources of water circulation as the range is small and density currents are only apparent in sheltered inshore waters during prolonged calm periods. There is limited water exchange between the open ocean and Cockburn or Warnbro Sound (Steedman and Craig, 1983).

In Cockburn Sound a system of gyres ('closed' circulation patterns), including one main gyre, is generated by the prevailing wind patterns. Sea-breezes are most important in establishing an anti-clockwise gyre in Cockburn Sound which is prevalent over 35% of the year, particularly between October and May. Winter low pressure storms and tropical cyclonic systems propel the main Cockburn Sound gyre in a clockwise direction. Such patterns prevail over less than 30% of the year. Other wind and weather conditions generally lead to only poorly developed inshore circulation (Steedman and Craig, 1983). The formation of a gyre would also be expected in Warnbro Sound and the present accretion of beaches and sand bars on the northern coast near Penguin Island and Peel Harbour may be facilitated by a predominately northward, anti-clockwise circulation in the Sound during the summer months. Shoalwater Bay is unlikely to have the same pattern of circulation as the larger embayments due to its small size, narrow shape, shallowness and higher exposure to the ocean, particularly to winter north-westerlies. Outside the embayments and across much of the continental shelf a weak, slow flowing long shore drift is suspected. However, the seasonal pattern of flow is not well known (Cockburn Sound Environmental Study, 1979).

Surface sea temperatures in the inshore waters around Penguin Island are probably similar to those recorded for Cockburn Sound (Hodgkin and Phillips, 1969). These range from the seasonal extremes of 24.7°C (February) to 12.8°C (August). The monthly means of daily maxima and minima over an eight year period averaged 23.2°C in the warmest month (February) to 15.2°C in the coolest (July). Around late March and early April there can be an influx of warm, low salinity, near shelf, surface water (Webster et al, 1979). This raft of tropical water, which is an offshoot of the Leeuwin Current (Cresswell and Golding, 1980), effectively maintains winter surface sea temperatures on the outer shelf 2-3°C warmer than would otherwise be the case. It has been suggested that the Leeuwin Current is responsible for the appearance of a number of tropical marine organisms in the south-west (Garrey et al, 1981) and is almost certainly involved with the extension of breeding range in some tropical seabirds (two species nest in Shoalwater Bay) and the anomalous prolonged breeding seasons of some subtropical seabird species in the area.

## 2.6 Vegetation

The list of plant species of Penguin Island presented here is based on Storr (1961). Since the present survey (see Appendix A) took place over the summer months it was not possible to confirm the presence or absence of the large number of annuals previously recorded. However, the exotic annual Urtica urens has been added to the list. Since Storr's survey a large gull colony has become established on Penguin Island and this may have increased the number of annuals and lead to the establishment of the short-lived coprophilous shrubs Lavatera arborea and L. plebeia in the new rookery areas. Storr (1961) does not record marram grass (Ammophila arenaria) which was initially introduced to Penguin Island at some stage before 1943 (Serventy and White, 1943). At present the only stands of marram are located in the trough of the northernmost and most active blowout (see Map 3). Among the perennial plants Spinifex hirsutus has apparently become more abundant stabilising mobile sand near the centre of the blowouts. In these locations the reduced wind velocities have allowed Spinifex to become established and build low dunes.

The one clump of Acacia cyclops recorded by Storr has now disappeared. Five specimens of Pittosporum phylliraeoides survive on the eastern edge of Penguin Island. This attractive tree is of particular interest because the surviving specimens on Rottnest, Garden, Seal and Penguin Islands and on the coastal plain near City Beach are ecological relicts of a drier period in history. The nearest populations of this fire susceptible species outside the metropolitan area are in the lower rainfall areas of the Irwin botanical district and in the Eremean Province. Tuarts (Eucalyptus gomphocephala), Rottnest tea trees (Melaleuca lanceolata) and Norfolk Island pines (Araucaria heterophylla), have been successfully established in the settlement area. Fig trees (Ficus carica) which were introduced to the island around 1910 can still be found at two points on the eastern side.

Two important dynamic processes are involved in shaping the plant communities of Penguin Island. There is a dunal succession with distinctive plant assemblages on foredune, mobile dune and stable dune areas. The vegetation of sheltered swales and leeward dune slopes also differs from that on exposed seaward faces and dune crests. The important factors controlling the distribution of plant species within the natural regime are exposure and sand mobility. However, distribution has been substantially modified with the additional factor of human disturbance. Figure 2 shows the gross changes which have occurred in vegetation cover over time since 1942.

Another plant succession is particularly evident on the plateaux. This is a secondary cycle brought about by the disturbance affects of nesting seabirds. The result of manuring and trampling by dense colonies of cormorants, gulls and terns is the regression of vegetation dominated by woody perennials (for example, Frankenia pauciflora) to succulent shrubs and mesophytes such as Rhagodia baccata and Lavatera spp to, in extreme cases, only annuals including Senecio lautus and exotic nitrophilous grasses (Gillham, 1960). The impact of burrow nesting species in sandier parts of the island is much less marked but the activities of Little Penguins have possibly increased the abundance and distribution of tolerant bower spinach Tetragonia decumbens and Threlkeldia diffusa.

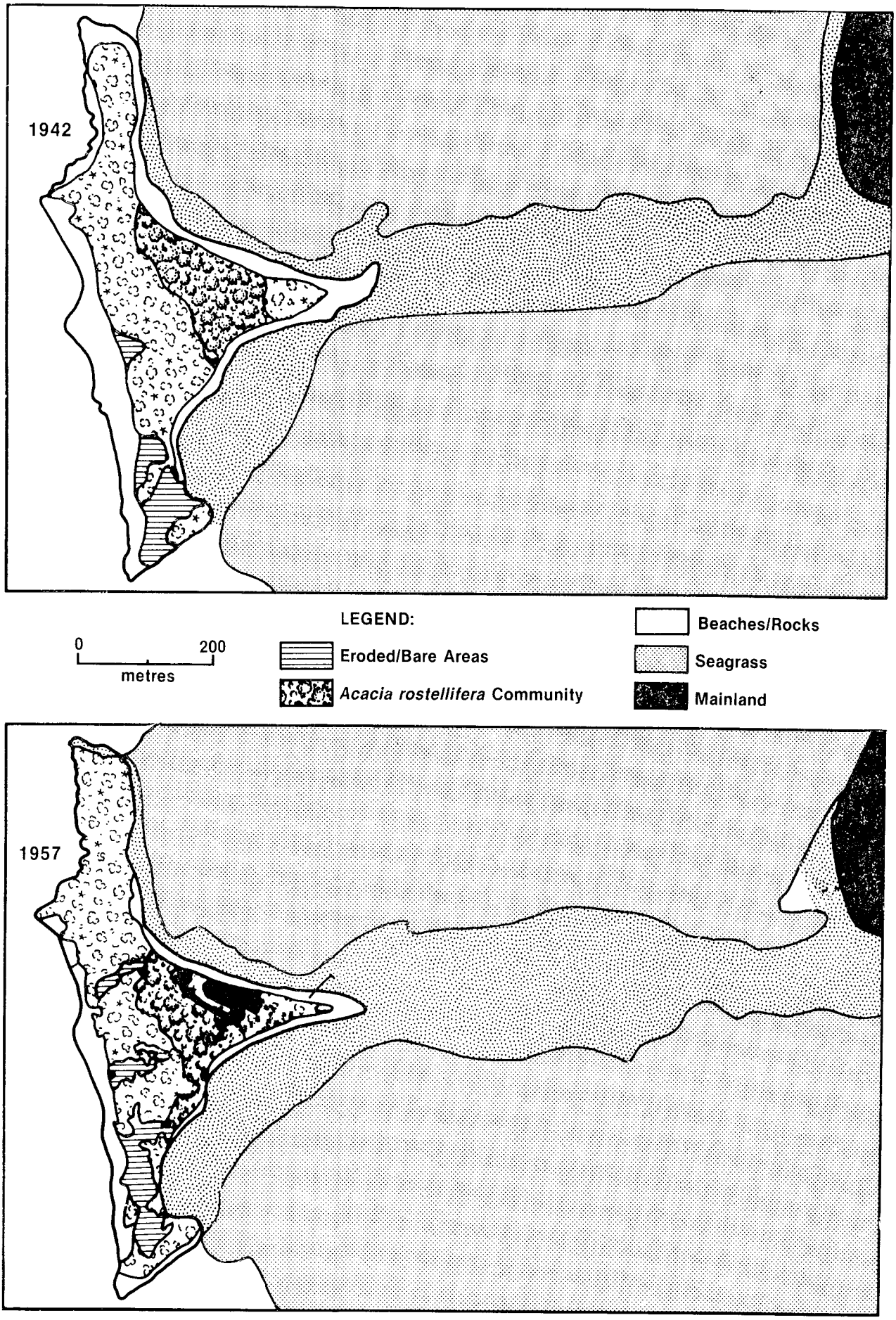
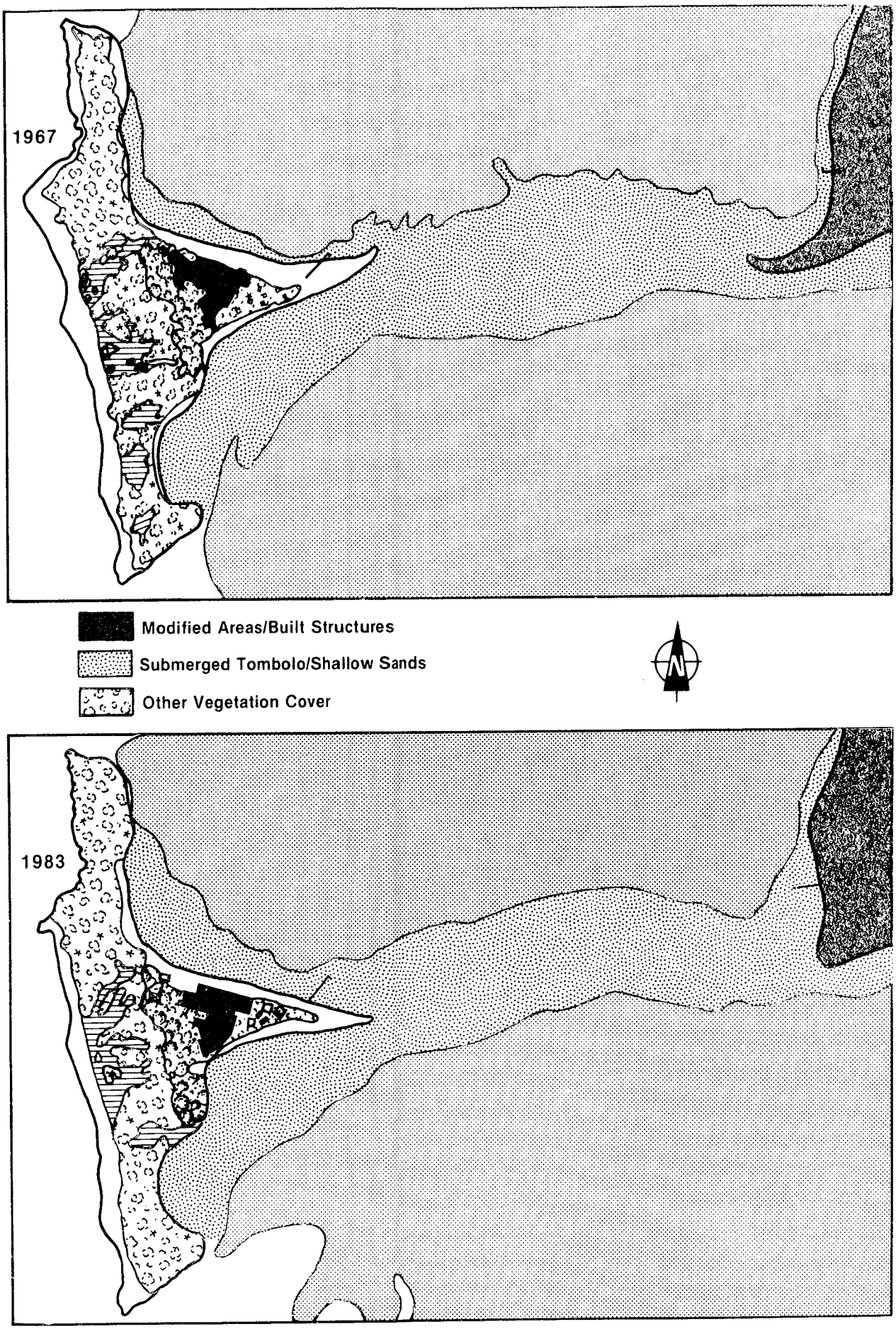
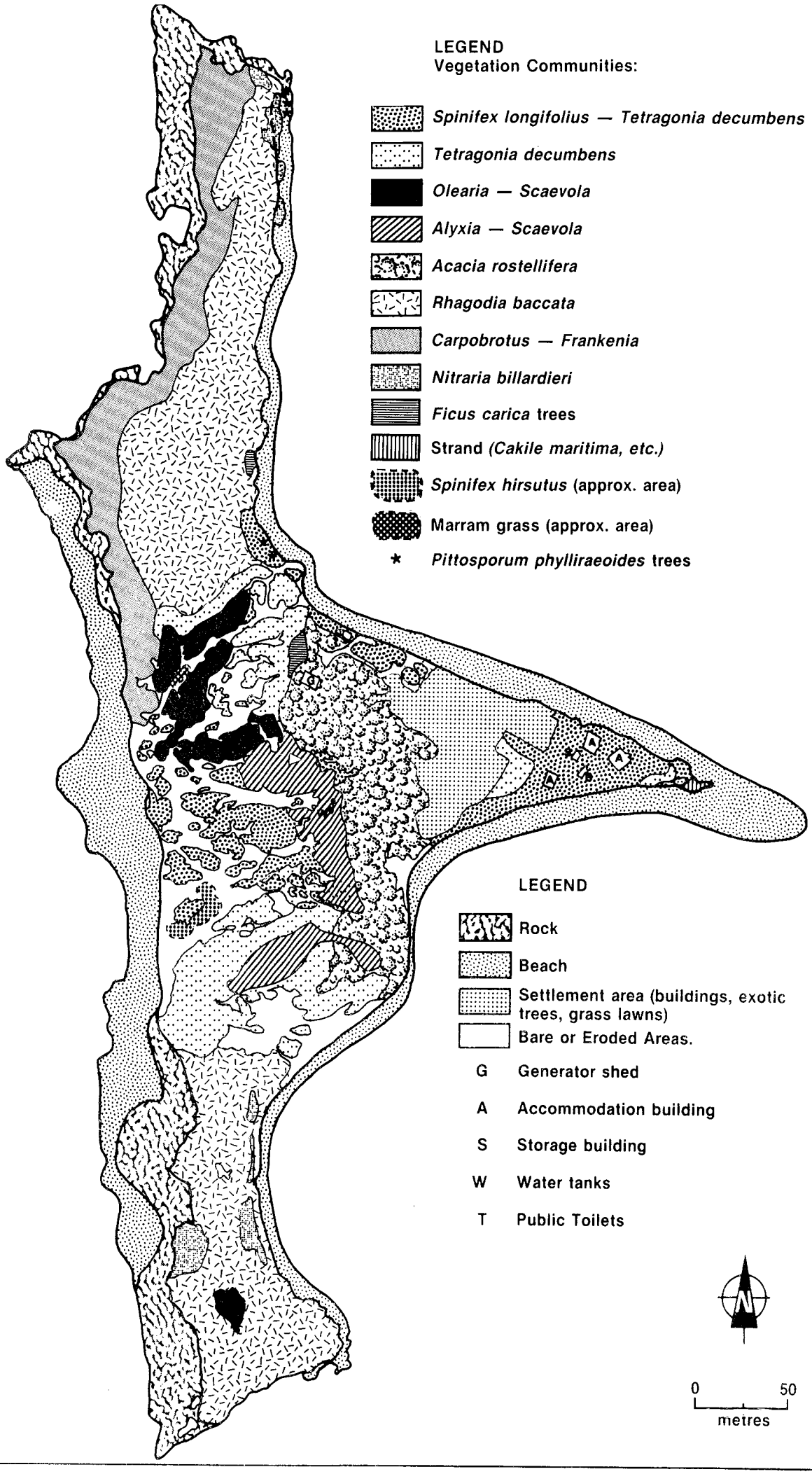



**Figure 2 Changes in vegetation cove**




942, 1957, 1967 and 1983




MAP 3 VEGETATION

Some plant communities are associated with microhabitats, of which there are at least two. Namely, the eroded talus slopes of the island dominated by nitre bush Nitraria billardieri and the spray zones along the western edges of the plateaux dominated by Frankenia pauciflora and Carpobrotus virescens.

### 2.6.1 Plant Communities

The widespread pattern of human and natural disturbance on Penguin Island has lead to some fragmentation of plant communities, especially the central dunes which are badly eroded with a number of 'blow-out' gullies. However, nine vegetation units have been described and mapped, classified in terms of dominant plant species (see Map 3 and Figure 1). The following units are a compromise between patterns evident in the field and those delineated on an aerial photograph enlarged to approximately 1:1000:

- Cakile maritima community

  The dominant plant of the strand on Penguin Island is Cakile maritima. Other species include Salsola kali and Arctotheca pupilifolia. One small area occurs at the base of the sand spit.

- Spinifex longifolius - Tetragonia decumbens community

  On the foredunes on both sides of the island the vegetation is dominated by Spinifex longifolius and Tetragonia decumbens. In the broad swale behind the foredune on the eastern side of the island Scaevola crassifolia, Lepidospermum gladiatum and Rhagodia baccata become important plants in this community. Erosion of the western dunes has lead to Spinifex and Tetragonia colonising mobile areas further inland.

- Tetragonia decumbens community

  Mats of Tetragonia decumbens now occur in various disturbed areas on the island, particularly in locations subject to inundation by wind blown sand.

- Olearia axillaris - Scaevola crassifolia community

  This plant community occupies exposed areas of mobile dune with Olearia axillaris colonising the most exposed crests and the walls of the blow-outs. Scaevola crassifolia is also common in this community.

- Alyxia buxifolia - Scaevola crassifolia community

  This community occurs on the crest and windward (western) slopes of the main central dunes. The dominant plants are Alyxia buxifolia and Scaevola crassifolia. The presence of Scaevola indicates that the dunal areas occupied by the community are becoming more unstable. Other common plant species include Spyridium globulosum, Angianthus cunninghamii, Conostylis candicans, Acanthocarpus preissii and Muehlenbeckia adpressa.

- Acacia rostellifera community

  A thicket of Acacia rostellifera covers the leeward (eastern) slopes of the central dunes and the swale seaward of the main dune crest. The other plants common in these sheltered, stable areas are Myoporum adscendens, Alyxia buxifolia, Acanthocarpus preissii, Stipa variabilis and Conostylis candicans. The climbers Clematis microphylla, Cassytha racemosa and Hardenbergia comptoniana are also common growing over the Acacia shrubs.

- Rhagodia baccata community

  The sandier parts of the limestone plateaux are dominated by the succulent shrub Rhagodia baccata with the trailing herbs Carpobrotus virescens and Threlkeldia diffusa also being present. Where there have been high densities of nesting Silver Gulls or roosting Pied Cormorants the vegetation becomes rather open and there are stands of the coprophilous shrubs Lavatera plebeia and Lavatera arborea and, in the winter, mats of annuals, the most conspicuous being Senecio lautus. Many exotic herbs and grasses favoured by high soil nitrogen levels and constant disturbance have invaded the seabird rookery areas.

- Carpobrotus virescens - Frankenia pauciflora community

  In areas of shallow soil over the limestone Carpobrotus virescens becomes dominant. Near the northern and western edges of the northern plateau in areas subject to considerable salt spray the woody shrub Frankenia pauciflora becomes an important plant species. In microhabitats where pools of splashed seawater form after winter storms are clusters of halophytes including Sarcocornia australis, Enchylaena tormentosa, Sporobolus virginicus and Wilsonia backhousei.

- Nitraria billardieri community

  On the talus of the limestone cliffs grow clumps of nitre bush, Nitraria billardieri. The other common plants in this habitat are Tetragonia implexicoma, Threlkeldia diffusa, Enchylaena tormentosa and Carpobrotus virescens.

## 2.7 Wildlife

Appendix B presents a list of vertebrate fauna recorded live on Penguin Island between 1978 and 1983, and/or recorded by Serventy and White (1943). Breeding seabirds are undoubtedly the most significant fauna of the island and are documented in some detail. Much of the material presented has been gathered from observations made by J.N. Dunlop (pers.comm.) between 1978-1983 during detailed studies of the behavioural ecology of the Silver Gull (Larus noveahollandiae), Crested Tern (Sterna bergii) and Little Penguin (Eudyptula minor) on the Fremantle islands. Species observed on the ocean around the island and not recorded above the low water mark are not included.

Discussion of breeding biology is limited to those aspects most pertinent to management. Because of its small area Penguin Island supports few reptiles and no indigenous terrestrial mammals.

### 2.7.1 Reptiles

The four lizard species which are present (see Appendix B) are also common on the adjacent mainland. During a stormy period in September 1982 a juvenile Hawksbill Turtle was picked up alive on the western side of Penguin Island. This species was previously not recorded south of Shark Bay.

### 2.7.2 Mammals

Rabbits were introduced to Penguin Island at some stage prior to 1940 (Serventy and White, 1943) but fortunately became extinct sometime between 1943 and 1960. House mice (Mus musculus) were probably established around 1920 and, as on Carnac and Rottnest Islands, these rodents tend to plague during late summer and early autumn. An occasional Australian Sea-lion (Neophoca cinerea) will haul out on the eastern shore of Penguin Island from time to time, although the main concentration in Shoalwater Bay is on Seal Island.

### 2.7.3 Birds

Except for two resident land birds, the Singing Honeyeater (Lichenostomus virescens) and the Welcome Swallow (Hirundo neoxena), terrestrial bird species are transient, or irregular visitors. In 1982, a pair of Australian Shelducks (Tadorna tadornoides) nested on the island. Each summer a range of wader species use the island's intertidal habitats for foraging. Most of these are trans-equatorial migrants from the northern hemisphere and are listed under the migratory birds agreement between Australia and Japan. A small flock of feral pigeons regularly roost in a limestone shelter at the northern tip of the island.

- Little Penguin (Eudyptula minor)

  In 1981/82 counts by D. Montague and J.N. Dunlop estimated that 500-700 pairs of Little Penguins were nesting on Penguin Island. This estimate was based on a direct, monthly count of occupied burrows on the eastern (tombolo) part of the island and on irregular counts of birds landing at night at various points around the island (see Appendix C). The population on Carnac Island, the northernmost colony of Little Penguins in Western Australia, was estimated at 50-80 pairs in 1980/81 (Dunlop, 1981) but subsequent work suggested a breeding population closer to 150 pairs. Little Penguins occur widely on the islands of the south coast including the Recherche Archipelago but populations on these islands are apparently small, generally under 50 pairs. A slightly larger colony occurs at Twilight Cove near Eyre at the base of the Nullabor cliffs (Montague, pers. comm.). Penguin Island therefore appears to be the largest single colony in Western Australia.

Nests are concealed in burrows excavated by the birds or, more commonly on Penguin Island, under dense bushes or in caves or concealed spaces under limestone. Although nesting penguins utilise most of the island, including the broken limestone on the edges of the limestone plateaux and the central dunes, the greatest concentration is found on the sandy leeward side in and around the settlement (see Figure 3). Artificial sites under buildings have become increasingly important with the clearing of the central part of the settlement. The remaining vegetation within the settlement area is heavily tenanted.

Penguins return to the colony in the second half of March each year after a short summer absence. Courtship and territorial behaviour usually begins in earnest by early April and at night, when most birds are ashore, the colony is extremely noisy. The onset of laying is variable with the earliest eggs being laid anywhere from April to June. The first laying peak is normally some time in June. Evidently all pairs do not occupy sites from the outset as some established pairs are known to have been evicted from territories by more dominant late arrivals in August and September. This is clearly an extreme situation which may be the result of sites being lost due to clearing of vegetation in the preferred colony area. Laying continues until late October or early November. Some pairs produce two or three clutches in a breeding season and a few may successfully fledge progeny from two broods. By mid-November the first birds in moult can be recorded and by early December about half the breeding population enters the moulting period.

Moult in penguins is rapid and physiologically traumatic. After a short period of fattening at sea the birds return to the colony and begin to shed their feathers. Whilst in moult the birds prefer open, cool and well ventilated shelters and become much more visible to the general public. Interference at this time has been causing significant mortality in this population. After completing the moult in late December and January most penguins leave the island. Limited banding returns indicate a partial, southward movement in the late summer period with a disporportionate number of recoveries from Geographe Bay.

- Little Shearwater (Puffinus assimilis)

This burrow nesting seabird was not previously recorded from Penguin Island (Serventy and White, 1943). The first birds were discovered in March 1982 and at present seven occupied sites have been located. All of these sites were within the settlement area (see Figure 3), the burrow entrances concealed under dense clumps of Rhagodia baccata and Tetragonia decumbens. Little Shearwaters have been observed in other parts of the island and it is estimated that there may be up to 20 breeding pairs. The

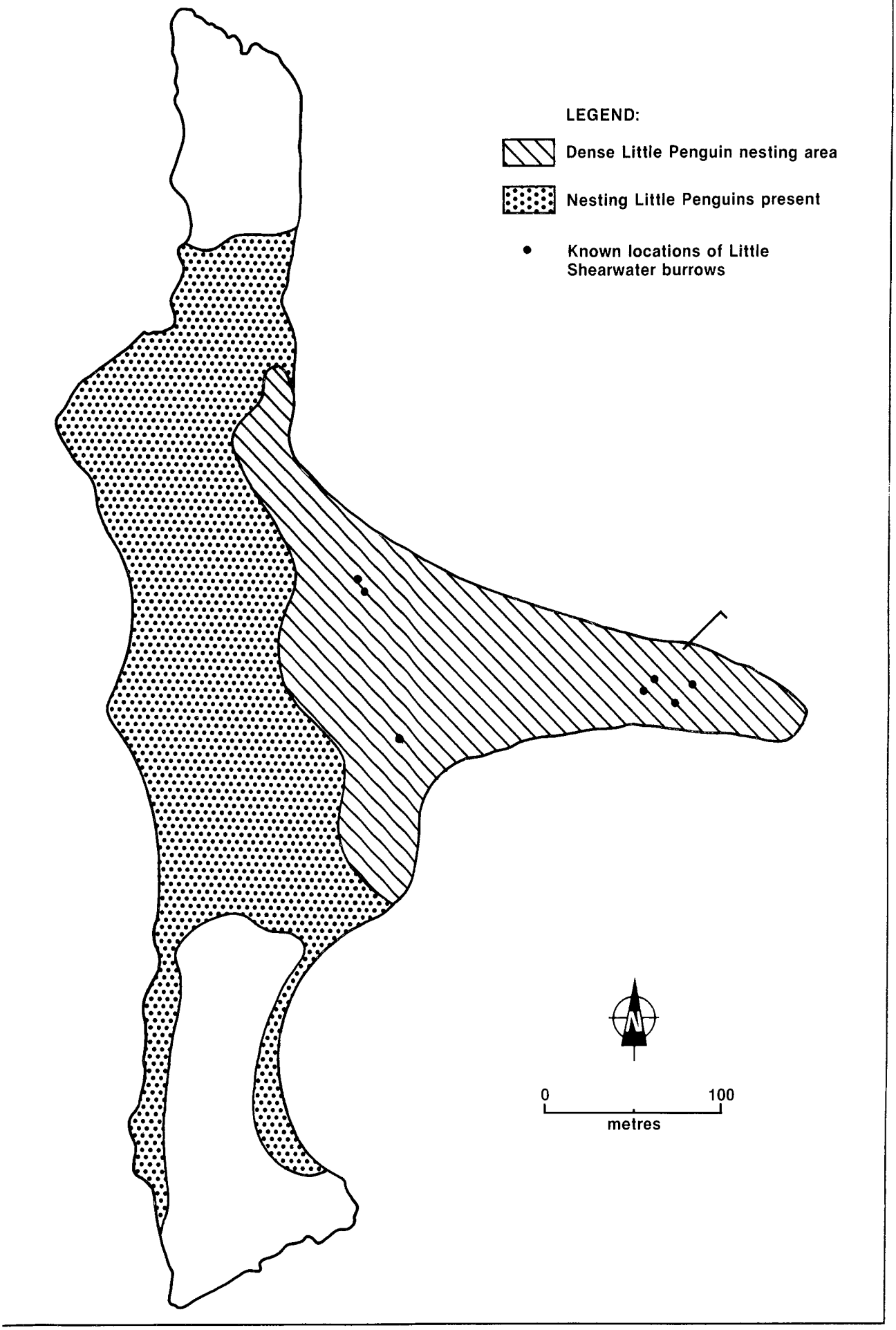



Figure 3 Distribution of Little Penguin *(Eudyptula minor)* Population and Location of Little Shearwater *(Puffinus assimilis)* Burrows. (Source: J.N. Dunlop)

Little Shearwater has been declining in some of its colonies north of Fremantle (R E Johnstone, pers. comm.). A small breeding colony which disappeared from Parakeet Island, Rottnest some time in the 1930's was the only previous record from the metropolitan islands.

The burrows are apparently occupied for most of the year, although there is a short period of absence in early summer. Little Shearwaters on Penguin Island are most vocal, at night, in March, April and May in what presumably is the pre-laying period. As yet there is no breeding data but elsewhere in south-western Australia laying takes place between the third week or June and Mid-July. It takes about 19 weeks from egg-laying until the chick fledges so the nesting burrows remain occupied for much of the rest of the year (Serventy et al, 1971).

Silver Gull (Larus novaehollandiae)

There were no Silver Gulls nesting on Penguin Island between 1940 and 1943 (Serventy and White, 1943) and Storr (1960) makes no mention of gull colonies on the island during his visit in 1959. During the war years the only gull colonies in Shoalwater Bay were on Bird Island and Shag Rock with a few nests on some of the smaller rocks. Numbers totalled about 200 pairs. By 1959 Silver Gulls had evidently spread onto Seal Island. The first breeding pairs probably occupied the northern plateau of Penguin Island during the early 1960's and the colony had grown to about 1200 pairs in 1978. At present the population on Penguin Island is in excess of 2000 pairs and the breeding birds occupy all of the northern and southern plateaux and the periphery of the central dunes (see Figure 4). The Penguin Island colony is still expanding, with more birds and new areas being occupied each year. Shoalwater Bay has seen the most rapid increase in gull numbers over the last decade although colonies on Rottnest and Carnac Islands have also been increasing.

After a short, non-breeding period beginning in early November, during which the gulls complete a moult, the birds return to the colony. This is usually in early March and egg laying generally begins in late March or early April. All the breeding population participates in this early part of the season although by spring the number of pairs has declined. Breeding pairs frequently lay two, three or even four clutches in a season (Wooller and Dunlop, 1980) usually to replace losses sustained to egg predators, in particular the King's Skink (Egernia kingii). A few pairs fledge two broods in a breeding season (Nicholls, 1974). Generally, however, breeding success per pair per season is very low and the ability to increase in numbers in response to an expanded food supply is due to the long reproductive life (12-16 years) of many breeding adults (Dunlop, 1981) and the tendency for breeding success to increase with age.

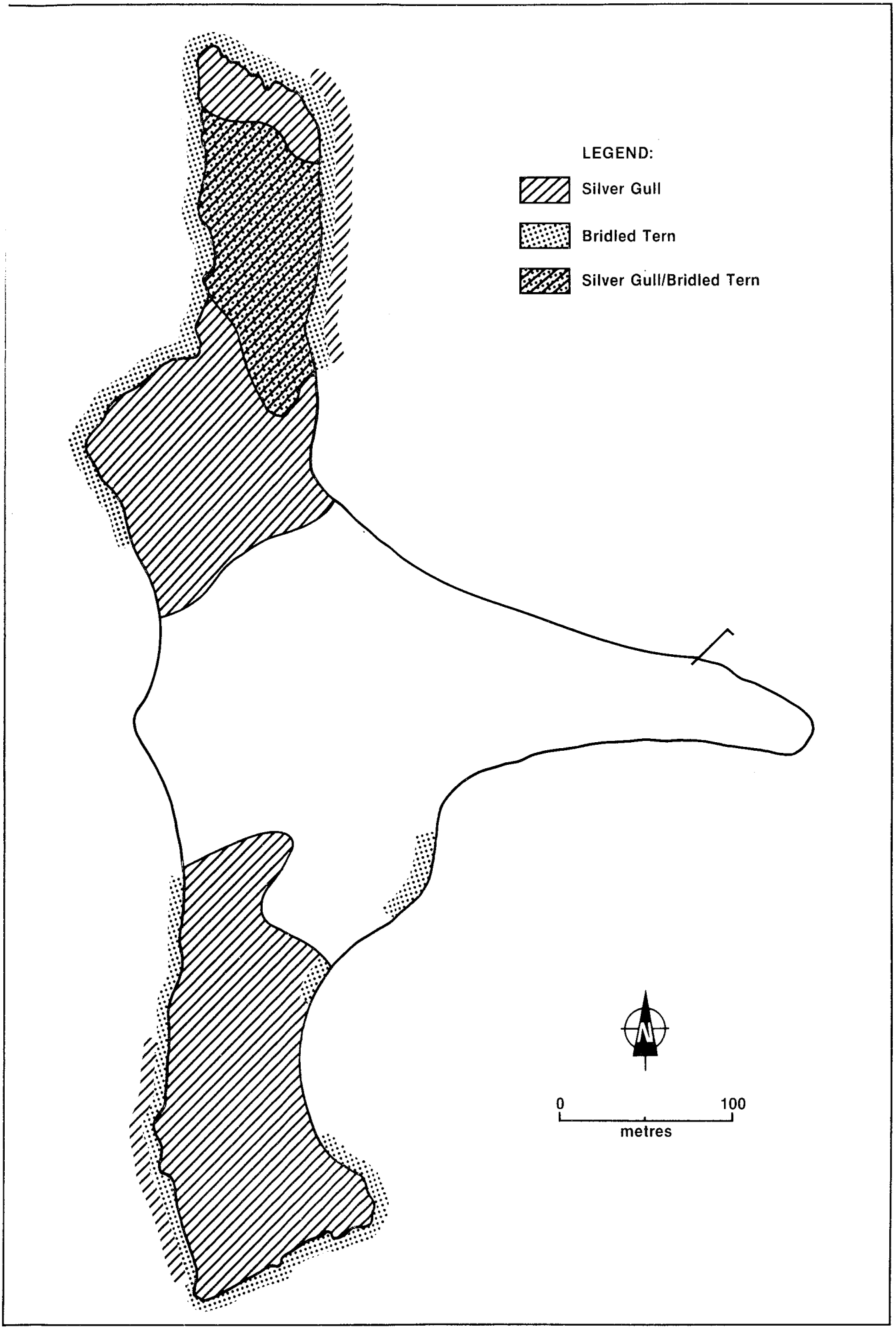



**Figure 4 Distribution of Silver Gull *(Larus novaehollandiae)* and Bridled Tern *(Sterna anaetheta)* Populations** (Source: J.N. Dunlop)

- Bridled Tern (Sterna anaetheta)

  This species has greatly expanded its range southwards along the west coast during recorded ornithological history. A tropical species, the Bridled Tern did not nest south of the Abrolhos Islands in the period 1839-43 (Serventy et al, 1971). The Shoalwater Islands were considered the southern limit in 1920 and the species now nests at Cape Leeuwin and Robe in western South Australia. During 1940-42 only small numbers of Bridled Terns nested on Bird Island and Shag Rock in Shoalwater Bay. Today there are many more breeding birds including a large colony on Seal Island and about 700 pairs on Penguin Island. The Penguin Island colony is apparently still expanding and beginning to move into more marginal nesting habitats (see Figure 4).

  The first breeding pairs of Bridled Terns arrive at Penguin Island in about mid-September, the birds roosting on the island near their nest sites only at night. By early October many pairs are occupying territories during the day and courtship and nesting activities are under way. The nest scrapes are concealed under limestone slabs and boulders or under bushes. The greatest number of pairs occupy the cliffs of the northern plateau with some birds now nesting under bushes on top of the island. Areas of broken limestone on the southern end of the island are also utilised.

  In most years the first eggs are laid in late November and egg-laying continues with the arrival of additional breeding pairs through December and the early half of January. Adults and young vacate the colony by the middle of March and begin a return northward migration to the tropics.

- Potential Breeding Species

  All the species which currently nest on Penguin Island are characterised by fixed site fidelity; that is, each pair tends to return to the same area in successive seasons. There are five other seabird species which frequently roost on and around Penguin Island and nest in the Shoalwater Bay area. These are all species which are, to varying degrees, colonial and readily shift sites, (for example, from one island to the next) in successive seasons, or even within one season. Such site changes in Caspian, Crested, Roseate and Fairy Terns are frequently due to predation, interference or repeated human disturbance at a previous site. In the Pied Cormorant colony movement is primarily due to the destruction of the nesting habitat (woody bushes) by the nesting birds themselves during the course of each breeding season.

  Suitable nesting habitat for all five species, the Caspian Tern (Hydroprogne caspia), Crested Tern (Sterna

bergii), Roseate Tern (Sterna dougallii), Fairy Tern (Sterna nereis) and Pied Cormorant (Phalacrocorax varius) is available on Penguin Island and it appears that a long period of persistent human disturbance has precluded these species. Indeed by the 1940's, when the only historical bird survey was undertaken, there was no evidence of these species nesting on the island (Serventy and White, 1943). At this time the southern end was badly eroded (see Figure 2) and both plateaux had been scraped for nitrogenous fertiliser in the fairly recent past. These changes would have effectively eliminated habitat for surface nesters including Silver Gulls which have colonised (possibly recolonised) the regenerated plateaux. As discussed in Chapter 1, the island has been readily accessible and sporadically inhabited since early this century. The resulting constant disturbance no doubt belied the affects of habitat alteration on surface nesting seabirds. Table 1 summarises the relevant characteristics of the potential breeding species.

TABLE 1

Nesting Habitat, Movements and Laying Periods in Potential Breeding Species for Penguin Island (Source: J.N. Dunlop)

| SEABIRD SPECIES | *NESTING HABITAT | +MOVEMENTS | oLAYING PERIOD |
|---|---|---|---|
| Caspian Tern (Hydroprogne caspia) | Lightly vegetated plateaux overlooking the ocean. | Sedentary with local movements. | June-November |
| Crested Tern (Sterna bergii) | As above | As above | Early April to late October. |
| Roseate Tern (Sterna dougallii) | Craggy limestone and talus slopes, close to cover. | Migrant, from tropical waters. | Early April. |
| Fairy Tern (Sterna nereis) | Sheltered beaches, above summer high tide line. | Migratory south of Abrolhos Islands (Storr, 1960). | October to early February. |
| Pied Cormorant (Phalacrocorax varius) | On Nitraria or Acacia bushes on talus slopes. | Sedentary, with local movements. | Early March to early June. |

* On coastal aeolianite islands S. bergii, S. nereis and H. caspia also nest on banks of shelly limestone on salt lakes.

\+ Breeding adults only.

o Period when eggs are laid, not total span of breeding season.

### 2.7.4 The Importance of Penguin Island to Seabird Populations

The colonial breeding habit in seabirds, and the tendency for each generation to return to natal areas to breed, leads to the formation of fairly discrete populations. In addition, the Fremantle group of islands are separated by more than 100 kilometres from the nearest nesting stations. Even species with low year to year site fidelity such as the highly sedentary Crested Tern alternate between a small number of traditional colony locations within the Fremantle area. Thus it is apparent that in terms of seabird conservation the islands must be managed as a system. That is, measures taken on one island controlled by one of a number of responsible authorities will not necessarily be effective in maintaining populations. There are many anomalies, for example many small offshore islands are designated sanctuaries, whilst the large Wedge-tailed Shearwater colonies on the main island of Rottnest are afforded no protection whatsoever. An integrated seabird management plan is required which involves not only protection of colony sites but also of the marine environment. Appendix C summarises general information on the size and distribution of seabird populations in the Fremantle area compiled from observations made by J.N. Dunlop between 1978 and 1983.

Penguin Island is the largest Little Penguin colony in Western Australia and probably supports about 70% of the local population. (J.N. Dunlop, pers. comm). The other major site is Carnac Island which is the northernmost point in the breeding range of this species. The only remaining breeding Little Shearwaters in the area also nest on Penguin Island. This species may be in decline in south-western Australia. Since the early 1960's Penguin Island has become the second largest and most rapidly expanding Silver Gull colony in the metropolitan area and also supports a significant number of nesting Bridled Terns.

If managed with greater emphasis on wildlife management and conservation Penguin Island possesses suitable nesting habitat for at least five other species of seabird. Given adequate protection these could be induced to nest on the island by habitat and behavioural manipulation. As pressure continues to grow on the sites presently used by surface-nesting seabirds in the region the provision of additional nesting sites on a carefully managed island reserve such as Penguin Island may be of great importance in conserving populations. At present levels of impact, the island reserves in Shoalwater Bay may cease to be viable as conservation reserves. Clearly these sites should be managed in conjunction with Penguin Island.

## 2.8 Marine Environment

The marine biology of the Penguin Island, Shoalwater Bay area has not as yet been studied in detail and there is no complete inventory of marine plant and animal life. However, sufficient information is available to make some generalisations (R. Lethbridge, pers. comm.).

The littoral and sub-littoral biota are generally similar to those at Rottnest Island. Shoalwater Bay is rich in algae with about 70 species being recorded to date. However, the area lacks some of the tropical corals (Pocillopora damicornis and Montipora sp) and sea urchins (Echinometra mathaei), which are found at Rottnest. This is possibly because Rottnest is much closer to the edge of the

continental shelf and is influenced directly by warmer, lower salinity water.

In general, the littoral and sub-littoral environments have been relatively undisturbed by pollution or exploitation. However, in recent times populations of Roe's Abalone (Haliotis roeii) and certain whelks have been seriously depleted on the more accessible intertidal platforms by amateur fishermen. In 1976-77 the main south-western intertidal platform on Penguin Island supported good numbers of abalone. In February 1983 there were no longer any of these molluscs present, although some were still present in the sub-littoral zone (R. Lethbridge, pers. comm.).

Although there is currently a prohibition on the taking of molluscs and sea urchins between high water mark and 200 metres offshore this will be reviewed towards the end of 1983 (see 3.4.1). Both Penguin Island and Garden Island form an important part of the local professional abalone fishery and when Penguin Island is open for harvesting the combined harvest from the islands is about 30 tonnes, worth $150,000 annually (J. Penn, pers. comm.). It should be noted that professional fishermen are subject to stringent regulations with respect to size limits and length of harvesting season. They also fish reef areas which tend to be inaccessible to most amateurs. The nearshore rock platforms and reefs also provide an essential habitat for juvenile Western Rock Lobster (Panulirus longipes cygnus).

Four broad marine habitats occur around Penguin Island: the sandy bay east of the island, the shallow bay underlain by limestone south of the settlement, the intertidal platforms fringing the southern, western and northern shores and the benthic sub-littoral west of the island.

2.8.1 Sandy Bay

This system is continuous with the general Shoalwater embayment and is dominated by meadows of the seagrasses Posidonia australis, P. ostenfeldii and P. sinuosa. The meadows, which in the case of P. australis and P. ostenfeldii develop in locations where sediment is accreting, form a mosaic with patches of bare sand. The biomass of the Posidonia beds is quite high with levels of 152.0 +/- 8.0 g dry weight.$m^{-2}$ (leaves) and 238.5 +/- 49.3 g dry weight.$m^{-2}$ (rhizomes).

The leaves of the Posidonia plants are covered with many algal epiphytes such as the coralline algae Pneophyllum sp., Fosliella farinosa and Jania micrarthrodia, and algae such as Bryopsis plumosa, Ceramium puperbulum, Hypnea sp., Giffordia spp. and Laurencia spp. as well as many diatoms and blue-green algae. The Posidonia leaves also support large populations of gastropods such as Calliostoma australe, C. interruptum and Pyrene bidendata. The sediments under the seagrasses support a rich infauna including polychaete worms, crabs and anemones. Figure 5 shows the relative abundance of invertebrates found in a sample taken from the Posidonia beds off Penguin Island.

The most abundant fishes in the sea-grass meadows include the hardyhead (Pranesus ogilby), gobbleguts (Apogon ruppelli), trumpeters (Helotes sexlineatus and Therapon humeralis), cobbler (Cnidoglanis macrocephalus), King George whiting (Sillaginoides punctatus) and sand whiting (Silago bassensis).

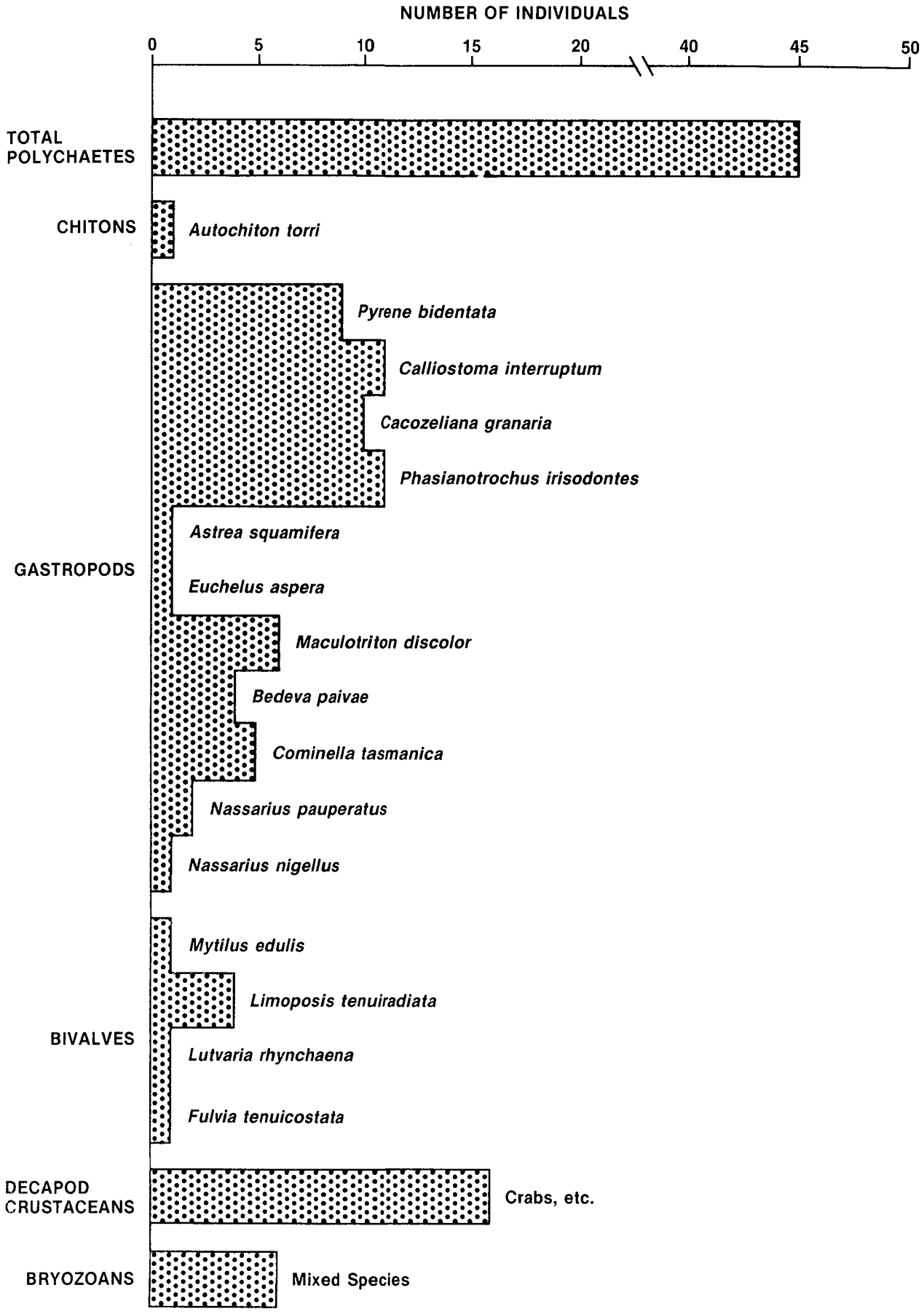



Figure 5 Relative abundance of invertebrates found in a sample taken from *Posidonia* beds off Penguin Island. (Source: R.C. Lethbridge and M.A. Borowitzka)

### 2.8.2 Shallow Rocky Bay

The embayment at the south-eastern section of the island consists of limestone covered by a variable depth of sand. This bay slopes gently and has small patches of the seagrasses Halophila ovalis and Heterozostera tasmanica. Growing further out to sea and in deeper parts of the bay (that is, at depths >0.5m) are the seagrasses Posidonia australis, Amphibolis antarctica and A. griffithsii. Near the shore, where there is little sand over the limestone pavement, large areas are covered with mussels.

The small patches of seagrasses support a small, diverse flora and fauna. Some of the epiphyes which are particularly common are the algae Enteromorpha intestinalis, Laurencia sp., Metagoniolithon stelliferum, Ceramium rubrum, C. puberbulum, Polysiphonia spp. and many diatoms. The sand areas also support burrowing and sand-dwelling invertebrates.

The fish fauna of this bay is also very diverse, with juveniles of a number of species being well represented. Populations of the elongate hardyhead Antherinosoma elongata occur here, the only known habitat outside of local estuaries. Other fish species include the flounders Pseudorhombus jenynsii and Ammotretis elongatus, the hardyheads Antherinosoma presbyterioides and Pranesus ogilby, the gobbleguts Apogon rueppellii, the yellow-eye mullet Aldrichetta forsteri, and the western sand whiting Sillago schomburgkii.

### 2.8.3 Intertidal Platforms

The structure of the platforms is described in the geology section. What follows is a generalised account of important life zones. Patterns of vertical and horizontal zonations are evident on most marine platforms with the important controlling factors being elevation within the intertidal area (that is, degree of exposure to the atmosphere), nature of substratum and wave action. These are in turn determined by platform height, slope, width, dissection and orientation (Marsh and Hodgkin, 1956).

Since most of the platforms lie at approximately Mean Low Water level, there is little vertical zonation except at the seaward rim and at the back of the platform where there are undercut, vertical limestone walls (see Figure 6). There is, however, some horizontal zonation resulting from the diminishing effects of wave action from front to rear. This zonation varies around the island, depending on the degree of exposure to the ocean swells and the width of the platform. There have been very few studies of the intertidal plant and animal communities in Western Australia, but Figure 6 illustrates the kind of zonation observed at Penguin Island. Descriptions of zonation on other local platforms can be found in Smith (1952) for Point Peron, where the intertidal platforms are very similar to Penguin Island, and in Hodgkin et al (1959) for Rottnest Island, which differs in some respects from Penguin Island.

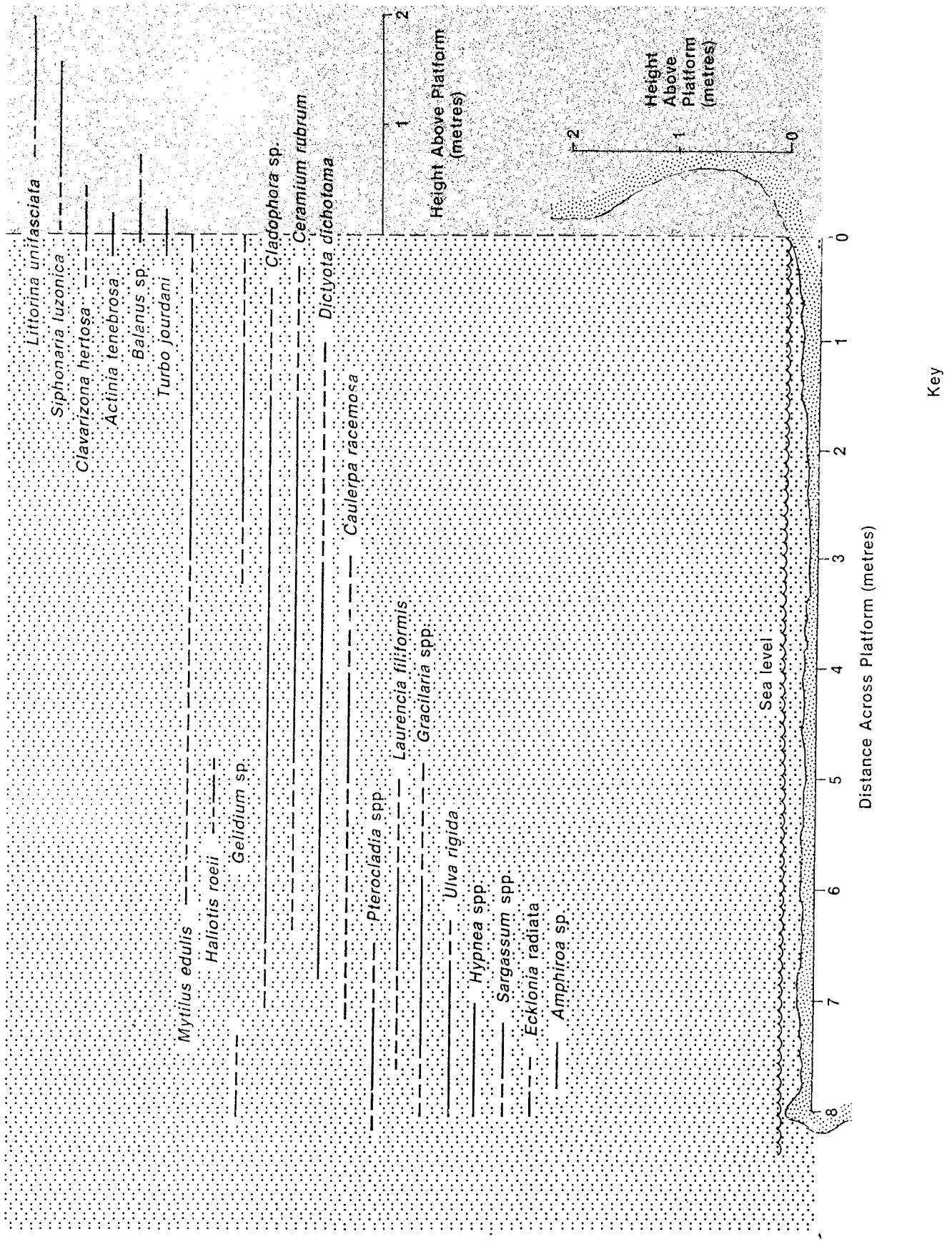



Figure 6 Profile of intertidal rock platform at the south-eastern corner of Penguin Island showing distribution of common algae and invertebrates
(Source: M.A. Borowitzka and R.C. Lethbridge)

The zones on the Penguin Island platforms can be divided into four broad categories:

- Coralline Lip

  The seaward edge of many of the platforms is raised 4-10 cm above the level of the rest of the platform. It consists of a pavement of crustose coralline algae (especially Neogoniolithon sp.) overgrown by a mat of red and brown algae such as Laurencia spp., Champia sp., Hypnea spp., Pterocladia capillacea and Sargassum spp. This lip is especially well developed on the platform at the south-eastern end of the island.

- Macrophyte Zone

  Most of the horizontal, intertidal parts of the platforms, which are normally washed by waves, are covered with a dense growth of large algae such as Dictyota dichotoma, Dictyopteris sp., Pterocladia lucida, Hypnea musciformis, H. episcoplis, Laurencia filiformis, Ceramium rubrum, Centroceras clavulatum, Polysiphonia spp., Amphiroa sp., Sargassum spp. and many others. Other algae such as Caulerpa racemosa, Cladophora spp., and Padina sp., grow in deeper depressions on the platforms. Within this algal community there are many amphipods, copepods, polychaetes, molluscs (for example, the abalone Haliotis roeii) and seastars such as Patriella gunni. Most of the platforms at Penguin Island have a well developed macrophyte zone, and this is best developed on the widest platforms at the western side of the island.

- Actinia Zone

  At the rear of the platforms there is narrow band of the red alga Gelidium sp. and in areas sheltered from direct sunlight for much of the day, such as the platform at the south-eastern end of the island, there are abundant representatives of the anemone Actinia tenebrosa. Associated with these and occurring higher up the vertical limestone faces there is also a band of chitons and limpets.

- Littorinid Zone

  In the splash zone, above the High Water Mark, is a broad band of the mollusc Littorina unifasciata. The limestone here is also sometimes covered by the green alga Chaetomorpha area and by blue-green algae.

### 2.8.4 The Benthic Sub-littoral

There are two broad habitats within the sub-littgoral in the vicinity of Penguin Island: rocky limestone and sandy bottom. The rocky platforms that characterise the south-western corner of Penguin Island, as well as isolated patches of limestone reef immediately offshore, are characteristically undercut, dissected, and sometimes developed into submerged caverns beneath their seaward edge.

The immediate subtidal perimeter and surfaces of both the isolated reefs and rock platforms are dominated by the kelp Ecklonia radiata and many other large red, brown and green algae. Among the most conspicuous of these are Sargassum spp., various Caulerpa species, Metamastophora flabellata, Curdiea obesa, Sporochnus comosus and many large red algal species. The rock surface under the Ecklonia canopy is covered by curstose corralline algae. Dr M.A. Borowitzka of Murdoch University has collected over 200 species of large algae around Penguin Island, and these species include some new to science. The shaded undercuts and caverns are almost exclusively populated by a rich invertebrate fauna. The invertebrate community is predominantly composed of encrusting filter- and suspension-feeding animals, with an apparently smaller proportion of slow-moving scavengers, herbivores and carnivores.

In most areas shaded from direct sunlight, expecially under overhangs and in caves, the limestone substratum is coated with encrusting or erect sponges, including species representing the genera Aplysilla, Tethya, Clathraria, Thorectandra, Spongia and Dysidea as well as several species of calcareous sponge, for example Sycon. The sponge matrix supports many other sessile species of various genera. The delicate colonial hydroid Halocordyle disticha is common in some areas, and yellow, orange or red colonies of one gorgonian, Mopsella sp., are also locally abundant. Bare rock surfaces often support small colonies of the scleractinian coral Plesiastrea versipora, and in certain localities the solitary mussid coral Scolymia australis is also present. Other coral general (for example, Turbinaria and Favites) that are found around Rottnest Island and within Cockburn Sound are, however, rarely encountered adjacent to Penguin Island. Other predominant members of the sub-tidal sessile community include delicate lace-corals (bryozoans) with intricate calcified skeletons, several species of tubiculous polychaete fan-worms, and a very considerable diversity of simple and compound sea-squirts (ascidians). This encrusting mat of sedentary organisms serves to camouflage a variety of cryptic species such as freely mobile polychaetes and crustaceans, and large numbers of scavenging brittlestars which are most active at night.

Large mobile species, representing several phyla and trophic levels, also abound either at the surface or partially hidden within crevices. Thus, detritus-feeding or suspension-feeding echinoderms such as sea-cucumbers (Stichopus sp. and others), and black or honey-coloured feather-stars (Comanthus trichoptera), are very common. Apart from fish, herbivores are well represented by sea-urchins, especially Heliocidaris erythrogramma, which are commonly aggregated during daylight hours in crevices and between the holdfasts of Ecklonia radiata. Sea-stars, which are mostly opportunistic slow-moving carnivores, are also extremely common. Penguin Island has conspicuous populations of Pentagonaster duebeni and Plectaster decanus, in several colour variants, as well as the highly predaceous and virtually cosmopolitan species Coscinasterias calamaria. Other sea-urchins and sea-stars (for example, Nepanthia troughtoni) are also well represented.

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Large mobile species, representing several phyla and trophic levels, also abound either at the surface or partially hidden within crevices. Thus, detritus-feeding or suspension-feeding echinoderms such as sea-cucumbers (Stichopus sp. and others), and black or honey-coloured feather-stars (Comanthus trichoptera), are very common. Apart from fish, herbivores are well represented by sea-urchins, especially Heliocidaris erythrigramma, which are commonly aggregated during daylight hours in crevices and between the holdfasts of Ecklonia radiata. Sea-stars, which are mostly opportunistic slow-moving carnivores, are also extremely common. Penguin Island has conspicuous populations of Pentagonaster duebeni and Plectaster decanus, in several colour variants, as well as the highly predaceous and virtually cosmopolitan species Coscinasterias calamaria. Other sea-urchins and sea-stars (for example: Nepanthia troughtoni) are also well represented.

Despite the fact that molluscus are not especially conspicuous, they are very common. The whelk Dicathais orbita is frequently encountered in the sub-tidal, although it is less common than the larger Turban shells. Nudibranch sea-slugs (for example, Chromodoris spp. and Phyllidia sp.) are also present, and larger crevices or holes form natural habitats for octopuses and carnivorous cuttlefish. The rock lobster Panulirus cygnus is also found under ledges and in crevices.

The sandy sublittoral supports extensive seagrass beds composed mainly of Posidonia or Amphibolis species, but also including Halophila ovalis and Syringodium isoaetifolium. The Posidonia and Amphibolis beds support a rich epiphytic flora and fauna. Studies by M.A. Borowitzka and R.C. Lethbridge have found over 135 species of algal epiphytes and 23 species of epiphytic invertebrates. These epiphytic organisms provide a direct source of food to many crabs, sea-stars, molluscs and fish as well as contributing to the detrital food chain. Also associated with the seagrass beds and the adjacent sandy areas are the sea-stars Astropecten sp. and the large Luidia ausralie. Both of these are usually buried in the sand during daylight hours. The sea-urchin Amblypneustes formosus is often found associated with the seagrass beds, as are many molluscs and ascidians such as the large solitary Herdmania sp. and the stalked solitary Pyura sp. The stems of Amphibolis are also often enveloped by compound ascidians, bryozoans and sponges. The sea-anemone Heteractis malu occurs frequently in associated with shallow sea-grass beds where it is partially buried in the sand. Some of the sand areas also support beds of the green alga Caulerpa trifaria as well as another, undescribed, species of Caulerpa. Where there is some hard substratum under the sand communities many macrophytic red, brown and green algae also develop.

### 2.8.5 Importance of the Marine Environments of Penguin Island

Penguin Island is the largest limestone island close to the mainland, other than Garden Island. It is surrounded by all the major marine habitats which can be found in the Perth region: intertidal limestone platforms, subtidal limestone reefs, seagrass beds dominated either by Amphibolis or Posidonia, and sandy soft bottoms. It is therefore an excellent site for both recreational (for example, snorkelling, S.C.U.B.A. diving, fishing), educational and research use. Murdoch University uses Penguin Island as the field area for its course on marine and estuarine biology, and researchers from Murdoch University and the Western Australian Institute of Technology are working around the island.

Penguin Island also differs significantly from Rottnest Island, the only other easily accessible island in the Perth region. The marine habitats of Rottnest Island show a range of unique features related o the closeness of the island to the edge of the continental shelf and the warm Leeuwin current. Penguin Island marine habitats lie very close to the mainland and are typical of the coastal marine environments of the Perth region.

At this stage there is no attempt at conservation of the coastal marine environment in the Perth area, except for a small reserve near Waterman, and therefore the inclusion of some of the marine habitats of Penguin Island in the management plan is of great importance.

## 2.9 Minerals and Construction Materials

Penguin Island contains no economic deposits of minerals or construction materials. Although the plateaux were scraped clear of their nitrogenous soils early this century there appears to have been little build up in subsequent years. It is unlikely that such an operation could again be considered economically viable or logistically feasible. Australian Iron and Steel proposed to dredge offshore lime sands near Penguin Island in 1970, but withdrew the proposal in May 1970.

## 3. EXISTING USE AND MANAGEMENT

### 3.1 Past and Present Uses

Penguin Island has been subject to varying degrees of public use for most of this century. The island was first gazetted as a reserve for "Public Utility" on 16 October 1918 in order that legal tenure, by way of an annual lease, could be granted to an illegal occupant known as "Seaforth" MacKenzie. The lease was subsequently cancelled in 1926. During his stay on the island MacKenzie excavated several caves in the soft limestone. Most of these have been subjected to erosion and roof-fall, including the main cave which served as MacKenzie's home and general meeting place. The remnant of this cave can still be seen at the northern end of the island. Early this century both the northern and southern plateaux were scraped clear of their nitrogenous soils to provide fertilizer. The southern plateau remained bare until the 1950s (see Figure 2).

The island was later administered by a Board appointed under the Parks and Reserves Act in November 1935. Administration was then passed over to the Rockingham Road Board in November 1945, at which time the gazetted purpose of the reservation was changed to 'Recreation (camping excluded)'. The Rockingham Road Board experienced difficulties in managing Penguin Island and it was subsequently vested in the State Gardens Board in September 1949, with power to lease for 21 years. At the same time the purpose of the reserve was changed to 'Recreation camping and enjoyment by the public for holidays and for purposes ancillary thereto'. The State Gardens Board sought to develop the island into a tourist resort and tenders were called in 1950 for a ten year lease over a triangular portion of the island for a holiday camping site (see Figure 7). In August 1950 the Rockingham Road Board wrote to the Under Secretary for Lands to request the (then) Lands Department to police the island as "considerable vandalism" was occurring. In October of the same year the W.A. Naturalist's Club wrote to the Gardens Board stating that leasing the island would endanger bird-life and increase erosion and destruction of vegetation.

Approximately 2.5 hectares was subsequently leased to Messrs Heales and Griffiths (see Figure 7). The State Gardens Board visualised that the lessee would provide tents for campers because the construction of buildings was not considered practical. The lease eventually changed hands to Mr and Mrs R G Carlberg, during which time hut accommodation was constructed. The reserve was vested in the National Parks Board in March 1957, with the gazetted purpose and power to lease remaining unchanged. Action was taken in early 1966 to seek Class A status for the reserve, which was gazetted in September 1966.

Penguin Island Pty Ltd, representing a group of 15 people, purchased the leasehold in mid-1969. Development of the island increased from that time. The Company requested an extension of the lease area in August 1972 on the basis of a changing coastline. The requested extension was granted by the National Parks Board in September 1972. The lease (not surveyed) covers approximately eight hectares and does not extend below high water mark (see Figure 7). The current lease term was due to expire on 31 December 1987. However, a submission

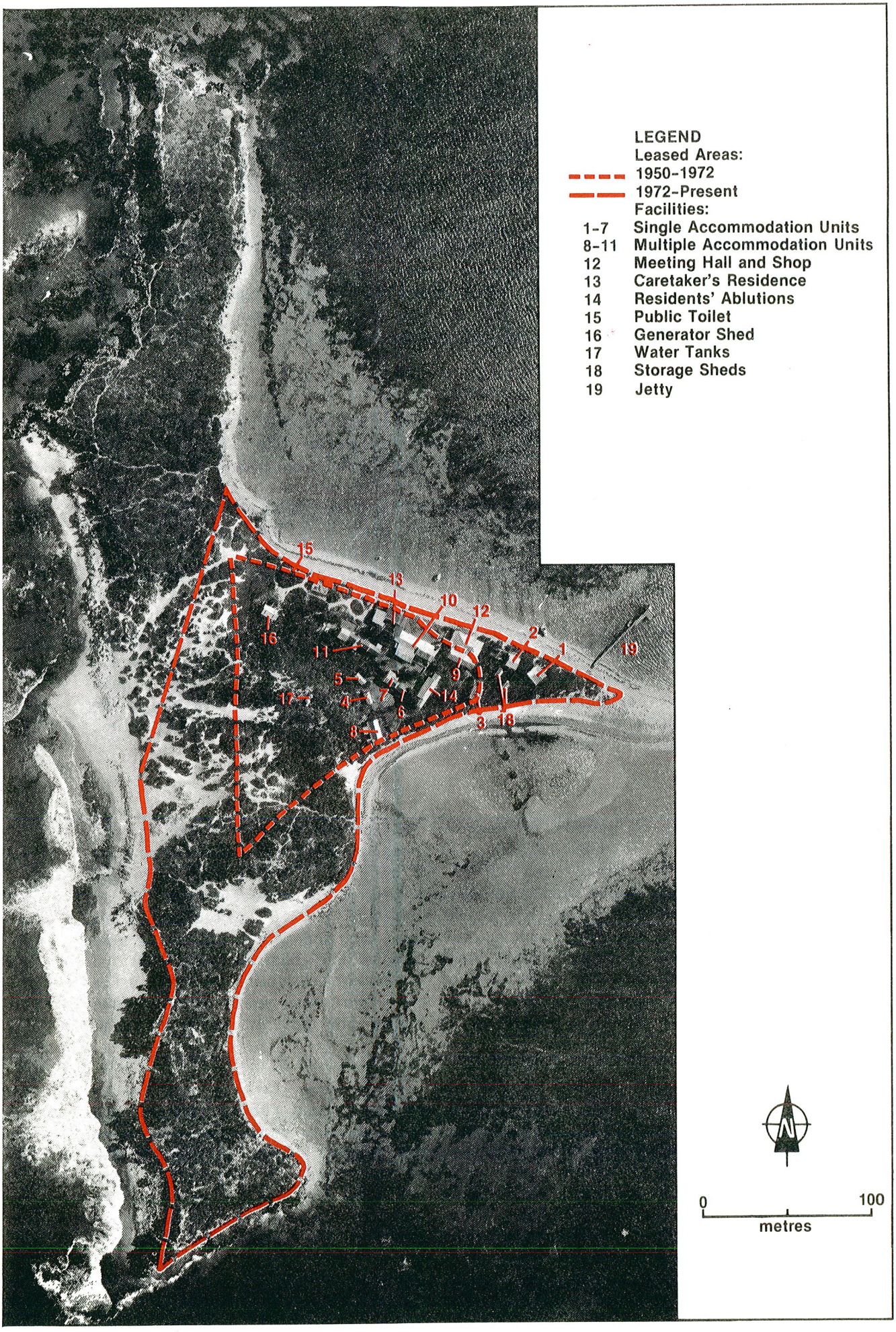



**Figure 7 Leased Areas, Facilities and Structures**

was made by the Company in August 1974 for cancellation of the existing lease term and re-issue for a further period of 21 years. This was granted by the Board in September 1974.

Current public use of Penguin Island and its nearshore waters by holiday and day visitors centres on activities dependent on the natural attributes of the island's resources. The clean white summer beaches and clear shallow waters attract beach users, swimmers, divers and fishermen. The surrounding waters also attract boating enthusiasts who launch boats directly from the mainland foreshore. Penguin Island Pty Ltd estimates that approximately 8,000 visitors come to the island on their ferry service annually (see 3.3), while an equal number walk across the shallow sand bar from the mainland. Intensity of use is highest in the summer months.

### 3.2 Facilities

Development of the island has increased since Penguin Island Pty Ltd became the lessees in 1969. A water pipeline was laid from the mainland to the island in 1970 with the (then) National Parks Board contributing towards the cost. A telephone cable to the island was laid in 1972, a power plant installed and accommodation facilities upgraded. Existing facilities include accommodation units, meeting hall and shop, caretaker's residence, residents' ablutions, public toilets and free-standing external shower, storage and generator sheds, water tanks and the jetty.

According to National Parks Authority records, the National Parks Board established a grassed picnic area in 1970 and installed picnic facilities, including barbecues and tables. However, this picnic area no longer appears to exist. The only items remaining are barbecues, tables and rubbish bins on the north-eastern shoreline, some of which are in derelict condition.

### 3.3 Access

Safe boat or ferry access to Penguin Island has been provided by the various lessees of the island. At present Penguin Island Pty Ltd operate a ferry, which can carry 60 people, between the mainland jetty on Mersey Point and the island jetty. The ferry runs on an hourly and two-hourly basis on weekends and public holidays but is not operated between May and August when the accommodation units are closed each year. Many people walk across the shallow sand bar to the island, despite the erection of prominent signs on Mersey Point warning of the dangers of the crossing. Over the years some people have lost their lives attempting to cross the bar in adverse tidal conditions.

Access on Penguin Island itself has always been largely undirected with visitors following the eastern beaches around the settlement and traversing the northern and southern ends of the central dune area to reach the popular beach on the western shore. Over the years the impact of foot traffic has resulted in loss of vegetation and exposure of the unconsolidated sands to wind erosion, especially in the central western foredune area. Apart from these main access routes, uncontrolled access occurs throughout the island and numerous tracks dissect the vegetation.

## 3.4 Past and Present Management

### 3.4.1 Statutory Controls

At the statutory level Penguin Island and its nearshore waters have been, and are, subject to a number of Acts and their by-laws and regulations, including the Parks and Reserves Act 1895, Fisheries Act 1905, Health Act 1911, Harbour and Jetties Act 1928, Land Act 1935 and the National Parks Authority Act 1976. A comprehensive lease document was drawn up between the National Parks Board and Penguin Island Pty Ltd in 1974 which is operative until the lease expiration in 1995. The conditions of the lease include, among other things, the following points:

- a nominal rental of $4.00 per annum subject to review before the expiration of the fifth (1979), tenth (1984) and fifteenth (1989) years of the 21 year term of lease;
- the lessees to provide and maintain the existing ferry service;
- maintenance of the lease area in a clean condition;
- maintenance of all improvements (including the planting and maintenance of grass);
- public use of the reserve for its gazetted purpose;
- the National Parks Authority to inspect the island and issue notices for repairs and works if required;
- the lessees to comply with all appropriate Acts;
- the lessees to appoint an honorary ranger (now in accordance with Section 29 of the National Parks Authority Act);
- co-operation with government departments in implementation of soil erosion works.

With respect to marine resources, in October 1982 the Minister for Fisheries and Wildlife declared a prohibition under the Fisheries Act on the taking of any species of molluscs of the class Gastropoda (including abalone, whelks, turbans, top shells, periwinkles, baler shell and giant conch shell) or any species of sea urchin of the class Echinoidea in "all that portion of the Indian Ocean surrounding Penguin Island bounded by the highwater mark of that island and a line offshore, parallel to and 200 metres from that highwater mark" (Notice No. 118, Government Gazette, 29 October 1982). The Department of Fisheries and Wildlife will be reviewing the closure of this area, as well as the area from Fremantle North Mole to Two Rocks, towards the end of 1983. The Department is considering the options of either declaring a short open season from 1 December 1983 or maintaining the closure for another 12 months and then declaring a normal open season from 1 October 1984 to 28 February 1985 (J. Penn, pers. comm.).

### 3.4.2 Management Action

No comprehensive management programme has been prepared for Penguin Island since its reservation in 1949 for public recreation and holiday purposes. Development, rather than management, works which have been implemented have been largely aimed at facilitating public use of the island, especially in the settlement area. Management and development costs have been borne by both the National Parks Authority (or Board prior to 1976) and lessees. Throughout its vesting period the Authority has variously paid for, or contributed towards, the cost of scheme water connection and rates, provision of firewood, picnic facilities, trees, repair and maintenance of public toilets (for example, $680 in 1973 and $5500 in 1980), and signs.

Management of the island's natural resources has been minimal. In 1972 the Board sought advice from the Department of Agriculture on erosion control and the Department responded with detailed advice on the need for fencing, brushing and the planting of marram, spinifex, and native shrubs, as well as offering staff assistance. However, these recommendations on erosion control were not implemented. In 1972 the Board also sought advice from Public Works Department on the increasing sand build up on the tombolo. The Department advised that the sand bar silting related to greater sand movement in Warnbro Sound, and suggested that a hydrographic survey could be carried out with a view to possible groyne construction. However, in its reply the Department also added that the results would be inconclusive and the proposal did not proceed.

Management of the island's wildlife populations has also been limited, being confined to construction of artificial nesting burrows for penguins. The Board sought advice from the Zoological Gardens Board on this matter in the late 1960's. Some work, largely voluntary, was carried out to save birds affected by an offshore oil spill in 1971. Again, in the late 1960's a portion of the northern plateau was roped off and sign-posted as an 'unofficial' bird sanctuary with the aim of controlling access into this area. However, this has proved to be an inappropriate and ineffectual form of management and the signs have fallen into disrepair.

In 1981-82 Penguin Island Pty Ltd erected a number of wire fences in an attempt to prevent public access across the steep dunes at the north-western end of the settlement. Where the fencing has prevented access bare areas are being revegetated by Tetragonia decumbens. In January 1983 the National Parks Authority provided a board and chain walkway which has been placed on the steep slope abutting the beach on the south side of the settlement.

# 4. ASSESSMENT OF MANAGEMENT NEEDS

## 4.1 Adequacy of Existing Management

Unfortunately, management of Penguin Island as a natural resource has been totally inadequate since its creation as a recreation and camping reserve in 1949. The concern expressed by the W.A. Naturalist's Club in its letter to the State Gardens Board in 1949 regarding degradation which could occur as a result of leasing the island (see 3.1) has proven to be justified. The management problems which have arisen over the last 34 years have resulted, up until the late 1970's, from a lack of understanding of management requirements with respect to the fundamental resource capability of the island environment, coupled with a general lack of funds and expertise on the part of the various government agencies and lessees which have been responsible for Penguin Island. In recent years the problem has been compounded by the urban expansion of the Rockingham area and the increasing pressures resulting from higher day visitor usage.

Although the National Parks Authority recruited professional management planning staff in the late 1970's and has been aware of the island's problems, their State-wide responsibilities and limited financial resources have precluded detailed planning and consistent management involvement with what has been perceived as a small recreation reserve. The terms of the lease drawn up between the Board and Penguin Island Pty Ltd in 1974 attempted to deal with management control by making the Company responsible for the general upkeep of the island, including the appointment of an honorary ranger. However, it appears that the Company has limited funds and staff resources to undertake basic management works, such as fencing and walkway construction, and day to day management operations with respect to day visitor control. The Company has appointed its resident Manager as honorary ranger, whose Company-related duties include operating the ferry service and managing the settlement area. Clearly, he has limited time to fulfill a wider management role.

While it may have been valid to regard Penguin Island as a suitable holiday venue in 1949 it is now appropriate to re-assess the validity of this type of use in the present and future context. As can be seen from the discussion of natural resources in Chapter 2 the island and its nearshore waters should be regarded as a valuable natural asset which will require a high degree of management input to restore and sustain its terrestrial and marine ecosystems. In a sense, Penguin Island (and Shoalwater Bay as a whole) has now become part of the metropolitan area and its existing use and management needs to be reviewed in the light of its regional context and the pressures which are, and will be, placed upon it.

The recent System 6 Study Report (1981) has recognised the regional conservation and recreation significance of the Shoalwater Bay area, including Penguin Island, by recommending the creation of a C-class aquatic reserve and further investigations into the biological significance of the islands and waters. The Study also made recommendations for aquatic reserves adjacent to Rottnest and Carnac Islands.

The close proximity of Shoalwater Bay and its diverse conservation and recreation resources to the mainland, with increasing use pressures as the metropolitan area continues to develop, will necessitate greater management input into indiviual reserves and a uniformity in approach to management of the bay as a whole.

With respect to Penguin Island, the National Parks Authority must increase its management commitment and determine the validity of the present holiday use and retention of the existing lease arrangement if the island's resources are to be conserved. It is essential that the management of natural resources which are subject to a high degree of public use is undertaken by a body which can commit an appropriate level of funds and staff, whether it be a government agency or private company.

## 4.2 Current Management Issues

Following is a summary of the main management issues affecting Penguin Island. Proposals for use and management of the island are presented in Chapter 5.

### 4.2.1 Landscape and Facilities

- The proximity of buildings to the shoreline and their predominantly white or off-white paint creates a visual intrusion which dominates the eastern side of the island and is clearly visible from the mainland.

- The north-western end of the settlement in the vicinity of the generator shed and public toilets has a 'junk yard' appearance with drums, timber, a damaged boat, wire mattresses, concrete and other derelict items scattered about. There are also large areas of bare sand.

- Fixed barbecues, rubbish bins, tables and seats on the north-eastern beach and in limestone caves are poorly located (below high water mark) and in derelict condition.

- The large areas of eroded dunes and numerous tracks which dissect the island impact on the landscape, both on the island itself and on the scenic amenity of the Shoalwater Bay area.

### 4.2.2 Soils and Topography

- Lack of effective access control has resulted in loss of vegetation and erosion of sands in the central dune area, especially on the western side facing the direction of prevailing winds.

- If the eroded areas are not stabilised the entire central dune area may eventually mobilise and spill down the steep eastern slopes, destroying what remains of the Acacia rostellifera community.

### 4.2.3 Geology

- Some of the limestone karst formations and fossil root structures have been vandalised.

- Thin limestone overhangs and caves, both natural and man-made, could be hazardous in some locations.

### 4.2.4 Coastal Processes

- The presence of the shallow sand bar connecting the island to the mainland provides a relatively easy, if hazardous, means of access for thousands of day visitors each year. However, construction of barriers to prevent access from the mainland or coastal engineering works to alter the tombolo formation would incur high initial and ongoing management costs.

- In periods of intense winter storms most of the beach sand is removed from the western side of the island, exposing the underlying beach rock and Pleistocene limestone formations. Continuing loss of binding foredune vegetation to foot traffic and wind erosion will result in further removal of sand from the foredune area and an increasing imbalance in the beach sand supply cycle. In time this imbalance between beach erosion during winter storms and replenishment during the summer months could result in substantial depletion of the central western beach and loss of recreation amenity.

- Winter storms also affect the eastern side of the island, with substantial erosion of the sandy shoreline of the northern and southern embayments. The buildings facing the northern embayment are subject to wave attack and inundation during severe storms. The buildings have been constructed at the edge of the beach without regard for a suitable setback and retention of a vegetated foredune.

### 4.2.5 Vegetation

- Uncontrolled access, erosion and progressive construction of the settlement has resulted in fragmentation and reduction of plant communities and loss of individual species (for example, Acacia cyclops). This in turn has further repercussions on the stability of the island's soils and topography.

  In those areas where regeneration is occurring disturbance or coloniser species predominate.

- A number of exotic species have been introduced to, or become established on, the island.

- The vegetation is an important wildlife habitat and its loss or change in species and structure has induced changes in the nesting habits of bird species, in particular the Little Penguin.

- Changes in the composition of plant communities on the plateaux are related to the presence of breeding seabirds, especially the Silver Gull, due to the enrichment of the thin soil with faeces.

4.2.6 Wildlife

- The island supports the largest breeding colony of Little Penguins in Western Australia. In the natural environment the penguins nest in burrows excavated in the sand, under dense bushes and in caves in the limestone. However, the widespread loss of suitable vegetation and undisturbed sand areas has resulted in large numbers of birds nesting under buildings in the settlement area during their breeding season (April-November). The penguins moult in November-December at which time they prefer open shelters. Significant mortality occurs during this period due to human interference.

- Little Shearwaters nest in burrows under dense clumps of Rhagodia baccata and Tetragonia decumbens. The burrows are occupied for most of the year and are susceptible to human disturbance. There is little data available on their breeding habits.

- Bridled Terns have an expanding breeding population on the island. Their nest scrapes under bushes and limestone slabs are susceptible to human disturbance.

- The Silver Gull population is rapidly expanding on the plateaux, probably in response to increased food supply on the mainland, in particular the Rockingham rubbish tip. The population will soon increase to a level where intense competition will occur between gulls and terns, such as predation of tern chicks and eggs by the gulls and kleptoparasitism (food stealing by gulls from terns). The gulls are already behaving aggressively to humans, especially during the breeding season. On the positive side, the presence of an appropriately sized gull population helps to maintain the vegetation in an 'open' condition suitable for seabird colonisation and an optimum gull population also favours interspecific social facilitation of breeding. Due to their longevity, culling the adult birds is the only real option if the population is to be contained.

- Penguin island has the potential to support populations of other seabird species if the existing level of management is upgraded, thereby increasing its already valuable role as an island habitat for a range of species.

- Burrows of the Kings Skink lizard which preys on Silver Gull eggs are susceptible to trampling in some areas.

- Feral pigeons roost in the remnant of MacKenzie's Cave at the north end of the island.

### 4.2.7 Marine Environment

- Amateur fishermen have had a major impact on shellfish populations on the accessible intertidal platforms around the island. The existing ban on this activity has not been widely publicised and the lack of staff to police the resource has limited its effectiveness.

- There is a need to undertake detailed studies of the marine ecology to determine suitable management procedures and options for use of marine resources.

# 5. MANAGEMENT PROPOSALS

## 5.1 Existing Use and Purpose of Reservation

A function of resource management planning is to achieve a balance between suitable use of resources and their conservation. If this balance is not achieved environmental degradation will occur which will result in significant increases in management costs and loss of amenity to users. As stated in Chapter 4 it is now appropriate to evaluate the suitability of the existing reserve purpose and the current level and type of use of the island, since it is obvious that this essential balance between human use and resource conservation is lacking. It is therefore important that this management plan proposes alternative uses for Penguin Island which reflect the island's potential as a valuable conservation, education and recreation resource within the metropolitan region.

While holiday recreation on the island has no doubt attracted and provided pleasure for a large number of visitors over the years, the following points need to be considered in determining the validity of this type of land use in the long term:

- Penguin Island will become increasingly important as a regional conservation and public recreation resource.

- There is a need for a comprehensive and integrated management approach to the entire Cape Peron-Shoalwater Bay area which recognises the wide range of existing natural resource uses and values, including holiday recreation on Cape Peron, conservation areas such as Seal Island, recreation on the mainland foreshore and in nearshore waters; and recognises the potential conservation, recreational and educational use of resources on Penguin Island and within the Shoalwater Bay marine environment as a whole.

- When placed within its regional and local context it can be seen that Penguin Island with its small area suitable for development (.55 ha), has limited capacity to sustain a viable holiday resort complex when compared to other existing areas able to provide a similar holiday experience, such as Rottnest Island and Cape Peron, as well as proposed holiday and recreation orientated developments at Port Kennedy, Secret Harbour and Woodman Point. Furthermore, the limited area available for public recreation on Penguin Island needs to be considered in determining the continuance of holiday uses. The benefits to the community as a whole in making the area occupied by the existing settlement available for public use must be weighed against the benefit to a relatively small number of people able to use the accommodation facilities at any one time, especially when this type of use is catered for in other parts of the metropolitan region.

- With respect to the physical suitability of the settlement site, any development beyond the present lease

period would have to be subject to stringent controls on siting and design. For example, setbacks to protect structures against storm waves, retention of foredune vegetation, re-establishment of other vegetation communitites, and protection of the landscape. This in turn would further limit the capacity of the site to support an economically viable holiday development. As a general approach it should be accepted that any commercial development within suitable Crown reserves, especially national parks and other conservation reserves, should be commercially viable, incur no costs to the relevant Government agency, provide public access and maintain a high level of management.

In consideration of the above points the following options need to be evaluated by the Authority in determining the long term use and management of Penguin Island.

1. Continuing the existing holiday use for the duration of the lease period (until 1995) subject to:

   - Strict adherence to the covenants contained within the lease agreement, especially those concerning reserve and structural (buildings, jetty, fences) maintenance.

   - The Authority issuing an immediate notice to the Company in compliance with Part 2(k) of the lease agreement to carry out the works specified in 5.3.7.

   - Performance of full ranger duties by a Company-appointed honorary ranger in accordance with Part 2(o) of the lease agreement (a work programme should be prepared by the Authority).

   - Re-assessment of the annual rental fee prior to 20 June 1984, in accordance with Part 4(b) of the lease agreement, to an amount which either reflects the Authority's annual management costs or is calculated on a purely commercial basis (that is, related to the economic value of the commercial holiday operation). The existing fee of $4.00 is totally unrealistic in view of the Authority's necessary management commitments to the island. A token rental may be appropriate where the lessee undertakes all management and associated funding in the commercial development of a given area, but this is not the case on Penguin Island.

   - Removal of unsuitable buildings and structures on termination of the lease in 1995 and implementation of a management programme in conformity with the goals and objectives set out in this plan (see 5.2.1).

2. Negotiating with the Company to obtain an early determination of the lease, remove existing structures, change the purpose of the reservation to one which better reflects the goals and objectives proposed in this plan and implement the recommended management and development proposals. This may necessitate

some form of compensation or payment to the Company, which in turn would depend on:

- The value of built structures on the island, and whether or not the Authority wishes to purchase them or whether the Company removes and sells the structures or materials.

- Estimated loss of income through early determination of the lease.

- The length of 'lead in' time before the Company actually leaves the island and the Authority develops an adequate management presence (a minimum of one year and a maximum of three years would seem appropriate).

In terms of natural resource management planning the second option is the recommended course of action, given the high conservation, education and recreation value of the island. If the Company remains on Penguin Island for the duration of the lease 11 years will elapse before planning and management proposals for the Tombolo Unit (see 5.2.2 and 5.2.3) can be implemented. During this period the factors which necessitate management planning at the present time can be expected to increase in intensity or importance, including:

- Local and regional population pressures and day visitor numbers.

- The impact on wildlife populations, especially the Little Penguin, within the Tombolo Unit.

- The increasing regional importance of the Shoalwater Bay area and its conservation and recreation resources, with the likely preparation of a comprehensive management and development plan for the bay as a whole.

- A substantial delay in developing the educational potential of Penguin Island with the loss of valuable opportunities for schools, tertiary institutions and individuals within the community (see 5.2.3 for proposals).

## 5.2 Proposed Use and Management

While the question of continuing holiday recreation on Penguin Island until 1995 should be resolved as early as possible it should not affect or delay implementation of the management recommendations outlined below. However, because there is a need to formulate use and management proposals for the island subsequent to determination of the lease, in 1995 or earlier, goals and objectives have been related to lease and post lease time frames.

### 5.2.1 Goals and Objectives

Although the existing Reserve A17070 does not extend below high water mark the nearshore marine environment should be considered an integral part of the island ecosystem, since it is important to recognise the interrelationship of the island's terrestrial and

marine natural resources, both from an ecological viewpoint and in terms of human use and management. The following management goals reflect this interrelationship.

- The overall management goal should be to protect, restore and sustain the island environment and its terrestrial and marine resources.

- Lease duration - bring the island to a managed condition, rationalise human use of natural resources and minimise human impact on the environment as a whole.

- Post lease - develop the island's potential as a public education, research and recreation resource consistent with conservation of its terrestrial and marine ecology.

These management goals should be pursued by implementing the following objectives:

(a) Lease duration

- implement a vegetation restoration and protection programme;

- implement a wildlife management programme;

- undertake erosion control works;

- control public access and recreational use;

- implement a landscape improvement programme;

- implement an ecological research and monitoring progamme;

- initiate a public education programme;

- initiate a marine resource management programme;

- encourage research projects useful to management.

(b) Post lease

- change the existing land use to one more suited to the island's value as a conservation, education, research and recreation resource;

- provide an extension and nature interpretation service to help visitors enjoy the ecological and recreational features of the island and its waters;

- provide special opportunities for education groups from schools, colleges and universities;

- maintain recreational activities compatible with protection and management of the island environment.

### 5.2.2 Use and Management Units

Effective management of Penguin Island hinges on the rigorous control of public access within the reserve and the clear definition of public use and conservation areas. Further development should be restricted to construction of fences, walkways and wildlife observation hides for the duration of the lease period, with no expansion of existing facilities or intensity of holiday uses.

Plan 1 shows a proposed pattern of access and specifies distinct management units in order to identify areas of different use and management emphasis for the reserve and surrounding waters. Recreation has been confined to the eastern (Tombolo Unit) and western beaches and the northwest rock platform area (Rock Platform Unit) as the majority of holiday and day visitors currently use these areas for beach and water oriented recreation activities. Management of the Tombolo Unit also has an important conservation emphasis. Although continuing use should be subject to monitoring and, in the case of the Rock Platform Unit, further investigation into human impact on the marine ecosystem, the specified management units should be able to sustain ongoing recreational use during the summer months. The proposed conservation management units (North Plateau, Central Dune and South Plateau) contain the major wildlife habitats and vegetation in need of rehabilitation and/or protection. The broad characteristics of each management unit are described in Table 2, while detailed management requirements are discussed in 5.3.

The existing ferry service should continue to provide access to the island from the mainland and people be discouraged from using the sand bar as a means of access. Since construction of physical barriers or alteration of the tombolo formation to prevent access would incur high initial and ongoing expenditure it will be necessary to increase public awareness of the dangers of crossing the bar and the purpose of management in controlling access to and within the island (see 5.4). Management will have to rely on suitably constructed fences, paths and steps on Penguin Island to implement the proposed use and management plan.

### 5.2.3 Options for Post Lease Development

It is anticipated that the proposed broad differentiation of recreation and conservation areas and pattern of access, including provision of a ferry service, will remain valid following expiration or termination of the current lease, although this would be subject to ongoing research into ecological management requirements and assessment of use pressures. The critical area which will require consideration for future use and management is the existing holiday settlement within the Tombolo Unit since, as already recommended, the buildings should be removed. Although the present lease arrangement may continue until 1995 it would be wise to undertake planning now, if only at a conceptual level, in order to avoid repeating the arbitrary decisions and ad hoc developments which have characterised the history of Penguin Island. Three options for use of the resulting flat area of land are:

1. Remove the buildings, grass lawns and exotic trees, re-establish the Acacia rostellifera community to its

1942 coverage, protect foredune vegetation and prevent public access.

2. Retain and manage the lawn area for public recreation and picnicking, retain exotic trees adjacent to the lawn and re-establish natural vegetation in surrounding areas.

3. Develop the site as a nature interpretation and educational display centre with provision for grassed picnic areas and re-establishment of natural vegetation in surrounding areas.

The first option would necessitate intensive management input, both initial and ongoing, to remove the existing exotic grasses and other vegetation and restore the Acacia community. The difficulties of such a horticultural exercise would be compounded by the management problems associated with preventing all access into the area, protecting it against fires and controlling litter and weeds during restoration, which would take at least five years. Since use pressures placed on Penguin Island from the nearby mainland can be expected to increase over time it would be necessary to maintain a high management input on a permanent basis to protect the restored area.

The second option would involve removal of existing buildings, retention and redesign of lawn areas for use as a public recreation area. The existing water supply system could be used to irrigate the lawn and supply a suitably designed and located toilet facility. Re-establishment of the Acacia vegetation onto other parts of the Tombolo Unit and retention of foredune vegetation would improve landscape amenity, maintain soil stability and increase the area available for wildlife habitat. Again, significant ongoing management input would be required to maintain the lawns and other facilities. However, because of the retention of a public use area the high management costs associated with maintaining a purely 'no access' protected area in this location should be reduced. This option would provide for a grassed recreation area sheltered from summer south-westerly winds which would complement nearby beach and aquatic recreation areas.

The third option goes beyond designation of basic recreation-conservation areas and recognises the island's potential as a natural environment education resource. Implementation of this option would involve construction of well designed, high quality facilities to provide a nature interpretation service to the public and special educational opportunities for schools, colleges and universities. Facilities could include an accommodation building for overnight stay by staff and students of educational institutions, as well as management and research staff, and a field study / educational display building to present, among other things, visual displays and disseminate information to the general public on the terrestrial and marine environments of the island and Shoalwater Bay. The latter building could also have work facilities for students and researchers separate from public areas. The provision of these facilities would complement a wider nature interpretation programme which could include wildlife observation hides, terrestrial

and marine nature trails and a penguin observatory. As the Little Penguin is the most significant wildlife component of the island environment it would be appropriate to provide a facility to enable researchers to study its behavioural ecology and to provide an educational experience for the public. A proposed design for a penguin observatory is presented in Appendix D, as well as supplementary notes on those aspects of penguin biology which are integral to the design concept.

In summary, the third option is considered the most suitable for the long term use of Penguin Island. Obviously, full implementation of this option will require comprehensive site planning and design, and will necessitate a relatively high capital outlay. Figure 8 is a pictorial representation of the island developed according to the third option and shows a field study/visitor centre (round building), accommodation building and a penguin observatory on the south-eastern foreshore. If financial or other constraints delay implementation then the second option could be implemented as an interim measure on expiration of the lease.

## 5.3 Management Recommendations

The following specific management recommendations (also see Plan 2) refer mainly to current management issues and should be implemented as soon as possible. Some recommendations are relevant to the post lease phase.

### 5.3.1 Public Access

The successful implementation of management recommendations concerning erosion control, vegetation and wildlife management depends on the effective control of public access on Penguin Island. The key to controlling access is the provision of clearly sign-posted, well constructed steps and paths to channel people from one side of the island to the other. This will necessitate:

- Erecting information signs at the end of the island jetty and on the mainland to direct people to the northern and southern access paths to the western beach (see 5.4).

- Constructing stepped and railed timber walkways at the eastern and western boundaries of the Central Dunes Unit of 21 metres and 17 metres length respectively. Similar construction to that used for walkways at Salmon Holes in Torndirrup National Park would be suitable. Although expensive, this type of walkway is recommended due to the steep slopes and, on the western shore, the unstable condition of the dune face. Well constructed, comfortable walkways will also encourage the large number of visitors to the island to confine themselves to designated access paths. Suitably constructed fencing also plays an important role in channelling public access, as well as protecting eroded areas and vegetation.

Table 2 : USE AND MANAGEMENT UNITS

| UNIT | DESCRIPTION | USE | ACCESS | MANAGEMENT EMPHASIS |
|---|---|---|---|---|
| 1. Tombolo | Low-lying modified sand bar feature with buildings, jetty, exotic trees, irrigated grass lawns, and modified dune vegetation, beaches. | • Beach and nearshore waters recreation — swimming, boating, fishing (except spearfishing).<br>• Holiday uses within settlement area. | • Public access from the jetty along beaches.<br>• Private access within settlement. | • Maintenance of the settlement area in a clean and tidy condition.<br>• No further construction of buildings.<br>• Protection and (re) establishment of natural vegetation |
| 2. Central Dunes | •The highest part of the island, rising to 20 metres above sea level.<br>•Deep unconsolidated dune sands, predominantly unstable and mobile in the western and central areas.<br>•Eastern slopes support the remaining *Acacia rostellifera* community. | No public use of this unit. | • Only management and research staff.<br>• A fenced public walkway to connect the Tombolo and Western Beach units. | • Revegetation of unstable areas, maintenance of existing vegetation.<br>• Monitoring and management of fauna populations.<br>• Development works restricted to construction of fences and walkways.<br>• Annual monitoring of revegetation programme. |
| 3. Western Beach | •A narrow sandy beach overlying Pleistocene limestone.<br>•Susceptible to erosion by severe winter storms.<br>•Intertidal rock platforms fringe the beach and reef platforms lie offshore. | • Beach recreation activities:— sunbathing, swimming, surfing, fishing (shellfish only in declared open seasons), diving.<br>• Spearfishing and netting not permitted. | Open public access within the defined management unit. | • Monitoring of public use to assess, among other things, numbers of visitors and possible impact on marine ecology.<br>• Maintenance and restoration of foredune vegetation.<br>• Development works confined to fence construction and sign-posting. |
| 4. South Plateau | •Includes the raised limestone plateau with low vegetation (as per North Plateau), aeolianite limestone formations and fringing intertidal platforms.<br>•The clear nearshore waters contain diverse marine habitats: reefs, caves, sea grass meadows, sandy bottoms. | • Education orientated uses and research in both terrestrial and marine environments.<br>• Spearfishing, professional and amateur shellfish harvesting and collection of sessile organisms (for example, gorgonians) should be prohibited within the protected area shown on Plan 1. | • Controlled access into this unit for wildlife observation, (terrestrial and marine environments) | • Conservation and management of terrestrial and marine ecology. |
| 5. North Plateau | Predominantly level limestone plateau with shallow sandy soil supporting *Rhagodia baccata* and *Carpobrotus virescens* communities. | Supervised education orientated uses (nature study, research), photography. | • A fenced walkway to connect the Tombolo and Western Beach units.<br>• Controlled access into the North Plateau Unit for wildlife observation | • Conservation and management of wildlife and associated habitats.<br>• Development works restricted to construction of a walkway, fencing and observation hide. |
| 6. Rock Platform | •Westernmost edge of the northern plateau, undercut cliff face, rock platforms, aeolianite features, intertidal platforms and nearshore waters. | • Education orientated uses (nature study, research), diving, swimming, fishing (shellfish in open seasons), viewing MacKenzies Cave.<br>• Spearfishing not permitted. | • Along a fenced walking track on the edge of the plateau.<br>• Access to water and platforms at specified points. | • Monitoring of public use to assess impact on marine ecology, seabird populations, geological features.<br>• Restriction of public access to some or all parts of the management unit as required to protect the marine ecology and breeding seabirds. |


**PLAN 1 USE AND MANAGEMENT UNITS**

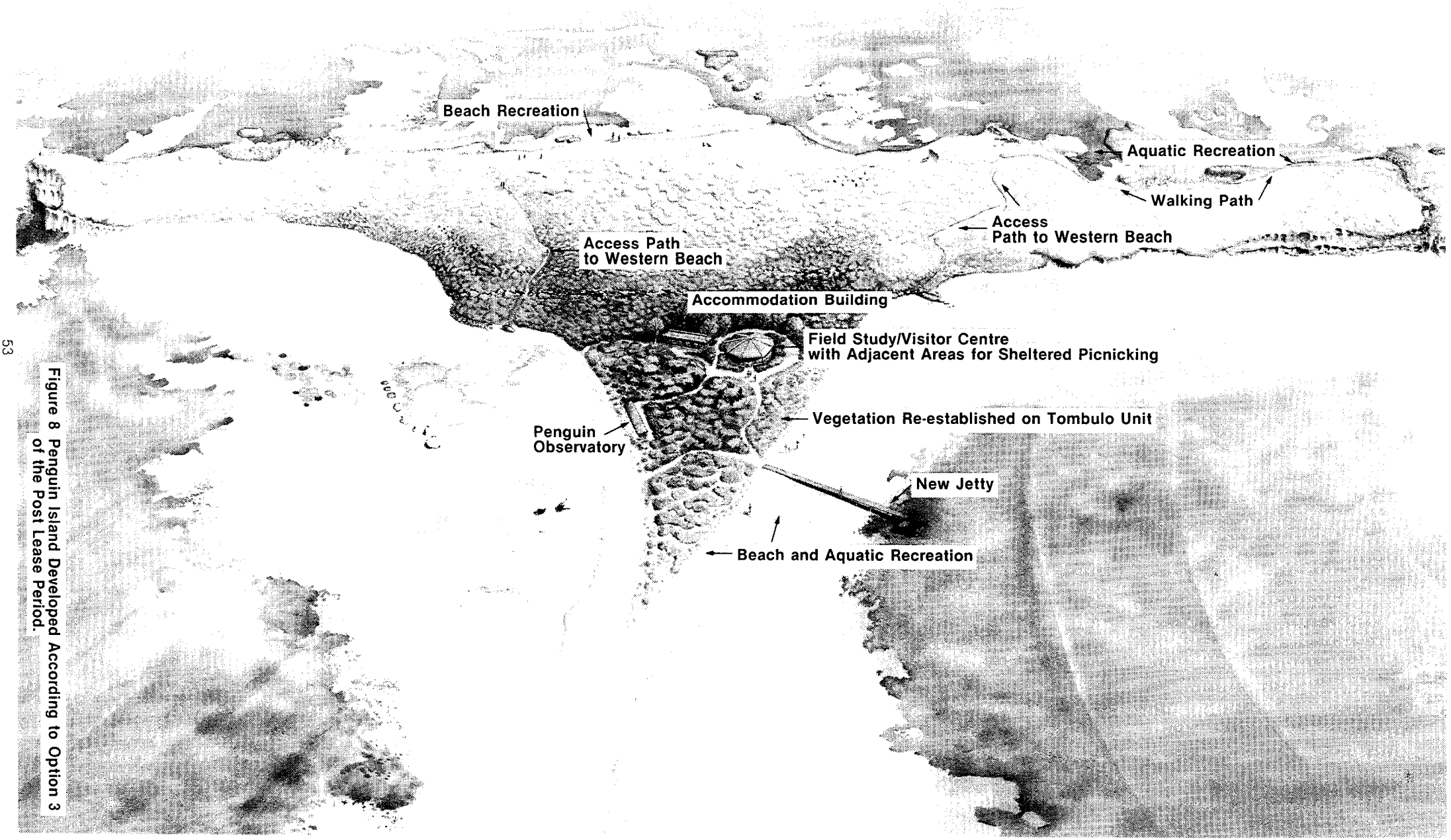



Figure 8 Penguin Island Developed According to Option 3 of the Post Lease Period.

- Establishing a walking path through the Central Dunes Unit (see Plan 2) to connect the eastern and western stepped walkways. This path should be surfaced in gravel or, preferably, with a boardwalk pathway to prevent gullying which could occur if the soft sands remained unsurfaced.

- Forming an access path across the North Plateau Unit to the western shore (see Plan 2) to formalise one of the routes currently used by the public. Apart from widening and fencing, the path should not require much work to upgrade it since most of the route traverses thin plateau soil and surface limestone which provides a stable surface for foot traffic. A limestone shelf provides access to the path from the eastern beach, although a timber sleeper walkway of 4.5 metres may be required to provide access to the beach on the north side of the shelf. A fenced, stepped walkway of 16 metres length will be necessary to provide permanent access from the path to the western beach. Fixed timber sleepers should be adequate for this construction.

- Upgrading and defining an existing access path on the western edge of the northern plateau to allow public access into the Rock Platform Unit and MacKenzie's Cave. Fencing, and in some sections, widening should be sufficient to formalise this route. Provision may have to be made to close this track during seabird breeding seasons.

- All paths and walkways should be fenced with ringlock mesh (of appropriate dimensions to allow free access to penguins) topped with strands of plain wire. Treated pine posts should be used for their durability and appearance. The estimated cost is $4.00 per metre, based on recent beach protection works undertaken by the Department of Conservation and Environment. The unit cost may be higher on the limestone plateau where the shallow soil will necessitate extra work to erect fence posts.

### 5.3.2 Erosion Control

Erosion control (also see Plan 2) relates directly to the management recommendations concerning public access. The initial management approach to this important issue should be the prevention of access into the Central Dunes Unit and encouragement of natural revegetation. The widespread presence of dune coloniser species, in particular Spinifex hirsutus, S. longifolius, Tetragonia decumbens and Olearia axillaris and their success in stabilising some areas of mobile sand indicates that complete stabilisation will occur naturally if foot traffic is removed as the primary agent of erosion. However, additional work will be required at the following locations:

- Brush the bare sand areas of the badly eroded foredune on the western shore to trap wind blown sand, facilitate

establishment of coloniser plant species and, eventually, reform the foredune. Brush will have to be supplied from the mainland.

- Brush the steep slope of the large bare area at the southern edge of the Central Dune Unit where it abuts the shoreline in order to reduce sand movement and establish vegetation. Due to the steep nature of the slope it will be necessary to tie down the brush with wire mesh or fencing wire anchored to star picket fence posts hammered into the face of the slope. Cuttings of T. decumbens may be planted amongst the brush to facilitate early stabilistion.

- Brush and plant the steep bare slope at the southern junction of the Central Dune and Tombolo Units. Again, it will be necessary to tie down the brush on this slope. T. decumbens cuttings should be planted on the lower section of the slope abutting the beach and Acacia rostellifera seedlings planted amongst the tied brush across the entire upper slope.

Storm erosion should be regarded as a natural phenomenon and part of the island environment. Re-establishment of the western foredune and fencing of the Tombolo Unit foreshore to protect and restore vegetation should reduce the impact of winter storms on the island's shoreline. Ringlock mesh and treated pine fencing should be constructed according to the layout shown on Plan 2 to prevent public access into unstable or susceptible areas. The estimated cost of fencing the Central Dune and Tombolo Units is $6000.

Following fencing and specified stabilisation works the extent of vegetation cover should be plotted annually on aerial photographs to assess the success of the initial management strategy. If there is no substantial colonisation and stabilisation after three years then a more intensive revegetation programme will have to be implemented based on seeding unstable areas with appropriate species.

5.3.3 Vegetation

Overall vegetation management is related to the recommendations for erosion control. That is, prevention of public access, recolonisation, stabilisation, maintenance or restoration of natural successional cycles and annual monitoring of vegetation cover. However, the following specific recommendations should also be applied:

- Determine the cover and structure of the Acacia rostellifera community; assess age structure and regeneration rates and the need for a more intense management approach, such as supplementary planting within the remaining natural area.

- Assess extent and numbers (species and individuals) of exotic species over time to identify any gross changes in endemic vegetation communities or replacement of individual endemic species by exotics. Develop an exotic

species eradication programme as required. The existing exotic and non-endemic trees planted in the settlement area should be retained as shelter trees.

- Use endemic species to landscape the Tombolo Unit (see Plan 2 and 5.3.7), especially Acacia rostellifera and Pittosporum phylliraeoides. Examine the feasibility of re-introducing A. cyclops to the island using seed stock from Garden Island, which should be genotypically similar to the plants originally established on Penguin Island.

- Regard the seabird related secondary vegetation cycle as a natural phenomenon even though some stages of the cycle are visually unattractive, in particular the death of woody perennials due to manuring and trampling by seabird colonies. The North Plateau Unit should be fenced to prevent public access which could result in erosion of areas temporarily denuded of vegetation as part of the secondary cycle, as well as protecting wildlife. Estimated cost of fencing is $2,000.

### 5.3.4 Fire Management

Although the fire history of Penguin Island has not been recorded, the vegetation is similar to the highly flammable plant communities on Rottnest Island which have undergone major changes in structure and extent as a result of numerous fires since settlement. Accordingly, a complete prohibition on external fires should be imposed on Penguin Island. All wood-burning barbecue facilities should be removed and replaced with gas barbeques if the facility is still required within the settlement area for the duration of the lease. Day visitors should be advised by sign-posting on the mainland and through information supplied by Penguin Island Pty Ltd, National Parks Authority, Rockingham Shire Council and other agencies that fires are prohibited and to provision themselves accordingly.

Penguin Island Pty Ltd should maintain their existing mains pressure hose for use against any fire outbreak. The hose should be long enough to reach the outer western perimeter of the settlement area and provide some protection to the Acacia rostellifera community as well as the settlement buildings. If necessary, extra main connections and fittings should be installed to provide full coverage. Flammable material such as wood, rubbish and litter should be removed from vegetated areas, expecially the Acacia thickets, and adjacent to buildings. The proximity of beaches in designated public use areas and provision of two constructed access paths will reduce the hazard to day visitors in the event of bushfires on the island.

### 5.3.5 Wildlife

Habitat restoration and protection through implementation of erosion control, vegetation and fire management recommendations is fundamental to wildlife management on Penguin Island. The following specific recommendations should also be implemented:

- Include pertinent information on the island's wildlife in the proposed public awareness programme (see 5.4). Construct a bird observation hide within the North Plateau Unit to provide nature study opportunities for educational institutions and supervised individuals/groups.

- Provide ranger staff during November-March to coincide with the high public use period and important phases in seabird ecology. For example, the Little Penguin is most susceptible to human interference during its moulting period (November - January) and the Bridled Tern has its egg-laying and rearing period during this time. An informed ranger presence on the island, if only during weekends when visitor numbers are highest, could be used to encourage people to adhere to designated paths and public use areas.

- Monitor the South Plateau Unit to assess public adherence to the use and management plan (see Plan 1) and the need to fence off the upper plateau area to protect vegetation and wildlife. Although it has already been recommended to fence large sections of the island for management purposes it is not intended to recommend fencing the South Plateau at this stage in an attempt to reduce initial management costs. However, if the proposed public awareness programme and improved policing of visitors proves ineffective then the area should be fenced.

- Initiate a programmed removal of penguins from beneath the settlement buildings so that the birds' dependency on these artificial habitats is reduced over time in readiness for the eventual removal of existing buidings on termination of the lease. Fencing the foundations of buildings should be undertaken in concert with natural revegetation of protected or landscaped areas, perhaps at the rate of one or two buildings a year. Fencing will have to be buried below ground level to prevent burrowing by penguins. Installation of artificial burrows (see Appendix D) in natural areas would help to reduce the impact on penguins of preventing their use of the buildings. Fencing off the old nesting sites should be carried out during the penguins' short summer absence from the island before they return in the second half of March.

- Locate and mark Little Shearwater burrows. Where they will not be protected by the fencing proposed in 5.3.1 and 5.3.2 the burrow areas should be fenced separately to prevent human disturbance. Undertake research into the birds' behavioural ecology to assist future management.

- Implement a culling programme to control the Silver Gull population within the limits of 1000-1500 pairs in order to maintain an appropriate ecological balance between all species dependent on the island's habitats. Lethal

narcotic baiting (using - Chloralose) of adult birds should be undertaken after the first laying peak in late April when nest site tenacity is maximal. Initial culling should be concentrated adjacent to public access and use areas to reduce the hazard of aggressive birds to the public. Baiting should be carried out at dusk to minimise the chance of killing non-target species. Annual monitoring of the population will have to be undertaken to assess the need for, and extent of, culling for each respective season. The habitat of the King's Skink which preys on gull eggs is protected within the proposed fencing of the North Plateau Unit.

- Undertake a seabird management programme aimed at diversifying the range of species found on the island in order to increase the value of Penguin Island as a conservation reserve and an educational resource. This action would also have important implications for the regional conservation of many species of seabird by providing a protected and managed breeding environment. Other species (see 2.7.3) could be encouraged to nest on the island through behavioural manipulation such as the display of suitably marked decoys. This method has proved successful for terns on Rottnest Island (J.N. Dunlop, pers. comm). Close liaison with researchers working in this field would be essential to such a management programme.

- Remove the small colony of feral pigeons which use the roof of MacKenzie's Cave as a night roost. Pigeons are recognised disease carriers and their droppings foul the floor of the cave, which has historic significance for Penguin Island. Lethal narcotic baits (as per gulls) should be effective in removing the birds if applied with a grain feed.

- Encourage management orientated research into seabird ecology, the results of which can be incorporated into an ongoing management programme.

5.3.6 Marine Environment

The fact that the marine environment is presently outside the jurisdiction of the National Parks Authority inhibits the preparation of a comprehensive management programme in conjunction with terrestrial management planning for Penguin Island, especially with respect to administrative control and funding. Although the System 6 Study has recommended an investigation into the natural resources of Shoalwater Bay with a view to creating a C-class aquatic reserve within the entire bay area (see 4.1) the National Parks Authority should request the Minister for Fisheries and Wildlife to proceed with declaration of an aquatic reserve surrounding Penguin Island under Section 30 of the Fisheries Act. The aquatic reserve should be vested in the National Parks Authority in its capacity as a body corporate in accordance with Section 30 (4), which would then be

responsible for management of the reserve. The precise area and boundaries of the reserve would have to be determined following a survey of resources to ensure inclusion of all pertinent ecosystems within the island's terrestrial-marine interface. It is anticipated that an outer limit of 200 metres offshore from low water mark would suffice.

The creation of this aquatic reserve would allow the National Parks Authority to extend management controls into the marine environment surrounding Penguin Island. This has important implications with respect to the conservation of marine habitats which characterise Shoalwater Bay and provides an opportunity to develop a complementary terrestrial-marine management programme for the island ecosystem as a whole, since natural resources and human users interact with, and are dependent upon, both types of environment. Should the System 6 Study recommendations be implemented at some future date the aquatic reserve could be incorporated into a wider reserve encompassing all or part of Shoalwater Bay and administered by a single agency, although use and management objectives for the island's nearshore waters which relate to overall island management would still apply.

As an interim measure the following recommendations should be implemented.:

- Support and cor-ordinate research which will result in increased understanding of the marine environment around Penguin Island and facilitate its future management. This would include work undertaken by Murdoch University, the Western Australian Institute of Technology, Department of Fisheries and Wildlife and the Western Austalian Museum.

- Request the Minister for Fisheries and Wildlife to declare a ban on the taking of all marine organisms by amateur and professional fishermen from the area shown on Plan 1. The basis for this recommendation is the need to (re)establish a healthy, diverse rock platform/reef community adjacent to the island by which the impact of human use on nearby marine environments can be assessed, such as abalone harvesting and line fishing of reef dependent fish species. As well as eventually providing base line data for future management of the Shoalwater Bay marine environment and protecting commercially important species, such as juvenile rock lobster, the proposed protection area could play an important role in the development of a nature interpretation programme for the reserve through establishment of a marine nature trail.

- Prohibit spearfishing from all nearshore waters and police the prohibition on net fishing under Fisheries Act

Regulations. All types of net fishing, except crab scoop and drop nets, are currently prohibited within the area 1600 metres surrounding Penguin island. The proposed presence of a ranger (see 5.3.5) could also be used to encourage public compliance with management objectives for the island's nearshore waters.

- Include the nearshore marine environment in the proposed public awareness programme (see 5.4), especially with regard to fishing bans and protected areas.

5.3.7 Landscape and Facilities

On Penguin Island landscape management is closely related to the location, size and colour of built facilities within the Tombolo Unit. While implementation of erosion control and vegetation management recommendations will, in the long term, remove the overall visual impact of eroded areas restoration of full landscape amenity will also require implementation of the following management recommendations concerning the settlement area. The National Parks Authority should direct Penguin Island Pty Ltd, in accordance with Part 2(k) of the lease agreement, to:

- Make an assessment of all settlement buildings with a view to removing those which are in poor condition and/or visually prominent (especially the four structures identified on Plan 2) and renovating others in need of repair.

- Paint all remaining buildings in colours which will harmonize the structures with their surrounding environment and reduce their visual impact on the island and Shoalwater Bay landscapes. Roofs should be painted with a dark olive-green colour and walls in a light grey-brown colour similar to weathered limestone. The public toilets should be painted in the same colours.

- Clean up the north-western corner of the Tombolo Unit in the vicinity of the generator shed and public toilets. This will necessitate removal of drums, tyres, a derelict boat, mattress wire, iron, a concrete block used to break up firewood, wood stockpiles and other assorted rubbish. The strips of conveyor belt rubber used for walkways between buildings should be removed and replaced with crushed limestone gravel or other suitable surfacing material in publicly visible areas. Timber and mattress wire 'beach-shelters' should be removed and, if this facility is still required, replaced with properly designed and constructed timber units. The existing barbecues and tables on the northern beach and in an adjacent limestone cave should be removed.

- Replace damaged rubbish bins with new containers and shift the bin in front of the dune opposite the jetty to a more suitable location.

- Remove old tyres embedded in the sand on the beach in front of the jetty and replace existing painted metal signs near the jetty ('do not litter' and directional signs) with a single routed wood information sign (see 5.4).

- Repair and maintain the jetty as required.

- Undertake a vegetation planting and fencing programme in the areas shown on Plan 2. Endemic shrub and tree species, especially A. rostellifera and Pittosporum phylliraeoides should be used to screen the buildings facing onto the northern beach of the Tombolo Unit and to repair the area around the generator shed and public toilets.

5.3.8 Reserve Maintenance

It is essential that new fences and walkways are maintained in good condition, since a visually well managed area does not attract the misuse and vandalism which is prevalent in reserves where a management presence is lacking. This is an important consideration because the long term stability of the island's dune sands depends on limiting access to designated walking paths and recreation areas. National Parks Authority staff and, for the duration of the lease, the Penguin Island Pty Ltd manager/honorary ranger should make regular inspections of all management works and have them maintained in good order. Similarly, the settlement buildings and grounds must be maintained in a neat and tidy condition. Regular rubbish collection from bins and periodic inspection of all public areas around the island to pick up any litter must be carried out. This is especially important during the high use months of the year.

## 5.4 Public Awareness

Public education or awareness programmes play an important role in the management of natural areas which are subject to varying degrees of human use. Such programmes have the twofold purpose of, firstly, making the public aware of management objectives and the need to comply with directives relating to them and, secondly, educating or informing the public about the environmental features of the location. It is essential that the National Parks Authority initiate a basic public awareness programme in conjunction with implementation of the proposed management recommendations.

Although the preferred option for future use of Penguin Island on expiration of the lease (see 5.2.2) proposes the complete development of the island's potential as a natural environment education resource, a comprehensive interpretation programme would have to be prepared prior to, and as part of, such development. Accordingly, the present discussion refers to immediate needs.

5.4.1 Signs

Informative and directive signs should be erected on both the mainland foreshore and the island. A silk-screened metal or

compressed asbestos cement sign, in muted colours, should be placed on or near the mainland jetty and contain the following information:

- a schematic map of Penguin Island showing the broad designation of conservation, public recreation and settlement areas, and access on the island;
- the need for visitors to confine themselves to access paths and recreation areas in order to protect vegetation and wildlife;
- access to the island, ferry timetable;
- controls on fishing and shell fish harvesting (the proposed protected marine area should also be shown on the schematic map of the island);
- fires prohibited.

Sign-posting on Penguin Island should take the form of:

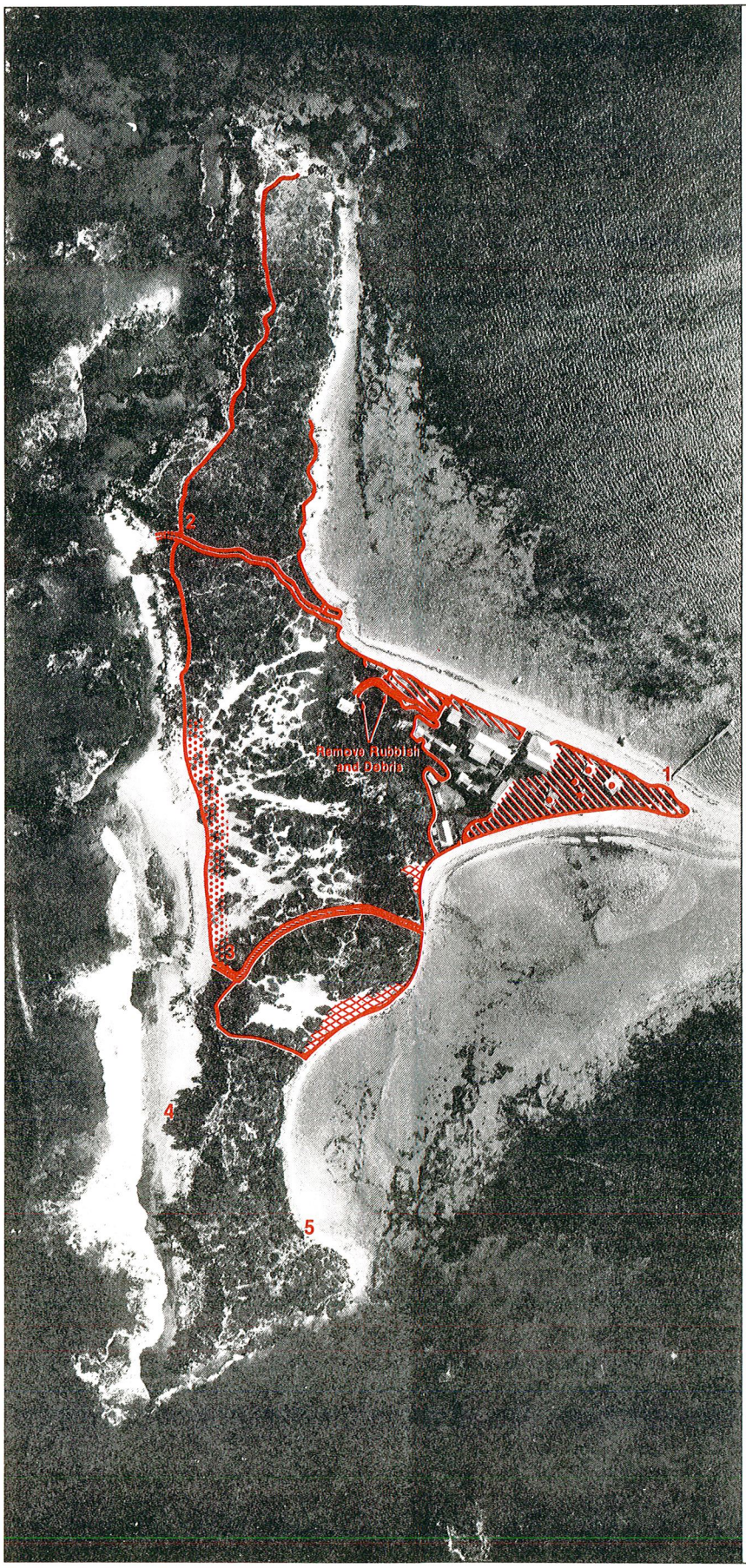
- a routed wood sign at the base of the foredune opposite the jetty displaying 'Welcome to Penguin Island'; directions to access paths to western beach, north-west rock platforms and MacKenzie's Cave; the need to remain on paths; direction to shop; fires prohibited;
- brief directive signs on the western side of the island advising 'To Jetty' and 'To Mackenzie's Cave';
- a notice identifying the location of the proposed protected marine area on the south-western beach, specifying that all fishing and removal of marine organisms south of the sign is prohibited, similarly on the south-eastern beach (see Plan 2).

### 5.4.2 Pamphlet

A brief pamphlet should be prepared for distribution to the public, either free or at nominal cost, through the National Parks Authority, Penguin Island Pty Ltd, Rockingham Shire Council and its local tourist bureau, and Department of Tourism. The pamphlet should contain notes on the history of Penguin Island, its geology, vegetation, wildlife (including pertinent notes on the ecology of the Little Penguin and other common seabird species), marine environment and a summary of use and management objectives. Line drawings or photographs, depending on the availability of funds, could be used to illustrate the pamphlet, which could have a similar size and format to National Parks Authority brochures for individual national parks.

### 5.4.3 Other Approaches

While the installation of informative, quality signs and the preparation of an information pamphlet are considered essential to the ongoing management of Penguin Island, other aspects more related to public education could be considered, even though they are not essential at this stage. For example:




Signs:

1. 'Welcome to Penguin Island', etc.
2. 'To MacKenzie's Cave, To Jetty'
3. 'To Jetty'
4. & 5. 'Protected Marine Area — Taking of all Marine Organisms Prohibited

LEGEND:

- Railed timber walkways
- Ringlock mesh — Pine post fence
- Gravel or boardwalk path
- Timber sleeper walkway
- Brush
- Tied brush and planting
- Areas to be planted with endemic shrubs/trees.
- Buildings to be assessed for removal

0 100
metres

## PLAN 2 MANAGEMENT RECOMMENDATIONS

- the marking of nature trails (cross referenced to the information pamphlet) to facilitate nature study activities by supervised groups, especially school children;

- construction of observation hides in seabird breeding areas in conjunction with nature trails;

- preparation of a more detailed guidebook to island resources and wildlife;

- involvement of the WA Naturalist Club and tertiary institutions in nature interpretation activities, especially during school or public holidays.

# 6. IMPLEMENTATION

## 6.1 Funding of Management Works/Programmes

Table 3 summarises the management works and programmes, on a priority basis, which were recommended in the preceding section. An issue which should be of concern to the National Parks Authority is the funding of these works in view of the fact that a considerable portion of Penguin Island is subject to the current lease agreement with Penguin Island Pty Ltd. Although the lease clearly states that the Company is responsible for maintenance of the lease area and for meeting associated costs, the Authority has at various times aided the Company in the provision of services (see 3.4.2). However, it is recommended that the funding of management works proposed in this plan be carried out on a cost sharing basis which reflects the interests of both parties in an equitable manner.

Should the Authority decide to proceed with the recommended option of negotiating with Penguin Island Pty Ltd to obtain an early determination of the lease (see 5.1) a flexible approach should be taken to the management works proposed in 5.3.7 and Table 3. If the Company leaves the island within one to two years of an agreement to terminate the lease then the requirement to paint and renovate buildings should be waived. If departure takes place in two to three years then all proposed works should be carried out, in which case the Company should be responsible for funding the proposed fencing, landscaping and revegetation works in the immediate settlement area. This will require expenditure of approximately $2000 for fencing, $500 for paths, $2500 -$3000 for painting and $1000 for general landscaping and planting.

The National Parks Authority should be responsible for implementation of management proposals throughout the rest of the island on the basis that the remaining areas are either heavily used by the general public or are important conservation areas. While it is acknowledged that the Authority has limited staff and financial resources to apply to its numerous management responsibilities it is essential that provision is made for implementation of the proposed management recommendations as soon as possible. This may necessitate a special application to the State Government for immediate funding and staffing to implement the recommendations. The Authority should also explore the feasibility of obtaining funds through the Commonwealth Community Employment Program to employ tradesmen and labourers on fencing and soil conservation works. Although costs can probably be reduced through the use of volunteer labour it is important to stress the need for the use of quality materials to achieve a durable result and well managed appearance.

## 6.2 Duration of the Plan

It is recommended that the Penguin Island Management Plan be reviewed after 31 December 1988. If there are changes in circumstances on or around Penguin Island within this time, such as early termination of the lease agreement or development of comprehensive management planning for Shoalwater Bay, then appropriate amendments should be made.

# TABLE 3: MANAGEMENT PROGRAMME

| Priority | Works/Development | Planning | Estimated Cost | |
|---|---|---|---|---|
| | | | National Parks Authority | Penguin Island Pty. Ltd. |
| A | Fencing | | $6000 (Estimates based on a total of 2000 metres @ $4.00/metre) | $2000 |
| A | Walkways and paths | | $3000-$3500 | |
| A | Erosion control (brushing planting, etc) | | $2000 (20 man days @ $10/hour plus materials) | |
| A | | Annual monitoring to assess success of erosion works | $300 p.a. | |
| A | Programmed removal of penguins from beneath buildings (construction of fences) | | $500 p.a. for 1 or 2 buildings until all buildings fenced | |
| A | Installation of artificial penguin burrows to provide alternative habitat. | | Not known | |
| A | Culling gull population | Annual monitoring of gull population | Not known | |
| A | Removal of feral pigeons | | Not known | |
| A | Painting settlement buildings | | | $2000-$2500 |
| A | Painting public toilets | | $300 | |
| A | Landscaping (rubbish removal, planting etc) of settlement area | | | $1000 |
| B | | Preparation of public information pamphlet | Not known (price variable on quality and quantity) | |
| C | Establishing nature trails and observation hides on the island | Determining appropriate location(s) | Not known | |
| C | | Preparation of more detailed guidebook | Not known | |
| A | Sign-posting (island and mainland) | | $1000 | |

## 7. REFERENCES


Cambridge, M.L. (1979). Cockburn Sound Environmental Study. Technical Report on Seagrass. Department of Conservation and Environment. Report No. 7.

Cockburn Sound Environmental Study 1976-1979. Department of Conservation and Environment. Report No. 2 (1979).

Cresswell, G.R. and Golding, T.J. (1980). Observations of a south flowing current in the south-eastern Indian Ocean. Deep Sea Res. 27A, 449-466.

Department of Conservation and Environment (1981). The Darling System, Western Australia - The System 6 Study Report. Report No. 8, Western Australia.

Dunlop, J.N. (1981). SEABIRD ISLANDS. Carnac Island, Western Australia. Corella 5: 71-74.

Garrey, J., Maxwell, H. and Cresswell, G.R. (1981). Dispersal of tropical marine fauna to the Great Australian Bight by the Leeuwin Current. Aust. J. Mar. Freshw. Res., 32: 493-500.

Gillham, M.E. (1961). Alteration of the breeding habitat by seabirds and seals in Western Australia. J. Ecol., 49: 289-300.

Hodgkin, E.P. and Di Lollo, V. (1958). The tides of south-western Australia. J. Roy. Soc. West. Aust., 41: 42-54.

Hodgkin, E.P., Marsh, L. and Smith, G.G. (1959). The littoral environment of Rottnest Island. J. Roy. Soc. West. Aust., 42: 82-88.

Hodgkin, E.P. and Phillips, B.F. (1969). Sea temperatures on the coast of south-western Australia. J. Roy. Soc. West. Aust., 52: 59-62.

Fairbridge, R.W. (1950). The geology and geomorphology of Point Peron, Western Australia. J. Roy. Soc. West Aust., 34: 35-72.

Marsh, L. and Hodgkin, E.P. (1956). A survey of the fauna and flora of rocky shores of Carnac Island, Western Australia. W.A. Nat., 8: 62-72.

Nicholls, C.A. (1974). Double-brooding in the WA population of the Silver Gull Larus novaehollandiae Stephens. Aust. J. Zool., 22: 63-70.

Seddon, G. (1972). A Sense of Place (University of Western Aust. Press: Perth).

Serventy, D.L., Serventy, V. and Warham, J. (1971). The Handbook of Australian Sea-birds. (A.H. and A.W. Reed, Sydney).

Serventy, V.N. and White, S.R. (1943). Birds of Warnbro Sound, Western Australia. Emu, 43: 81-95.

Smith, G.G. (1952). A Contribution to the Algal Ecology of the Cockburn Sound and Rottnest Areas. M.Sc Thesis, Botany Department, University of Western Australia.

Steedman, R.K. and Craig, P.D. (1983). Wind driven circulation in Cockburn Sound. Aust. J. Mar. Freshw. Res., 34: 187-212.

Storr, G.M. (1960). Migration and breeding season in Sterna nereis and S. albifrons. Emu, 60: 135-137.

Storr, G.M. (1961). Flora of the Shoalwater Bay Islands. W.A. Nat., 2: 43-51.

Webster, I., Golding, T.J. and Dyson, N. (1979). Hydrological features of the near shelf waters off Fremantle, Western Australia, during 1974. C.S.I.R.O. Aust. Div. Fish. Oceanogr. Rep. 106.

Wooller, R.D. and Dunlop, J.N. (1979). Multiple laying by the Silver Gull Larus novaehollandiae Stephens, on Carnac Island, Western Australia. Aust. Wildl. Res., 6: 325-335.

## APPENDIX A
## FLORA OF PENGUIN ISLAND

**POACEAE**
* *Avena fatua* L.
* *Brachypodium distachyon* (L.) Rolm.
*Bromus arenarius* Labill.
*Bromus maximus*
* *Ehrharta longiflora* Sm.
* *Lolium rigidum* Gaud.
* *Parapholis incurva* (L.) Hubb.
* *Poa annua* L.
* *Poa australis* R. Br.
*Spinifex hirsutus* Labill.
*Spinifex longifolius* R. Br.
*Stenotaphrum secundatum* (Walt.) O. Kuntze
* *Stipa variabilis* Hughes.
* *Vulpia myuros* L.

**CYPERACEAE**
*Lepidosperma gladiatum* Labill.
*Scirpus antarcticus* L.
*Scirpus nodosus* Rottb.

**LILIACEAE**
*Acanthocarpus preissii* Lehm.
*Trachyandra divaricata* (Jacq.) Kunth.

**HAEMODORACEAE**
*Conostylis candicans* Endl.

**URTICACEAE**
*Parietaria debilis* G. Forst
*Urtica urens* L.

**POLYGONACEAE**
*Muelenbeckia adpressa* (Labill.) Meisn.

**CHENOPODIACEAE**
*Enchylaena tormentosa* R. Br.
*Rhagodia baccata* (Labill.) Moq.
*Sarcocornia australis* Banks and Sol.
*Salsola kali* L.

**AIZOACEAE**
*Carpobrotus edulis* (L.) N.E.Br
*Carpobrotus virescens* (Haw.) N.E.Br
*Tetragonia decumbens* Miller
*Tetragonia implexicoma* (Miq.) Hook. F.

**PORTULACACEAE**
*Calandrinia calyptrata* Hook F.

**CARYOPHYLLACEAE**
* *Cerastium glomeratum* Thuill.
* *Polycarpon tetraphyllum* Loef
* *Stellaria media* (L.) Vill.
* *Spergularia rubra* (L.)

**RANUNCULACEAE**
*Clematis microphylla* DC.

**LAURACEAE**
*Cassytha racemosa* Nees

**BRASSICACEAE**
*Cakile maritima* Scop
* *Sisymbrium orientale* L.

**CRASSULACEAE**
*Crassula colorata* (Nees)
*Crassula pedicellosa* (F.V.M.) Ostenf.

**PITTOSPORACEAE**
*Pittosporum phylliraeoides DC.*

**LEGUMINOSAE**
** *Acacia cyclops* A. Cunn.
*Acacia rostellifera* Benth.
* *Medicago polymorpha*
* *Melilotus indica* (L.)

**OXALIDACEAE**
*Oxalis corniculata* L.

**ZYGOPHYLLACEAE**
*Nitraria billardieri* D.C.

**RHAMNACEAE**
*Spyridium globulosum* (Labill.) Benth.

**MALVACEAE**
*Lavatera arborea* L.
*Lavatera plebeia* Sims

**FRANKENIACEAE**
*Frankenia pauciflora* DC.

**PRIMULACEAE**
* *Anagallis foemina* Mill

**APOCYNACEAE**
*Alyxia buxifolia* R. Br.

**CONVOLVULACEAE**
*Dichondra repens* J.R. and G. Forst.
*Wilsonia backhousei* Hook.

**SOLANACEAE**
* *Solanum nigrum* L.

**SCHROPHULARIACEAE**
* *Dischisma arenarium* E. Mey

**MYOPORACEAE**
*Myoporum adscendens* R. Br.

**GOODENIACEAE**
*Scaevola crassifolia* Labill.

**ASTERACEAE**
*Angianthus cunninghamii* D.C.
* *Arctotheca calendula* (L.) Levyns
* *Arctotheca pupilifolia* Arctotheca
* *Carduus tenuiflorus* Curtis
* *Erigeron canadensis* L.
* *Helichrysum cordatum* D.C.
* *Hypochoeris radicata* L.
*Olearia axillaris* (D.C.) FUM.
*Senecio lautus* G. Forst.
* *Sonchus oleraceus* L.

* Exotic species
** Now extinct on Penguin Island

## APPENDIX B
## FAUNA OF PENGUIN ISLAND

**BIRDS**

Australian Kestrel (*Falco cendroides*)
Australian Magpie (*Gymnorhina tibicen*) *
Australian Pelican (*Pelecanus conspicillatus*)
Australian Raven (*Corvus coronoides*) *
Australian Shelduck (*Tadorna tadornoides*) B
Banded Plover (*Charadrius bicinctus*) *
Bar-tailed Godwit (*Limosa lapponica*) +
Bridled Tern (*Sterna anaetheta*) B +
Caspian Tern (*Hydroprogne caspia*)
Crested Tern (*Sterna bergii*) +
Curlew Sandpiper (*Calidris ferruginea*) +
Fairy Tern (*Sterna nereis*)
Feral Pigeon (*Columba livia*)
Grey Plover (*Pluvialis squatarola*) +
Grey-tailed Tattler (*Tringa brevipes*) +
Knot (*Calidris canutus*) +
Little Black Cormorant (*Phalacrocorax sulcirostris*) *
Little Penguin (*Eudyptula minor*) B
Little Pied Cormorant (*Phalacrocorax melanoleucos*)
Little Shearwater (*Puffinus assimlis*) B
Pacific Gull (*Larus pacificus*) *
Pied Cormorant (*Phalacrocorax varius*)
Pied Oystercatcher (*Haematopus longirostris*)
Red-necked Stint (*Calidris ruficollis*) +
Reef Heron (*Egretta sacra*)
Roseate Tern (*Sterna dougallii*)
Ruddy Turnstone (*Arenaria interpres*) +
Sacred Kingfisher (*Halcyon sancta*)
Sanderling (*Calidris alba*) +
Silver Gull (*Larus novaehollandiae*) B
Singing Honeyeater (*Lichenostomus virescens*) B
Welcome Swallow (*Hirundo neoxena*) B
Willie Wagtail (*Rhipidura leucophrys*) *
Whimbrel (*Numenius phaeopus*) +
White-faced Heron (*Ardea novaehollandiae*)

B — Species nest on Pengiun !sland.
* — Recorded by Serventy & White (1943) but not recorded during the recent period of study.
\+ — Listed under migratory birds agreement.

**REPTILES**

Hawksbill Turtle (*Eretmochelys imbricata*)
King's Skink (*Egernia kingii*)
Marbled Gecko (*Phyllodactylus marmoratus*)
Skink (*Ctenotus fallens*)
Skink (*Morethia lineoocellata*)

**MAMMALS**

Australian Sea-Lion (*Neophoca cinerea*)
House Mouse (*Mus musculus*)

## APPENDIX C

## SUMMARY OF BREEDING POPULATIONS AND IMPORTANT NESTING SITES OF SEABIRDS IN THE FREMANTLE AREA (Source: J.N. Dunlop)

| SEABIRD SPECIES | ESTIMATED POPULATION (breeding pairs) | RELIABILITY | BREEDING SITES | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| Little Penguin | 700 — 900 | 3 | | | | | | | | | | ● | | | | ● | | ● | | ● | ● | ● | | |
| Little Shearwater | 20 | 2 | | | | | | | | | | | | | | | | | | | | ● | | |
| Wedge-tailed Shearwater | 2200 — 2500 | 2 | | | | | | | ● | ● | ● | ● | ● | | | | | | | | | | | |
| White-faced Storm Petrel | 20 | 2 | | | | | | | | | | | | | | | | ● | | | | | | |
| Pied Cormorant | 1200 — 1400 | 2 | | | | | | | ● | | | ● | ● | ● | ● | | ● | ● | ● | | | | | |
| Silver Gull | 8000 | 2 | ● | ● | ● | ● | ● | ● | ● | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | |
| Caspian Tern | 25 | 2 | | | ● | ● | ● | ● | ● | | | ● | | | | | | ● | ● | | | | | |
| Crested Tern | 1550 | 1 | | | ● | ● | | ● | ●* | | | ● | | | | | | | | ● | | | | |
| Roseate Tern | 16 | 1 | | | | | | | | | | | | | | | | | | | | | ● | |
| Fairy Tern | 500 — 1500 | 3 | | | ● | ● | ● | | | | | | | | | ● | | | | | | | | ● |
| Bridled Tern | 1200 — 1500 | 2 | ● | ● | | | | | ● | | | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● |

### RELIABILITY RATING

1. Complete count of breeding pairs or nests with contents.
2. Estimate based on partial count of breeding pairs or nests.
3. General estimate.

* Not used during period 1978 — 1983.

### KEY TO SEABIRD BREEDING SITES

**Rottnest**
1. Duck rock
2. Parakeet Island
3. Lake Bagdad
4. Lake Herschel
5. Government House Lake
6. Green Island
7. Dyer Island
8. Cape Vlamming
9. Radar Head

**Carnac**
10. Main Island
11. Flat Rock
12. Orelia Pt. Islet
13. Fraser Pt. Islet

14. **Garden Island**

**Shoalwater Bay**
15. Peron Rock
16. Bird Island
17. Gull Island
18. Seal Island
19. Shag Rock
20. Penguin Island
21. Murray Rocks

22. **Lake Walyungup**

APPENDIX D

## Notes on the Design of a Penguin Observatory
by Steven Davies

Observing nesting penguins 'in situ' presents a few difficulties in the field, the main problems being associated with minimising disturbance to the birds and the burrow. Because natural burrows are excavated in sand they frequently collapse after a time and, unless re-excavated, they are of no further use to the penguins. Artificial burrows overcome the inherent weaknesses found in natural burrows created by the penguins and have the additional advantage of being permanently located which is more suitable for observation purposes and demographic studies.

The simplest artificial burrow which facilitates observation without much physical disturbance to the nesting birds consists of a dome shaped nesting chamber with a short entrance tunnel and a false roof. Observations may alternatively be made through a chimney fixture which at most times has a lid attached to prevent direct sunlight from entering the nesting chamber (Reilly and Balmford, 1971). The small amount of disturbance created by removing the lid from the 'chimney' does not seem to provoke desertion of the nest and is adequate for most study purposes. However, Penguin island receives a great number of visitors over the birds' breeding season and without completely restricting access to the breeding colonies (which are widespread over the island) the degree of disturbance to nesting activities would be difficult to control. Having said this, artificial burrows installed on the island in the late 1960s proved to be successful in attracting nesting birds and continue to do so despite human disturbance.

Apart from natural burrows, the penguins also nest beneath the floors of holiday chalets on Penguin Island. This may be used to advantage in relocating some of the nesting burrows to the prepared penguin observatory (see design illustration). There is intense competition for nesting sites on the island, which should help to ensure the success of such an installation, if strategically located near the penguins usual landing place on the sheltered south-eastern beach.

The observatory design hinges on the concept of being able to see the nesting penguins from many different angles, hence the use of acrylic domes. Though the penguins appear exposed and vulnerable the lighting conditions within and around the dome in conjunction with the materials used are designed to create a burrow environment which (as far as the birds are aware) is similar to their natural nesting environment. The dimensions of the nesting chamber and entrance are similar to those of the concrete burrows already established as viable nests on the island.

To keep disturbance to a minimum consideration has to be given to the acuity of the birds' sensory mechanisms, in particular the visual mechanisms. Early observations concluded that the penguin eye is optically adapted to aquatic vision with the result that they are very myopic out of water. However, this popularly held belief was refuted after a recent study involving the Blackfoot Penguin (Spheniscus demersus) indicated that little or no refractive error

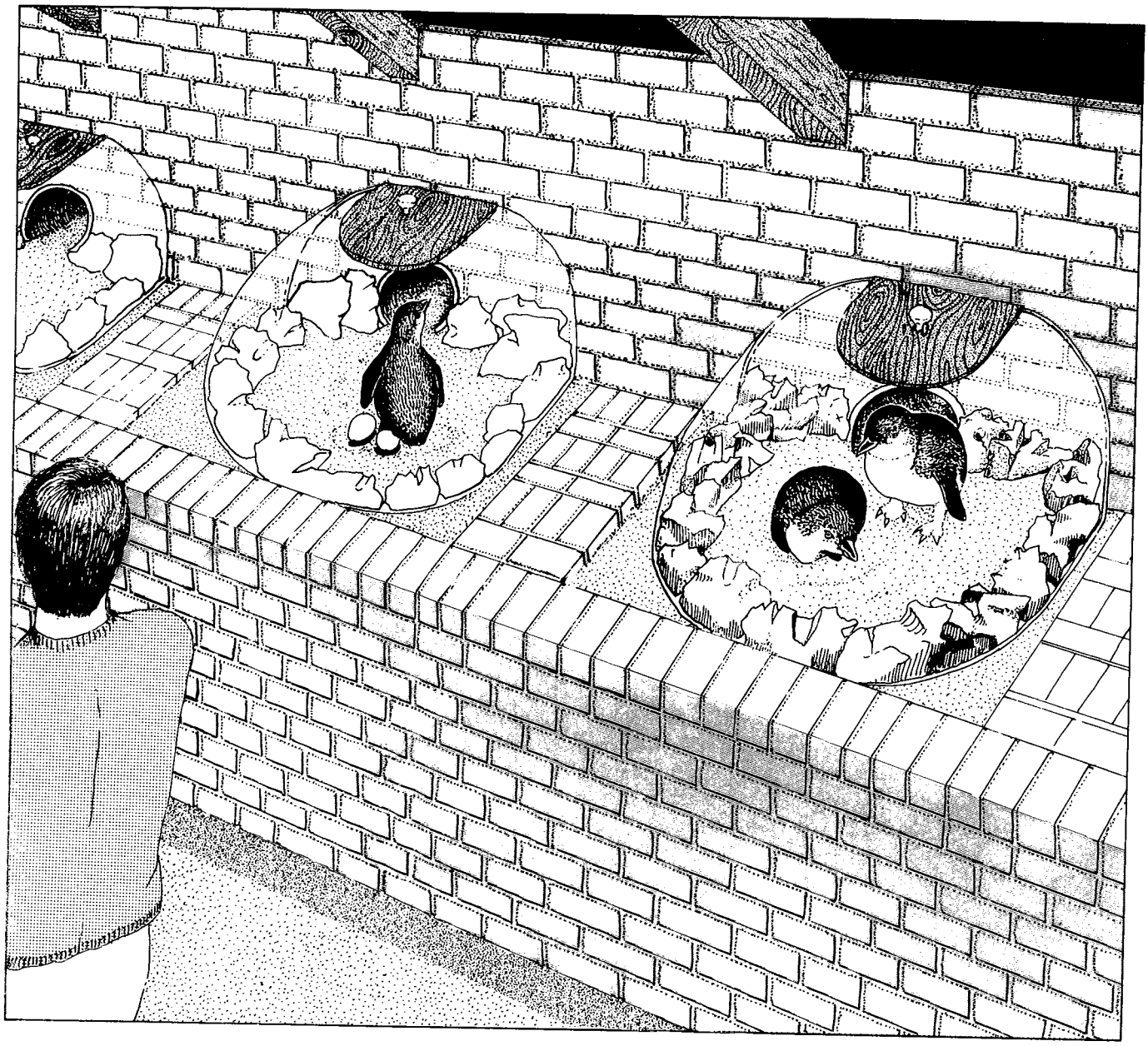
exists in air and that moderate hyperopia (insufficient refractive power to focus light on the retina) exists in water (Sivak 1976). In view of the dependence of penguins on the aquatic environment for food (Kooyman 1975; Sparks and Soper 1968) it was suggested that the hyperopic condition of the eye in water may be mitigated by a) accommodation and b) by an increase in refractive power resulting from the relationship between the chromatic aberration* of the eye and the blue or blue-green of an aquatic habitat to which colours, it is believed, the penguin eye is more sensitive.

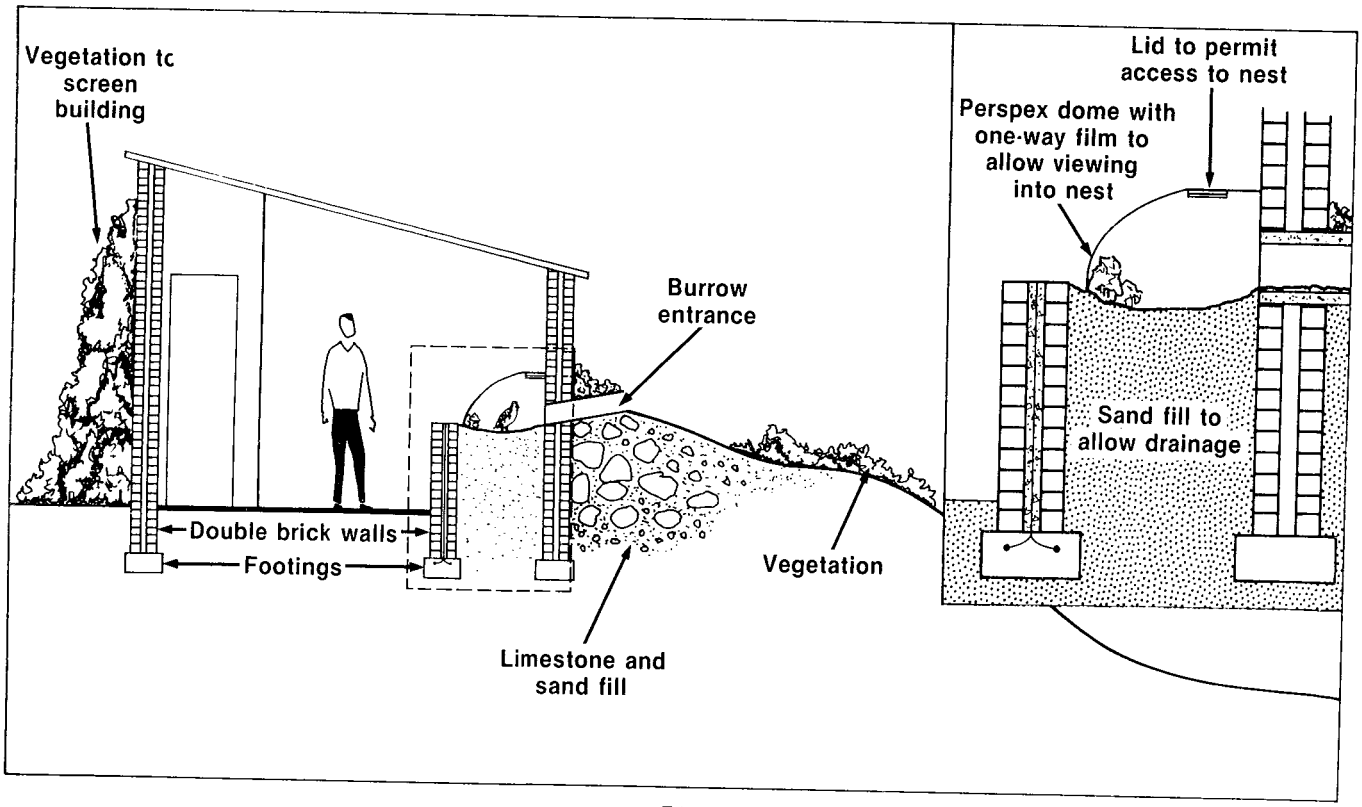
There is some reason to believe that penguins are slightly less sensitive to the red end of the spectrum, but generally they possess the same powers of adaptation to low light intensities as man. In view of this fact it is important to assimilate burrow lighting conditions which would serve equally well (in theory) to prevent two way vision through the acrylic dome as would be seen by penguins and humans alike.

One-way film stretched over the dome would help to facilitate humans being able to see into the domes and at the same time prevent the penguins from seeing out through the dome from the inside. However, the film loses its one-way viewing facility when lighting conditions on the inside equal or exceed in intensity those of the outside (as can be seen at night time through some office windows in Perth's central business district). Lighting conditions which ensure a contrast in illumination between the inside of the dome and outside are therefore necessary to prevent the penguins from being disturbed by the sight of movement outside the domes. Dim red light would be sufficient for people to find their way around the observatory (as in a photographic dark room) whilst the nests and birds may be illuminated from the inside by ordinary white light - the intensity and graduation of which may be controlled by installing a dimmer, rather than to suddenly expose the nesting penguins to bright light when a simple switch is thrown. It is expected that during the daytime there will be some indirect sunlight reflected into the burrow through the tunnel entrance, so it can be assumed that certain levels of light should be acceptable to the penguins.

In addition to visual disturbance, noise obtrusions must be minimised, since movement and talking around the domes may disturb the birds. The thickness of acrylic in the domes is crucial in helping to abate noise levels or vibrations transmitted through the domes. The acrylic domes used over public telephone booths effectively reduce noise levels for users despite being open ended. Since the domes may be easily sealed around the ends which adjoin the walls in the observatory (see illustration) a similar thickness of acrylic (3 to 6mm) would be sufficient to reduce outside noise considerably.

*Chromatic aberration (the difference between refractive errors as measured through red and blue filters) amounts to double that of the human eye.




Vegetation tc screen building
Lid to permit access to nest
Perspex dome with one-way film to allow viewing into nest
Burrow entrance
Sand fill to allow drainage
Double brick walls
Footings
Vegetation
Limestone and sand fill

Burrow hygiene is an important design consideration. Penguins are most susceptible to fungal related diseases, of which 'aspergillosis' is the most common, affecting the respiratory tract and various other organs in the body and often resulting in death. Aspergillosis is encouraged by nesting chamber conditions which retain the damp such as a poorly draining substrate beneath. Since penguins collect any readily available material for nest building, and are most partial to collecting leaf litter (whether fresh or dead) it is important to allow any moisture to escape from the chamber otherwise fungal growth is encouraged on the damp leaf litter. This is even more crucial when the chicks have hatched since their excreta would potentially increase the moisture levels inside the chamber. It is therefore necessary for the nests to be based on free draining sand. It would also be useful to be able to remove the dome or at least reach inside it to clean out blockages from the nesting chambers to maintain the free draining conditions (as well as perhaps for ringing and weighing purposes). To this end the acrylic may easily be cut to attach a removable roof, as suggested in the illustration.

Burrows are used intensively by the Little Penguin over its breeding season and, for some individuals, for part of the moulting phase, yet we possess a limited knowledge of their in-burrow activities which demand privacy and are therefore incompatible with usual observation methods as they create disturbance. The proposed penguin observatory would provide an ideal study opportunity to observe inside the burrows without disrupting the birds' natural activities patterns.

## REFERENCES


Kinsky, F.C. (1960) — The Yearly Cycle of the Northern Blue Penguin Eudyptula minor novaehollandiae in the Wellington Harbour Area. Rec. Dominion Mus. Wellington, 3: 145-218.

Reilly, P.N. and Balmford, P. (1975) — A Breeding Study of the Little Penguin Eudyptula minor in Australia. The Biology of Penguins, Ed. B. Stonehouse 1975.

Reilly, P.N. Cullen, J.M. (1979) — The Little Penguin Eudyptula minor in Victoria, II Breeding. Emu 1981, Vol. 81.

Serventy, D.L. Serventy, V. Warham, J. (1971) — The Handbook of Australian Seabirds. A.H. and A.W. Reed, Sydney

Sivak, J.G. (1976) — 'Visual Optics of the Penguin Eye'

Sivak, J.G. and Millodot, M. (1977) — 'Optical Performance of the Penguin Eye in Air and Water' - Journal of Comparative Physiology, 119: 241-247.

Sparks, J. and Soper, A. (1968) — 'Penguins' - David & Charles, Newton Abbot.

Warham, J. (1958) — The Nesting of the Little Penguin Eudyptula minor. Ibis, 100: 605-616.